National Park Service
U.S. Department of the Interior

Natural Resource Program Center
Fort Collins, Colorado

Landbird Monitoring Protocol and Standard Operating Procedures for the Sonoran Desert Network

Natural Resource Technical Report NPS/SODN/NRTR-2007/00X

ON THE COVER

Cactus wren. National Park Service/Don Dirks.

Landbird Monitoring Protocol and Standard Operating Procedures for the Sonoran Desert Network

Natural Resource Technical Report NPS/SODN/NRTR-2007/00X

Authors

Brian F. Powell[1]
Aaron D. Flesch[2]
Theresa Mau-Crimmins[3]
Debbie Angell[3]
Kristen Beaupre[3]
William L. Halvorson[1]

[1]USGS Southwest Biological Science Center
Sonoran Desert Research Station
School of Natural Resources
University of Arizona
Tucson, Arizona 85721

[2]School of Natural Resources
University of Arizona
Tucson, Arizona 85721

[3]Sonoran Desert Network
National Park Service
7660 E. Broadway Blvd., Suite #303
Tucson, Arizona 85710

Editing and Design

Alice Wondrak Biel
Inventory & Monitoring Program
National Park Service–Intermountain Region
12795 West Alameda Parkway
Denver, Colorado 80225

Contact

Andy Hubbard
National Park Service–Sonoran Desert Network
7660 E. Broadway Blvd., Suite #303
Tucson, Arizona 85710
Phone: 1+520-546-1607x1
Fax: 1+520-546-7601
http://www.nature.nps.gov/im/units/sodn/

August 2007, Version 1.02

U.S. Department of the Interior
National Park Service
Natural Resource Program Center
Fort Collins, Colorado

The Natural Resource Publication series addresses natural resource topics that are of interest and applicability to a broad readership in the National Park Service and to others in the management of natural resources, including the scientific community, the public, and the NPS conservation and environmental constituencies. Manuscripts are peer-reviewed to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and is designed and published in a professional manner.

The Natural Resource Technical Report series is used to disseminate the peer-reviewed results of scientific studies in the physical, biological, and social sciences for both the advancement of science and the achievement of the National Park Service's mission. The reports provide contributors with a forum for displaying comprehensive data that are often deleted from journals because of page limitations. Current examples of such reports include the results of research that addresses natural resource management issues; natural resource inventory and monitoring activities; resource assessment reports; scientific literature reviews; and peer-reviewed proceedings of technical workshops, conferences, or symposia.

Printed copies of reports in this series may be produced in limited quantity, and are only available as long as the supply lasts. You may send a request to:

Sonoran Desert Network
7660 E. Broadway Blvd, Suite 303
Tucson, Arizona 85710

This report is also available electronically from the Sonoran Desert Network website (http://www1.nature.nps.gov/im/units/sodn/index.htm).

When original printed copies are exhausted, copies can be obtained from:

Technical Information Center (TIC)
Denver Service Center
National Park Service
P.O. Box 25287
Denver, CO 80225-0287

Please cite this publication as:

Powell, B. F., A. D. Flesch, D. Angell, K. Beaupre, and W. L. Halvorson. 2007. Landbird monitoring protocol for the Sonoran Desert Network. Version 1.02. Natural Resource Report NPS/SODN/NRTR-2007/00X. National Park Service, Fort Collins, Colorado.

NPS D-XX, August 2007

Contents

Figures

Tables

Photos

Section 1
Protocol Narrative

Version 1.02 (May 4, 2007)

Revision History Log

Previous Version #	Revision date	Author	Changes made	Section and paragraph	Reason for change	New Version #

1 Background

The core mission of the National Park Service (NPS), as outlined in the agency's 1916 Organic Act, is the protection and preservation of natural and cultural resources for future generations. Responding to criticism that it lacked basic knowledge of natural resources within parks, the NPS initiated the Inventory and Monitoring (I&M) Program to detect long-term changes in biological resources (NPS 1992). Parks with significant natural resources were assigned to one of 32 monitoring networks, each based on ecological similarity and geographic proximity. Each network was charged with developing a monitoring program capable of detecting long-term changes in physical and biological resources within each network.

The Sonoran Desert Network (SODN) includes 11 parks in southern Arizona and New Mexico: Casa Grande Ruins National Monument (CAGR), Chiricahua National Monument (CHIR), Coronado National Memorial (CORO), Fort Bowie National Historic Site (FOBO), Gila Cliff Dwellings National Monument (GICL), Montezuma Castle National Monument (MOCA), Saguaro National Park (SAGU), Organ Pipe Cactus National Monument (ORPI), Tonto National Monument (TONT), Tumacácori National Historical Park (TUMA), and Tuzigoot National Monument (TUZI). These units range in size from 356 hectares (TUMA) to 133,882 hectares (ORPI; Table 1). Collectively, these parks are representative of most of the ecological communities present within the greater Sonoran Desert ecoregion (Mau-Crimmins et al. 2005). Recently, SODN I&M staff completed a monitoring plan that identified "vital signs," or parameters, representing a diverse range of natural resources, including air, water, climate, soils, plants, invertebrates, and vertebrates (Mau-Crimmins et al. 2005). Within each of these categories, vital signs were chosen by a workgroup of between four and eight regional and national experts. The vertebrate workgroup evaluated 171 potential parameters and reduced them to 32 on the basis of ecological significance, feasibility, and relevance to management (Mau-Crimmins et al. 2005). Landbird population parameters were considered among the most efficient and feasible vertebrate parameters for long-term monitoring.

1.1 Landbirds as a focus for monitoring efforts

Monitoring changes in landbird population and community parameters can be an important element of a comprehensive, long-term monitoring program, such as that being implemented for the SODN parks. Landbirds are a conspicuous component of many ecosystems and have high body temperatures, rapid metabolisms, and occupy high trophic levels. As such, changes in landbird populations may be indicators of changes in the biotic or abiotic components of the environment upon which they depend (Canterbury et al. 2000, Bryce et al. 2002). Relative to other vertebrates, landbirds are also highly detectable and can be efficiently

Table 1. Sonoran Desert Network parks, from largest to smallest.

Park name and code	Area		Elevation (meters)			
			Relief		Range	
	Acres	Hectares	Meters	Feet	Meters	Feet
Organ Pipe Cactus National Monument (ORPI)	330,688	133,882	1,158	3,800	305–1,463	1,000–4,800
Saguaro National Park (SAGU)	102,011	41,300	2,012	6,600	610–2,621	2,000–8,600
Chiricahua National Monument (CHIR)	11,984	4,852	815	2,675	1,570–2,385	5,150–7,825
Coronado National Memorial (CORO)	4,750	1,923	914	3,000	1,433–2,347	4,700–7,700
Tonto National Monument (TONT)	1,120	453	524	1,720	695–1,219	2,280–4,000
Fort Bowie National Historic Site (FOBO)	1,000	404	183	600	1,417–1,600	4,650–5,250
Montezuma Castle National Monument (MOCA)	858	347	140	460	963–1,103	3,160–3,620
Gila Cliff Dwellings National Monument (GICL)	533	216	52	170	2,027–2,079	6,650–6,820
Casa Grande Ruins National Monument (CAGR)	472	191	5	15	431–436	1,415–1,430
Tuzigoot National Monument (TUZI)	373	149	12	40	1,024–1,036	3,360–3,400
Tumacácori National Historical Park (TUMA)	356	144	104	340	994–1,097	3,260–3,600

surveyed with the use of numerous standardized methods (Bibby et al. 2000, Buckland et al. 2001).

Birds select habitat based on the presence of behavioral cues triggered by the environment (Hutto 1985a; Alcock 2005). In some environments, however, especially those that vary unpredictably, habitat may not be saturated and changes in resources may not always be tracked by changes in animal populations (Wiens 1985). In these situations, relating changes in bird populations to environmental features can be complex, especially when confounded by time lags that are characteristic of site-tenacious bird species. Additional complications occur if birds respond more sensitively to environmental change than we can detect and when cyclical environmental changes result in erratic changes in population size that are ultimately inconsequential. However, the utility of monitoring landbirds is strengthened by concurrent monitoring of a broad suite of environmental parameters (Dale and Beyeler 2001) that may assist with elucidating changes in the bird community to other environmental factors. Such a broad-based approach is now being undertaken by the SODN I&M program (Mau-Crimmins et al. 2005) and other broad-based monitoring approaches (e.g., Ringold et al. 1996; Stevens and Gold 2003; Barrows et al. 2005).

Perhaps the most compelling reason to monitor landbird communities in SODN parks is that birds themselves are inherently valuable. The high aesthetic and spiritual values that humans place on native wildlife is acknowledged in the agency's Organic Act: "to conserve . . . the wild life therein . . . unimpaired for the enjoyment of future generations." Birdwatching, in particular, is a popular, longstanding recreational pastime in the U.S., and forms the basis of a large and sustainable industry (Sekercioglu 2002). This is especially evident in southern Arizona, where the high diversity of birds creates some of the best birdwatching opportunities in the U.S.

1.2 Key ecological communities and stressors in SODN parks

As indicated above, Sonoran Desert Network parks include representative components of a diverse range of ecological communities present in southern Arizona and western New Mexico. Vegetation communities within the network range from lowland desertscrub dominated by creosote (*Larrea tridentata*) and bursage (*Ambrosia* spp.) that are characteristic of the Sonoran Desert, to highland mixed conifer forests dominated of fir (*Abies* spp.) and pine (*Pinus* spp.) found in the Canadian zone. This range of structural and floristic diversity is influenced further by varied biogeographic affinities of species within the network, including those of the Sonoran, Chihuahuan, and Mojave deserts, Rocky Mountains, Sierra Madre Occidental, and Great Plains (McLaughlin 1986; Brown 1994). Other important factors influencing the diversity in network parks include a range of topographic, geologic, edaphic, and climatic factors, and variable land-use histories (Marshall et al. 2000).

Ecological communities within the SODN are threatened by direct, human-induced changes to the landscape and by climate change (Nabhan and Holdsworth 1999). Among the ecological communities that have experienced much change in recent times are the Sonoran Desert uplands, semi-desert grasslands, and mesic riparian woodlands. The Sonoran Desert is the most widespread vegetation community in the network, and is well represented at ORPI, SAGU, and many of the smaller parks. A significant threat to the natural structure and function in this community is the invasion of non-native grasses, especially buffelgrass (*Pennisetum ciliare*), which is introducing fire into systems with no capacities with withstand its effects, thereby altering hydrology, nutrient cycling, and native-species composition (Burgess et al. 1991; Franklin et al. 2006; Bowers et al. 2006).

Semi-desert grasslands within the network are represented in small areas of CHIR, CORO, and SAGU. Within the parks, semi-desert grasslands are threatened due to shrub invasion and fire suppression. The spread of velvet mesquite (*Prosopis velunita*), in particular, has increased significantly in the region's once-open grasslands because of disruption of natural fire regimes and overgrazing by domestic livestock (Bahre and Shelton 1993; Van Auken 2000). Conversion of semi-desert grasslands to mesquite-invaded shrubland has had important implications for the quality and distribution of habitat for grassland-obligate birds, many of which have declined precipitously (Bock and Bock 1988; Knopf 1994; Rappole 1995).

Broadleaf riparian woodlands in the Sonoran Desert region are among the smallest community in area, yet support a higher density and diversity of native birds than any other major vegetation communities in the region (Rosenberg et al. 1991). Riparian vegetation is preferred nesting habitat for a disproportionate number of landbird species in the region (Bock and


NATIONAL PARK SERVICE

Riparian area, Tonto National Monument.

Bock 1984; Powell and Steidl 2000). Despite its value, however, the extent of riparian vegetation has declined as a result of water diversion, groundwater pumping, woodcutting, and drought (Rosenberg et al. 1991; Bahre 1991). For example, nesting riparian-obligate birds have virtually disappeared in the last few years from Rincon Creek, the site of the only stand of broadleaf riparian woodland in SAGU (B. Powell and C. Kirkpatrick, *unpublished data*). These declines have likely resulted from the degradation and loss of the riparian vegetation community from drought and excessive groundwater pumping (e.g., Stromberg et al. 1996).

Pine forests are found in four parks (CHIR, CORO, GICL, and SAGU). Montane forest birds of the southwestern "sky islands" have evolved in forests that experience low to moderate burns approximately every decade (Swetnam and Baisan 1996; Ganey et al. 1996). Active fire suppression has reduced the frequency of these burns, which have been replaced by high-intensity burns that radically alter forest structure (Allen 1996; Swetnam et al. 1999; Pyne 2001). All four parks with pine forests have experienced wildland fires in recent decades, and all have active fire management plans. Yet little information is available on the effects of these fires on bird communities.

Other stressors to bird communities in the Sonoran Desert are increasing due to rapid human population growth that is increasing at a rate faster than in most regions of the United States (U.S. Census Bureau 2000). Because many parks in the SODN are adjacent to expanding urban areas, habitat for some species of concern has been fragmented and degraded by urban environments (Germaine et al. 1998; Green and Baker 2003; Powell 2004; Powell

Elf owl (*Micrathene whitneyi*).

et al. 2005b). For example, prior to the early 1900s, CAGR likely supported a diverse native bird community. Now, because of vegetation change due to groundwater withdrawal and urban development, all common species are either non-native or adapted to the agricultural, commercial, or residential environments found adjacent to the monument (Powell et al. 2005b). Two SODN parks (CORO and ORPI) are located along the Mexican border, where impacts associated with illegal immigration, smuggling, and law enforcement are pervasive (NPS 2003; Segee and Neeley 2006). Other current and future stressors and drivers to regional bird communities include global climate change (Brown et al. 1997; Visser et al. 1998; Brown et al. 1999; Inkley et al. 2004), diseases such as avian influenza (Perkins and Swayne 2002; Kou et al. 2005) and West Nile virus (Rappole and Hubalek 2003; Caffrey et al. 2005), and additional non-native species (e.g., peach-faced lovebird).

1.3 Review of existing landbird monitoring programs in the region

Effective conservation and management of landbirds requires high-quality data that currently does not exist for network parks. The Breeding Bird Survey (BBS), a volunteer-based program, is the most widespread bird monitoring program in North America (Robbins et al. 1989; Sauer 1993). The program, in operation since the 1960s, seeks to monitor trends in detection rates (i.e., index-to-abundance) of most species throughout North America. The program has provided evidence for regional and national declines of some bird species (Robbins et al. 1989; James et al. 1996) in spite of some methodological challenges (James et al. 1996; Kendall et al. 1996; Link and Sauer 1998). Because only one BBS route exists inside an SODN park (ORPI), the BBS is insufficient to provide trend data for landbirds in SODN parks. Further, because BBS routes are placed along roadways, adding additional sites in parks would be insufficient for monitoring population trends at the network or park scales, both because of their limited inference and because of limited road coverage in network parks. The only other national bird monitoring program implemented in SODN parks is the Monitoring Avian Productivity and Survivorship program (Desante et al. 1995). The program was recently discontinued in all parks except TUMA, because of its inefficiency and lack of inference (Martinez and Hubbard 2003).

At a local scale, there was a comprehensive effort to inventory birds at nine of the 11 parks in the SODN between 2001 and 2005 (Albrecht et al. 2005; Schmidt et al. 2005a; Powell et al. 2005a; Schmidt et al. 2005b; Powell et al. 2005b; Powell et al. 2005c; Powell et al. 2005d; Powell et al. 2006) and in the two other parks that were not included in the recent effort: ORPI (Groschupf et al. 1988; Schmidt et al. 2006) and MOCA (Sogge and Johnson 1995). Although efforts to monitor birds in ORPI have been ongoing, data quality from this effort is limited due to constrained spatial extent, erratic sampling effort, and lack of standardization of the survey protocol (see Schmidt et al. 2006).

Given the insufficient data for determining long-term population trends from both national and park-based efforts, there is a significant need to design a new program with appropriate inference and statistical rigor. Such a program is especially critical given population declines for some species at both regional (Rosenberg et al. 1991) and national (Robbins et al. 1989) scales. The challenges in monitoring landbirds in SODN parks, then, are (1) to identify parameters that provide reliable information on status and trend of populations at meaningful spatial and temporal scales and (2) to establish a sampling design that is both efficient and informative.

2 Program Goals and Measurable Objectives

The broad goal of the landbird monitoring program is to detect biologically significant changes in population parameters over time. Ideally, we would estimate population size or abundance for all species in all parks each year and compare these estimates over time, both within and among parks. Such a goal, however, is unachievable due to numerous practical constraints, including the small size of many parks, diversity of ecological communities, the amount of effort required to generate precise estimates for small populations, and the large number of species that occur in SODN parks. To meet these challenges, we have tried to design a program that maximizes the strength of our inferences within the context of our finite resources. Our program provides a multi-tiered, flexible framework that will enable efficient estimation and monitoring of population parameters, periodic evaluation of assumptions, and the opportunity to adapt the program to meet additional needs.

We have selected three population parameters to estimate and monitor: density, relative abundance, and occupancy. Each parameter has different properties that vary in terms of the quality of information gained and estimated cost of measurement.

Density, the most desirable parameter, facilitates estimates of total population change (e.g., number of individuals lost or gained) over time. These estimates are directly comparable among species, because interspecific variation in detectability is explicitly accounted for during estimation (Buckland et al. 2001; Rosenstock et al. 2002).

In contrast, relative abundance (a.k.a. encounter rate; Buckland et al. 2001) provides an estimate of the ratio of overall population change (e.g., a 15% decline of an unknown number of individuals) among years and assumes constant detectability of the species in question. The main limitation in using a relative index of abundance is that variation in detectability, either among species or across time for the same species, can confound comparisons of trend estimates among species or preclude detection of a trend for a single species. For example, if detectability varies for a given species among years (due to habitat, observers, or other factors) and bias is systematic, the ratio of the index count to actual abundance will also vary, thereby confounding trend estimation (Lancia et al. 1996). This parameter will be measured only when density estimates are incalculable.

Occupancy, our third parameter, allows us to monitor changes in the number of sampling units occupied by a species over time (i.e., presence or absence) and allows adjustments for imperfect detectability during estimation (MacKenzie et al. 2002). Occupancy is an especially useful parameter when monitored in conjunction with density. For all parameters, when samples are drawn from a larger population of potential samples using a randomized design, inference will be at the scale of the population considered for sampling (Thompson 2002a).

Field methods for estimating all three parameters will be the same; analyses and evaluation procedures used to estimate trends will differ. Our benchmarks for effect size, power, and Type I error rate are similar to those recently presented in the literature (Bart et al. 2004). Specifically, we selected a Type I error rate ("false-alarm error") of 10% to increase the probability of detecting population declines that are, in fact, occurring.

As the properties of the parameters we selected vary, so too will their relative value for monitoring trends. Estimating and monitoring density is the most robust technique, yet precise estimates are often cost-intensive to generate and


NATIONAL PARK SERVICE

Harris's hawks (*Parabuteo unicinctus*).

sometimes not quantifiable at all, due to limitations in sample size (see Supplement A). Therefore, we will use a multi-tiered approach that emphasizes density estimation where possible. Where density estimation is not possible, we will estimate relative abundance by using the same methodology (see Field Methods), but restrict inference to only those species for which detectability assumptions can be evaluated. Although monitoring programs that rely on indices such as relative abundance have been criticized (Rosenstock et al. 2002; Thompson 2002b, Norvell et al. 2003), we can improve their application by assessing our assumptions and adapting the framework. It is our opinion that this approach is superior to vastly reducing the scope of monitoring by restricting inference to only common species. Supplementing this approach with occupancy information will provide yet another scale of information for monitoring populations of species that meet the appropriate assumptions. The rate of change that we will consider to be biologically significant will vary with the quality of the parameters estimated. Below, we briefly review the three parameters and present a framework for achieving the stated objectives.


NATIONAL PARK SERVICE

Northern cardinal (*Cardinalis cardinalis*).

2.1 Objective 1: Monitor density

We will monitor density of the most-common species with the goal of detecting a 2% annual decline over a 30-year period, with an 80% probability and a Type I error rate of 10%. (Note that a linear 2% annual decline over 30 years equals a 45% population decline overall.)

Of the three parameters, density is the most sensitive to change and, therefore, can most reliably inform managers of population declines. We will estimate density with the use of the point-transect distance-sampling method at fixed points and subsequent analyses using the Distance program (Thomas et al. 2005). Provided that assumptions are reasonably met, distance-sampling methods allow researchers to model a detection function that adjusts for imperfect detectability and is a robust, widely accepted method for estimating abundance of landbirds (Buckland et al. 2001). With reasonable effort, we will likely be able to estimate density annually for most of the common species in many parks (Supplement A). Annual estimates of density for less-common species, or in parks where detection data are spatially limited, will also be possible by pooling data across parks and using "park" a covariate when fitting the detection function—an approach that will enable comparisons among parks using a pooled estimate of variance. We also will explore the influence of other potential covariates on density across the network, such as variation among observers, timing, and environmental features.

2.2 Objective 2: Monitor relative abundance

We will monitor relative abundance of many other species with the goal of detecting a 3% annual decline over a 30-year period with an 80% probability and a Type I error rate of 10%. (Note that a constant 3% annual decline for 30 years equals a 60% population decline.)

Where sample-size constraints preclude precise estimates of density, we will monitor changes in relative abundance of less-common species and those of conservation or management concern. Relative abundance is an appropriate index for monitoring changes in population size if the ratio of the index count to the actual parameter of interest (e.g., population size) does not vary systematically over time, and if detectability does not change over time. Even significant variation in detection rates due to observers or other factors may not result in systematic temporal changes in the index ratio, but may reduce the precision of estimates of population change (Bart 2005).

To determine the applicability of our estimates of relative abundance for monitoring population change, we will periodically evaluate our assumptions for each species. Because systematic variation in detectability is likely the greatest potential source of error, we will first determine if detectability remains constant among years after standardizing our survey methodology. We will use distance-sampling methods to estimate a detection function for each year and for each species, and use goodness-of-fit tests to compare these functions among years. If no variation is detected, we will assume that trend estimates are not confounded by variation in detectability.

If detectability does vary systematically among years (e.g., decreasing detectability along a successional vegetation gradient) we will adjust relative-abundance estimates accordingly and use these adjusted estimates for trend estimation. Further, we will evaluate relationships between index ratios and true density of common species for which we will be able to approximate density, and assess the efficacy of using these relationships as correction factors for other ecologically similar, yet less-common species. Although trends in relative abundance over time may be less detectable than those of density, these trends should track those for density if the indices are proportional to abundance.

2.3 Objective 3: Estimate occupancy

We will estimate the proportion of sites occupied for most species in most parks with the goal of detecting a 1% annual decline over a 20-year period with an 80% probability and a Type I error rate of 10%. (Note that a constant 1% annual decline for 20 years equals an 18% population decline.)

Occupancy is a measure of presence or absence of a species in space that, when evaluated across time, indicates changes in the distribution of a species. Like those for density, techniques for estimating occupancy explicitly account for variation in detectability, thereby adjusting estimates for individuals that are present yet undetected during surveys, a situation that can confound the results of most wildlife surveys (Williams et al. 2002). Recent advancements in occupancy theory and modeling have provided sound justification of its application in monitoring programs (MacKenzie et al. 2003; Field et al. 2005; MacKenzie et al. 2006). Although temporal changes in occupancy are often smaller than those for density, especially when species are widespread and common, evaluating changes in occupancy can be especially valuable in SODN parks because many species are uncommon or rare, making reliable estimates of density impractical. Occupancy estimation has its limitations, including marked sensitivity to violations of assumptions (including misidentification of the species under consideration; Royle and Link 2006) and closure (i.e., no movement in or out) of the population during the sampling period (MacKenzie et al. 2006). As a result, we will use caution when estimating occupancy for groups of species that are often confused with others (e.g., ash-throated and brown-crested flycatchers) and constrain the sampling period for species that arrive late on the breeding grounds (e.g., yellow-billed cuckoo).


NATIONAL PARK SERVICE

Phainopepla (*Phainopepla nitens*).

To estimate changes in the proportion of survey points occupied by a species, we will use the same field methods as those for estimating density and relative abundance, and employ a multi-season model to derive annual estimates of distributional change (MacKenzie et al. 2006). Recent advances in modeling occupancy can provide the analytical tools necessary for evaluating relationships between occupancy

©R. BENNETTS

Cassin's finch (*Carpodacus cassinii*).

and abundance. When applied in SODN parks, these relationships can help describe variation in detection probability across the network (Royle et al. 2005) that may then be used to adjust the index ratio for monitoring trends in relative abundance (Royle 2004).

2.4 Objective 4: Document and monitor environmental features at bird survey points

We will measure environmental features at bird-survey points so as to relate changes in landbird population parameters to changes in the environment, such as vegetation structure and composition (Holmes and Sherry 2001; Krueper et al. 2003). Where appropriate, environmental data also will allow us to aggregate (i.e., to stratify, post-hoc) survey sites that share similar characteristics. Environmental monitoring at landbird survey points may be conducted in coordination with the SODN I&M vegetation monitoring program currently being developed. In addition to using vegetation and associated parameters, we will use data from other SODN I&M protocols (e.g., climate) as covariates when assessing population trends for birds. Finally, landbird population parameters, coupled with detailed environmental information, can be used to build habitat-association models (e.g., Manley et al. 2004) that can inform conservation efforts and scientific inquiry throughout the region.

2.5 Additional potential monitoring parameters

Future versions of this protocol narrative may articulate additional objectives. Most notably, species richness may be an appropriate landbird monitoring parameter (Cam et al. 2000; Kery and Schmid 2006) that can be estimated using the same methods of data collection and preparation as the other objectives (Nichols et al. 1998). We have not included species richness at this time because we feel it is less sensitive to change and, therefore, less informative for management. However, if additional monitoring partnerships can be established in the region, then species richness may become a more valuable tool at that broader scale (e.g., Kery and Schmid 2006). Additionally, in areas where species of conservation concern occur, we may monitor demographic parameters such as nest productivity, or implement single-species surveys (e.g., yellow-billed cuckoo at TUMA; Powell 2000).

3 Sampling Design

3.1 Overview

We will survey for landbirds at all SODN parks. In general, we will survey all areas that are easily accessible and present no safety problems. In most of the smaller parks, all areas will be included in the sampling frame. The sampling frame for larger parks (CHIR, CORO, ORPI, and SAGU) will be more restricted because of topography and difficulty of access to remote areas. References to the sampling frame throughout this document further clarify the scale of inference. The temporal sampling design has been changed since the last version of this protocol (Version 1.01). Based on a more thorough analysis of pilot day, we determined that attempting annual surveys of all parks would be inefficient. Therefore, we will conduct annual surveys at most low-elevation parks; at higher-elevation parks, surveys will be conducted every 3–5 years. We elaborate on the spatial and temporal designs below, as well as in supporting documents (Appendices C, D and Supplements A, B).

3.2 Spatial sampling design

We used a variety of spatial sampling designs to assign the location of bird-survey points (Table 3.2). For most parks, we stratified parks by mesic riparian or upland sites. We determined that a stratified sampling design was warranted because of the well-known and extreme differences in bird communities between riparian and upland areas. In cases where innately similar sampling units are considered together as a stratum, this sampling design increases sampling efficiency and precision (Thompson 2002a). We used a variety of approaches to assign the location of survey points. For many mesic riparian areas and upland sites, we chose to use sites that were established during the bird inventory work from 2001–2005 (see Introduction) if such an approach was prudent. A brief introduction to the process, and a rationale for choosing monitoring sites, appears below. Additional information can be found in Appendix C.

3.2.1 Riparian sampling sites

All SODN parks except for CAGR, ORPI, and SAGU's Tucson Mountain District (SAGU-TMD) have mesic riparian vegetation communities. Because mesic communities in the

Table 3.2. Spatial sampling frame and methods used to designate landbird monitoring sites, Sonoran Desert Network parks.

Park	Upland		Riparian	
	Sample frame	Method	Sample frame	Method
CAGR	Entire park (excluding 100m surrounding cultural features)	SRS	—	—
CHIR	Extraction from cost surface; 100m buffer around trails	SRS	Single riparian area	Non-random, from biological inventories
CORO	Eastern portion of park	SRS	Single riparian area	Non-random, from biological inventories
FOBO	Remainder of park (excluding circle in eastern portion)	SRS*	Single riparian area	Non-random, from biological inventories
GICL	Remainder of park	SRS*	Single riparian area	Non-random, from biological inventories
MOCA (castle unit)	Remainder of park	SRS	Single riparian area	Complete coverage via two transects
MOCA (well unit)	Remainder of park (excluding well unit)	SRS	Single riparian area	Complete coverage via one transect
ORPI	Cost surface calculated for areas within 2 km of roads	RRQRR	—	—
SAGU–RMD	Extraction from cost surface; 3 elevation classes	RRQRR	Single riparian area	Non-random, from biological inventories
SAGU–TMD	Extraction from cost surface	RRQRR	—	—
TONT	Northeastern portion of park	SRS	Single riparian area	Non-random, from biological inventories
TUMA	Entire park, split into agricultural and mesquite bosque	SRS*	Riparian treated as an area feature	SRS*
TUZI	Remainder of park excluding eastern portions	SRS	Single riparian area	Non-random, from biological inventories

*generated in 2005

See Appendix D for maps of designated sites and Appendix C for more detailed discussion of the methods used. See Table 1 for park acronyms.

SRS = stratified random sampling

RRQRR = reversed randomized quadrat recursive raster

Curve-billed thrasher (*Toxostoma curvirostre*).

other parks are spatially restricted, they can be surveyed without the need for sampling. Therefore, given the limited spatial extent of riparian resources and their importance for bird conservation, we chose a spatial design that would result in complete coverage of the most significant riparian resources. In many cases, these sites were established during the biological inventories of 2001–2005 (e.g., Powell et al. 2006). Maps in Appendix D depict the sample locations.

3.2.2 Upland sampling sites

Upland sampling points were allocated using two different approaches. In smaller parks, where we could achieve complete or nearly complete coverage using the design from the biological inventories, those points were used. In smaller parks where no inventories were conducted, such as at MOCA, all upland areas were given equal probability of being selected as a sampling location. Samples were randomly allocated using the Reversed Randomized Quadrant-Recursive Raster (RRQRR) algorithm (Theobald et al. 2005) using the "Generate Random Points" function in the Hawth's Tools extension in ArcGIS 9.0 (http://www.spatialecology.com/htools/index.php), with the constraint that points be ≥250 m apart (see Table 3.2).

At SAGU, we used the upland sites from the inventory effort (see Powell et al. 2006) because they were established using a stratified random design (Rincon Mountain District; SAGU-RMD) and simple random design (SAGU-TMD). This sampling design provided good dispersion of sampling locations and broad geographic coverage. In the RMD, we eliminated two low-elevation sites because of accessibility issues. Therefore, we added two new sites using the RRQRR algorithm. In years when we will be surveying the middle- and high-elevation strata, we will assess whether the inventory design is appropriate for surveying in those areas.

Organ Pipe Cactus National Monument was the only large park not inventoried in 2001–2005. Accessibility is not equal across the park; some areas are difficult to reach because of complex topography or simply because of their distance from a trailhead or road. At ORPI, we used a probabilistic sampling design and employed a continuous surface representing accessibility to represent inclusion probabilities (i.e., areas closer to trailheads and easier to access were given a higher probability of being selected as sites than areas far from trailheads and requiring a difficult hike). Some portions of the monument were excluded from the sampling frame altogether because it would have been unreasonable to expect an observer to reach them before dawn, as bird sampling requires. We will have no inference to areas not included in the sampling frame.

Incorporating the border-related safety regulations at ORPI into the sampling design has been a challenge (NPS 2003). Safety and park regulations about where, when, and how to access many areas of these parks remain fluid based on the changing nature of a variety of factors, including ranger staffing and the number and distribution of illegal border crossings. In early 2007, when we presented the list of potential monitoring sites to park managers and law enforcement officers, they eliminated most sites from consideration because of the potential for conflict with illegal immigrants and/or drug smugglers. The final list of approved sites included only a handful, all in the northwest corner of the park (see Appendix D). We were further required to have two field technicians working together, thereby reducing the number of sites that could be surveyed from ten to five. At this time, we are unsure what our biases and inference are for accepting this highly modified sampling design.

As mentioned in the introductory section of this protocol narrative, SODN parks contain a wide range of upland vegetation (and, by extension, bird) communities. Therefore, in the planning and data-analysis stages, it will be appropriate to further stratify parks based on the dominant vegetation communities represented there. The stratification of SAGU-RMD was based on this need. Striking a balance between too much and too little stratification will be one of the key design challenges of the program, because stratification has important consequences for sampling efficiency (Thompson 2002a). The dominant vegetation communities represented by upland areas in SODN parks can be roughly stratified into four communities:

- Desert: CAGR, FOBO, MOCA, ORPI, SAGU-TMD, and at <4000 feet in SAGU-RMD, TONT, TUMA, and TUZI.
- Semi-desert grassland: CORO and some areas of CHIR and SAGU-RMD.
- Pine-oak forest and woodland: CHIR and SAGU-RMD at 4,000–6,000 feet.
- Mixed conifer forest: GICL, CHIR at >6,000 feet, and SAGU-RMD at >6,000 feet.

The new sampling design for uplands emphasizes parks with desert communities. The small area of the other communities (especially semi-desert grasslands and mixed conifer forests), as well as access issues, further highlight the efficiencies of sampling the other park units more intensively.

3.2.1 Spatial arrangement of survey sites

Daily surveys will consist of a single observer visiting as many points as possible during the morning survey window (Supplement B). Points that can be surveyed together in a single morning will be considered a group (but note that this designation is one of convenience; points within groups were independently placed, except along riparian areas and in those situations where upland sites were placed non-randomly for the inventories).

This design is not appropriate at ORPI and SAGU, because of the size of the parks and, therefore, high travel times among points. At these parks, the designated sites represent the starting point of a transect, which will be made up of 6–9 survey points, each spaced at least 250 m apart. (The number of points in each transect was determined by terrain and access; e.g., those sites with difficult terrain and access were given the fewest number of points because of the limited survey window). The direction of each new transect will be parallel to any topographic gradient (Strindberg et al. 2004). At SAGU upland sites, we added survey points to the random transects. The number of new points varied from 2–4, depending on the terrain.

3.3 Temporal sampling design

3.3.1 Annual surveys

In a previous version of this protocol (Version 1.00), we suggested a temporal sampling design with annual visits to all parks. Based on analyses of pilot data (Supplement A), we modified this design to be more efficient, yet still maintain sampling in all parks. Specifically, we will sur-

Yellow-rumped warbler (*Dendroica coronata*).

vey annually at most low-elevation parks, while the remainder of the parks (CHIR, CORO, GICL, and high-elevation sites at SAGU) will be surveyed every 3–5 years. This decision was based on the low number of detections per survey effort in these higher-elevation parks and the difficult terrain and access issues in all these parks except GICL. Differences in efficiency, resulting from lower numbers of detections, meant that we would have spent approximately twice as much survey time for each detection in a higher-elevation park as we would have at low-elevation parks (see Supplements A, B). This reduction in efficiency was unacceptable given the financial constraints of the project. By surveying at high-elevation parks every 3–5 years, we lose the ability to more rapidly detect changes in bird density, but will still detect either dramatic changes in population parameters over short time periods or gradual declines over longer time periods.

We will revisit the same sites during successive years to each park. At larger parks, such as ORPI and SAGU, we considered employing a more complex design, such as a split-panel design in which sites in one panel are surveyed in all years and sites in additional panels are visited on a rotating basis once every 2–10 years (Urquhart and Kincaid 1999; McDonald 2003). These designs are especially useful in complex systems with high heterogeneity or over large geographic areas, but their complex, even uncertain analysis can be problematic. The landbird-monitoring program may employ this type of design based on the information gathered in the first 3–5 years (see Supplement A for a in-depth discussion of this topic). In short, we believe that it is better to focus extra effort on a smaller subset of sites in the first 3–5 years to inform this program review rather than dilute our effort on a larger set of sites that will reveal less information. Though the monitoring-program design may change based on this program review, this approach seems prudent, especially considering the expense and long-term nature of this program.

3.3.2 Intra-annual surveys

When we survey a park, we will visit all sites four times during each breeding season. We chose this revisit schedule because the breeding season in most SODN parks is long, and many species—particularly neotropical migrants of conservation concern—arrive at the breeding ground later in the season, after many of the resident species have initiated breeding. By visiting sites throughout the breeding season we ensure a greater chance of detecting all breeding birds. Visiting sites four times allows for more detections for estimating density; models used to estimate density are not biased by counting the same bird on consecutive counts (Buckland et al. 2001). Because many species of conservation concern are geographically restricted to riparian areas and these areas are further restricted within SODN parks, increasing the number of detections is the only means of obtaining sample sizes large enough for parameter estimation. Finally, occupancy estimation for highly detectable species such as landbirds usually requires at least three visits to each site (Field et al. 2005; Mackenzie and Royle 2005). Species richness, though not a monitoring parameter at this time, also requires multiple, intra-annual visits to each site (Colwell and Coddington 1994; Nichols et al. 1996).

3.4 Sample sizes

We determined the number of points and within-season surveys needed for annual, network-wide estimates of density with different levels of precision (Supplement A). In general, we found that we will likely be able to estimate density, with an acceptable level of precision, for only a few species at each park under reasonable field and budgetary constraints. However, we can analyze distance-sampling data to estimate density for additional species at each park by using pooled (among park) variance estimates and detection functions. Provided that assumptions are met, this approach will allow for estimation of park-specific densities for many additional species using fewer observations. Other possibilities for estimating density are to pool data from biennial or longer time periods. Similar extensions hold true for estimating relative abundance and occupancy. Therefore, based on an analysis of the inventory data, we believe that we will have sufficient detections among parks each year to estimate the parameters of interest for a reasonable number of species.

4 Field Methods

4.1 Overview of point-transect surveys

We will use the point-transect survey method to estimate and monitor landbird population parameters (Nelson and Fancy 1999; Buckland et al. 2001). The point-transect method is similar to the variable circular plot method (Reynolds et al. 1980), and is the most widespread and accepted method for estimating landbird density (Rosenstock et al. 2002). The method involves estimating the linear distance to individual birds while standing for a predetermined period of time at a fixed point in space. Estimating the distance to each bird allows density to be approximated via a species-specific detection function that accounts for variation in detectability due to surveyor, environmental, or weather-related factors (Buckland et al. 2001; Diefenbach et al. 2003). This method contrasts with traditional point-count techniques (Ralph et al. 1995) because it does not assume that all birds are detected equally within a fixed radius around survey points (Lancia et al. 1996).

Our use of distance sampling will provide data that are comparable both within and among parks, and will also facilitate comparisons with data from other locations in North America where the same survey methods are used (e.g., Peitz et al. 2004). We also will be able to compare our results to other monitoring efforts such as the Breeding Bird Survey. Finally, data from our program will be made available to researchers for a variety of purposes, such as modeling bird–habitat associations that may be useful for identifying bird communities or environmental features of conservation or management concern (e.g., Wiens and Rotenberry 1981; Rice et al. 1984; Strong and Bock 1990).

4.2 Seasonal timing of surveys

We will focus our survey efforts during the breeding season, when increased territorial behavior by songbirds results in higher detection rates and greater sampling efficiency. We also will count passage migrants (those that breed north of the region; e.g., Wilson's warblers) and those species that overwinter but do not breed in SODN parks (e.g., Brewer's sparrow and green-tailed towhee) (Rice et al. 1983; Hutto 1985b). In contrast to parks at more northern latitudes that have a fairly synchronous breeding season (McIntyre et al. 2004), the breed-

Table 4.2. Annual field schedule for bird monitoring at Sonoran Desert Network parks.

Park	Apr 1–14	Apr 15–30	May 1–14	May 15–31	Jun 1–14	Jun 15–30
Casa Grande Ruins National Monument	X	X	X	X		
Chiricahua National Monument	X	X	X	X	X	X
Coronado National Memorial	X	X	X	X	X	X
Fort Bowie National Historic Site	X	X	X	X	X	X
Gila Cliff Dwellings National Monument		X	X	X	X	X
Montezuma Castle National Monument		X	X	X	X	X
Organ Pipe Cactus National Monument	X	X	X	X		
Saguaro National Park	X	X	X	X	X	
Tonto National Monument	X	X	X	X	X	
Tumacácori National Historical Park	X	X	X	X	X	X
Tuzigoot National Monument		X	X	X	X	X

Note that sampling will not take place annually at all parks (see Sampling Design).


©R. BENNETTS

Hermit thrush (*Catharus guttatus*).

ing season in the Sonoran Desert region varies considerably among species (Corman and Wise-Gervais 2005), a phenomenon typical of more southerly latitudes. Resident birds at low elevations in the region typically breed from late February through mid-June, whereas those at higher elevations breed from early April through June or early July. Grassland-obligate sparrows (Cassin's, Botteri's, and grasshopper sparrows) typically breed after the start of the summer monsoon season (typically early July), though they usually establish territories earlier.

Surveys will coincide with the breeding season for the greatest number of species in each park, recognizing that some species may not be adequately surveyed because of later arrival dates (e.g., the yellow-billed cuckoo). Trend analyses for all species must consider whether a species is present during the chosen sampling window and adjust this window to meet program goals. For example, a review of the landbird monitoring program in ORPI found that the first sampling event of each year was too early for many migrant species to be detected (B. Powell, *unpublished data*). For this monitoring effort, we will attempt to time surveys similarly each year, because a shift in survey timing could bias trend estimates. To ensure that surveys are clustered around the time of peak breeding activity for each park and community, we will survey annually according to the general field schedule in Table 4.2, which is based on annual timing of breeding within each park. It is important to recognize that this window may shift in the coming decades, making it necessary to adjust the protocol (Visser et al. 1998; Brown et al. 1999).

4.3 Field-season preparation and scheduling

Prior to each field season, observers will read the entire protocol narrative and all standard operating procedures (SOPs). Observers should pay special attention to the tasks described in SOPs #2, #5, and #6. Practice and training identifying birds by sight and sound is critical; the misidentification of a species is the most serious error one can make during counts (Kepler and Scott 1981; Royle and Link 2006). All equipment and supplies listed in SOP #1 should be organized and made ready for the field season.

Weather-related interruptions during scheduled surveys account for approximately 5% of all field days in southern Arizona (B. Powell, *unpublished data*). Therefore, staff workloads and unpredictable weather (primarily high winds) necessitate maintaining flexibility in scheduling the sequence and duration of sampling events during each field season.

4.4 Field protocol

Point-transect surveys will be the primary field method. We also will collect vegetation data after the completion of bird surveys on most field days in the first year of surveys. These two activities will make up the bulk of the effort during the field season. Scheduling these activities will be the responsibility of the project manager.

The daily field schedule for each surveyor will involve visiting 6–10 points each day, arranged in transects (most sites at SAGU and ORPI) or groups of individually placed points (all other communities and parks). The bird crew should arrive at the park or survey area on the afternoon prior to the first day of sampling to familiarize themselves with the area and the birds present. If the area being surveyed is too far from a road, campsite, or trailhead to be reached in 30 minutes of hiking, every effort should be made to camp near the site on the night prior to scheduled surveys. Bird surveys will begin in the morning after the initial "dawn chorus," approximately 20 minutes before local sunrise. Because environmental sampling will only take place once at each site and sites will be surveyed four times per season, environmental sampling that follows bird surveys should be conducted on approximately two survey points each day. All environmental sampling will be completed prior to the onset of the monsoon rains. More information on the bird-survey protocol and on environmental sampling can be found in SOPs #5 and SOP #6, respectively.

For both bird surveys and environmental sampling, observers should review data forms for completeness and readability prior to leaving the field each day. The project manager is responsible for the safekeeping and organization of data sheets, and for ensuring that data are entered into the database.

4.5 Conducting the bird surveys

Details on how to conduct point-transect surveys, and for filling in data forms, are provided in SOP #5 and summarized here. All birds seen or heard at each point are recorded during an 8-minute sampling period (see Supplement B for justification of this survey length). We will separate bird observations into minute-long time segments to allow comparisons with BBS and other survey efforts, and possibly for use in other analytical applications such as removal sampling (e.g., Farnsworth et al. 2002). We will record all birds, regardless of detection distance from the surveyor. For most species, we will record each individual bird as a separate observation unless groups of birds are observed at the same distance, in which case the flock or group size will be noted. We will record any birds flying overhead with a designation of "F" in the distance category to indicate they were flyovers.

When conducting a point-transect survey, observers attempt to obtain an "instantaneous count" of the birds present. Birds that are flushed from the area around a point should be recorded and the count started as soon as the observer arrives at the point. Recording birds that are flushed, particularly those close to the center point, allows for a reduction in potential violations of the assumption of perfect detectability at the center point (i.e., $P_0 = 1$), an important assumption of distance sampling (Buckland et al. 2001). The most important birds to detect are those very close to the observer (within 20 m of the point), and it is highly desirable that estimated distances be within 1 to 2 m of actual distances for all birds detected within this radius. However, all birds seen or heard should be recorded with an estimate of distance measured with a laser rangefinder. Rounding distances to the nearest 5 or 10 m is discouraged unless accurate distance estimation is not possible because of vegetation or topography. Once counts are completed, observers locate successive points with use of a GPS. While walking from one point to the next, observers search for species not recorded during the previous count period. These data allow for a more complete count of species at a site (see Supplement B).

4.6 Establishing and marking points

We will mark each survey point with flagging at the beginning of each field season. To ensure that subsequent observers can efficiently locate all points, observers will describe access to each point from known locations (e.g., park entrance stations or trailheads) and mark topographic maps. If access changes, we will update these descriptions.

©R. BENNETTS

Mountain bluebird (*Sialia currucoides*).

Male hairy woodpecker (*Picoides villosus*).

4.7 Collecting environmental data at bird survey points

Course–scale relationships between birds and environmental characteristics are well-known for many species in the region (Rosenberg et al. 1991; Powell and Steidl 2000). At local scales, structural and floristic features of vegetation are good predictors of species richness and abundance (Macarthur and Macarthur 1961; Cody 1981). By collecting information on environmental features at each point, we will be able to (1) estimate population parameters of birds with greater precision by aggregating areas with similar environmental features, (2) explore relationships between changes in bird populations and their environments, (3) compare bird populations and environmental attributes across the network and in each park, and (4) generate predictions for possible causes of observed changes that can inform additional research efforts. We will use qualitative and quantitative techniques that are best-suited to assess changes over repeated observations, and that will provide detailed information at the appropriate scales for the previously mentioned applications. Although we will survey birds every year (at most parks), we will measure environmental features over longer time intervals (e.g., every 3–5 years), because gross changes in vegetation structure are not expected to occur annually. In the event of disturbance (e.g., fire or unnatural tree mortality), which can rapidly change an environment, we will resurvey points after the disturbance.

We will collect environmental data at two spatial scales: at a broad scale within 75-m-radius plots centered on bird-survey points, and at a finer scale at four subplots (one located at the survey point and the others located 36.6 m from the survey point). We will describe the dominant vegetation type and topographic position and measure slope and aspect within the 75-m-radius plots. Within each subplot, we will measure percent canopy cover, horizontal vegetation coverage, dominant species in the overstory and understory, and ground and foliage cover.

We will collect environmental data within 75 m of each survey point according to the protocol outlined in SOP #6. Environmental sampling at the four associated subplots will take place in the second field season (2008). This portion of the protocol will be carried out by two observers after they complete the bird surveys. It is designed to take approximately 1.5 hours per point, such that at least two points can be completed each day.

We may modify this portion of the protocol so that it is similar to those used to monitor vegetation communities within the network (once they are completed). Similarly, we may incorporate measurements of the environment gained from remote-sensing data. Incorporating these elements into the bird monitoring protocol will provide greater efficiency and provide additional analytical tools.

5 Data Management

5.1 Overview of database design

We developed a Microsoft Access 2002 database to manage the landbird community and associated environmental data (SOP #7). This database is compliant with the Natural Resource Database Template standards (Version 3) adopted by the national I&M program. The database comprises a front-end file and a back-end file that are linked using the Backend Linking Utility in the database. The front-end file, *SODN_BirdComm_.mdb*, acts as the user interface into the back-end database and contains the forms, queries, and VBA code for the application. *SODN_BirdComm_ be.mdb*, the back-end file, contains the data tables. This configuration facilitates improvements and revisions to the database front-end application without altering the actual data structure or any of the records in the back-end data tables.

The general data model for bird-community monitoring consists of core tables and two principal groups of field-data tables (see SOP #7 for entity–relationship diagrams). One group of tables manages bird detection data; the other, associated environmental data. Detection and environmental data are linked in time and space using standardized location and event tables that are shared with other SODN I&M protocols. When correctly linked, the bird-detection and environmental data may be transparently integrated for analysis.

The primary table for storing bird-detection data contains observation information such as species, distance from observer, age, sex, and flock size. Supporting tables include weather conditions and breeding behaviors. An environmental characteristics subplot table contains general vegetative cover information and serves as the focal table to which other environmental characteristics tables, such as dominant overstory and understory cover, are linked. Species, contacts, and attribute look-up tables provide standardized values for many data fields, and metadata tables track database revisions and data edits.

5.2 Data entry

Although the primary goal of data entry is to transcribe all data from paper records into the database with 100% accuracy, this target is rarely achieved. To facilitate data-entry accuracy, we have built into the database many quality assurance/quality control (QA/QC) mechanisms to eliminate as many potential data-entry errors as possible. We also developed a database user guide that accompanies the database. The project manager should ensure that data-entry personnel have read this user guide and understand how to use the database and follow the protocols.

Data-entry forms closely match the paper data sheets, and serve as the user's portal into the database. Location and sampling-event information are entered first. Then, associated bird or environmental data may be entered into the targeted tables. Where appropriate, pick lists limit values entered into a field to ensure that only valid names or measures are entered. Bird or environmental values are selected directly from a pick list or by typing the first few characters of the value. The form searches for a similar entry, typically locating the desired value after typing only a few characters.

©R. BENNETTS

Female hairy woodpecker (*Picoides villosus*).

5.3 Data certification process

Data verification is the process of checking the accuracy of the digital data against copies of the original paper data sheets, and it should immediately follow data entry. To minimize transcription errors in the final dataset, personnel familiar with the project's field and data collection methods should verify 100% of the records to the source documents. After any required corrections have been made, the project manager will review 10% of the records a second time. The results of that comparison will be reported in the metadata. If the project manager finds any errors, the entire dataset will be verified again. The paper data sheets will be archived after the project manager verifies that the digital data ac-

©R. BENNETTS

Rufous hummingbird (*Selasphorus rufus*).

curately reflects the original field data.

Data validation is the process of reviewing digital data for range and logic errors. Even when data are correctly transcribed from field-data sheets, some values may not be logical or accurate. Although some validation features, such as range limits, are built into the database itself via data-entry forms (see above) and queries, the project manager or another person familiar with the data will further review the dataset for these types of range and logic errors.

Data certification is the process of ensuring that the dataset (i.e., portion of the database related to all of the records for that year) has been verified and validated for accuracy, is complete, and that metadata/documentation for the dataset is finalized. Data certification will be completed annually for all tabular and spatial project data sets. The project manager will complete the certification form (in development) and notify the data manager that the data are ready for archiving and storage. Once the dataset is certified, it can be used in analyses and reports.

Validation of spatial data is accomplished using ArcGIS 9.*x* (ESRI, Inc.). Because *SODN_BirdComm_be.mdb* is maintained as an Access database, it can be imported directly into ArcCatalog (ArcGIS, ESRI, Inc.) to create a shapefile. The UTM coordinate values stored in the database for point locations will then be compared to the original GPS coordinates. The process of verifying, editing, validating, and certifying spatial data will follow the same process as for other electronic data.

5.4 Metadata procedures

Metadata will be developed using the NPS I&M Dataset Catalog (Version 3) and the ArcCatalog (ESRI, Inc.) metadata module in conjunction with the NPS Metadata Tools & Editor. For tabular datasets, all database objects (e.g., tables, fields) will be defined and documented in a data dictionary or in Section 5 of a Federal Geographic Data Committee (FGDC)-compliant metadata file (see Appendix 7 for example). FGDC-compliant metadata (including the NPS profile) will be created for all spatial data. In addition, a local dataset catalog record will be created for the project database. Both spatial and non-spatial metadata records for non-sensitive data will be uploaded to the NR-GIS Metadata Database and Data Store where they will be available to the public. All metadata records will be updated as needed whenever additional data are collected and added to the database.

5.5 Data archival procedure

After all data for a field season have been entered, verified, validated, and certified, the Access database will be archived on a secure server with regularly scheduled back-ups. A complete copy of the database also will be archived prior to any database version changes. To ensure data compatibility with other existing or newly developed software programs, each database table will be exported to an ASCII file using the Access_to_ASCII utility (developed by the Northern Colorado Plateau Network). These ASCII files are stored in the same folder with the native database format file. All archived files will be designated as "read-only."

Once the data have been archived, any changes made to data values must be documented in the edit log database table. From that point forward, paper field-data sheets will not be altered; field data will be reconciled to the database through the use of the edit log. Any editing of archived data will be accomplished jointly by the project manager and data manager.

Certified and archived non-sensitive data will be posted to the NR-GIS Data Server, where they may be downloaded for research and management applications. Other datasets, including those containing sensitive data, may be requested in writing from the SODN data manager. Sensitive data will be released only with a signed confidentiality agreement.

6 Reporting and Analysis

6.1 Reporting

Annual reports will contain information on the number of sites and frequency of sampling in SODN parks, as well as relative-abundance summaries (see SOP #8). The functions necessary to complete annual reports can be easily carried out by existing network staff, who will complete annual reports by March 31 of the year following data collection (refer to SOP #9 for details on report structure and style). Once data are entered and certified (SOP #7), we anticipate that preparation of each annual report will take approximately one week, though the amount of time will depend on the number and type of automated functions (currently under development) that can be built into the database. Annual reporting of environmental features will take more time after the first year, though summary statistics can be used in successive years provided no appreciable changes in these characteristics have occurred. After the first 3–5 years of data collection, we will conduct a complete review of the program that will include density estimation and sample-size evaluation. This review will determine if the sampling design is appropriate for meeting the program's goal and objectives. If not, the design will be changed. After the design is finalized, detailed reports will be produced every five years. These reports will include appropriate estimates of density, occupancy, as well as relative abundance and trend assessment in these parameters.

6.2 Density and occupancy data analysis

A critical component of any long-term monitoring program is consistent, systematic data analysis. In addition, it is important that data analysis protocols be flexible to accommodate better approaches as they become available. Data presentation (visualization) and time-series analysis are two approaches that we may use as the size and sophistication of the database increases. Our general approach to trend estimation will be to test for temporal trends in all parameters using a mixed-model, repeated-measures ANOVA. SOP #8 provides a general overview of our (1) approach to producing species lists and relative abundance estimates for annual reporting, (2) tools used to estimate density and occupancy, and (3) approaches to detecting trends and evaluating program effectiveness. Further development of the approaches to data analysis will take place in July 2006, and be incorporated into the next version of this protocol.

7 Personnel Requirements and Training

7.1 Roles and responsibilities

The project manager will implement this protocol and report to either the SODN I&M coordinator or ecologist. Due to the specialization of the work, it will be important for the project manager to be well-versed in all aspects of the protocol, especially with how to conduct landbird surveys. Ideally, the project manager will assist with data collection throughout the field season. The project manager is responsible for advertising field positions, reviewing applicant resumes, conducting interviews, and making

Mountain chickadee (*Parus gambeli*)

Northern harrier (*Circus cyaneus*).

hiring decisions. Hiring and payroll can also be conducted with the assistance of the SODN program administrator. Full-time field personnel (observers) will consist of a crew leader and one or more technicians. The crew leader will report directly to the project manager and will oversee the technician(s). The crew leader will begin work approximately two weeks prior to the start of training sessions and continue to work for two weeks after the field season ends. Data entry will be conducted by the field personnel during the field season and will be overseen by the project manager.

Project and data managers will share the responsibility of long-term data management. Throughout the field season, the project manager will be responsible for providing the original data forms and copies of the databases to the network data manager. At the end of the field season the project manager is responsible for directing a thorough review of all data entered. The data manager is responsible for designing, archiving, securing, and disseminating program data. In collaboration with the project manager, the data manager will also develop forms for data collection and other database features for quality assurance and automation. The bulk of this task will be done prior to the start of the first field season, and we anticipate that the automated reporting will become more refined each year. After all data have been cleared for quality assurance, the project manager will summarize, analyze, and report data to the coordinator and/or ecologist.

7.2 Qualifications and training

Having qualified, competent observers is one of the most essential components for the long-term success of this program. This point cannot be overemphasized. Numerous studies have shown that bias among observers can confound estimates of population trends of songbird populations (Sauer et al. 1994; Kendall et al. 1996; Link and Sauer 1998; Diefenbach et al. 2003). In addition to being able to identify birds visually, field observers must be proficient at identifying birds aurally, because many species are detected by sound only (Ramsey and Scott 1981). Further, the ability to precisely estimate distance to birds that are rarely seen is an essential skill (Buckland et al. 2004). To ensure rigor and consistency in data collection, we will hire only qualified observers (see SOP #2). We will then train them at the beginning of each field season and will periodically test each observer's ability to identify and estimate distances to birds.

The importance of hiring well-qualified observers for counting efforts in southern Arizona is particularly important because of high species richness, high proportion of congeneric, similar species, and presence of species that are not found in other parts of the U.S. Further, bird densities in some areas, such as riparian areas, are among the highest in the U.S. (Carothers et al. 1974), thereby reinforcing the need to hire observers with prior experience surveying in the Sonoran Desert or who have considerable bird-survey experience in general. Based on interviews with local biologists (Courtney Conway and Chris Kirkpatrick) and our own experience, wages of at least $13/hr are essential to attract well-qualified candidates for this program.

In addition to bird surveys, sampling for environment features is another important responsibility of observers. Ideally, these personnel would be familiar with the common shrub and tree species in the Sonoran Desert region. In the event that observers do not have these skills, the project manager will train them. It may be necessary to use SODN I&M staff who have expertise in plant identification to assist with environmental data collection.

8 Operational Requirements

8.1 Annual workload and field schedule

Observer training will begin in the third week of March, and surveys will take place from approximately March 21 to July 1, depending on the parks being surveyed. In most years, surveys will end sooner than July 1. For years when all parks are surveyed, we will begin surveys at lower elevation parks and survey higher elevation parks as the season progresses (see 4.2 Seasonal Timing of Surveys). We will complete environmental sampling throughout the season as time allows and conduct it as close to the time of bird sampling as possible in each park, so that these measurements represent conditions during surveys. Estimates of the annual survey effort (days) are based on monitoring all sites in all parks and the number of transects/groups of points, all of which are surveyed four times each season (Table 8.1).

Table 8.1. Estimates of annual survey effort.

Park unit	Days
Casa Grande Ruins National Monument	4
Chiricahua National Monument	28
Coronado National Memorial	12
Fort Bowie National Historic Site	12
Gila Cliff Dwellings National Monument	12
Montezuma Castle National Monument	20
Organ Pipe Cactus National Monument	56
Saguaro National Park	92
Tonto National Monument	12
Tumacácori National Historical Park	8
Tuzigoot National Monument	8

8.2 Facility and equipment needs

Bird surveys involve low-impact, passive sampling that requires only limited equipment needs and minimal office space and resources. The only capital equipment item is a vehicle. The list of personal field equipment needed for the project is itemized in SOP #1 and includes binoculars, laser rangefinders, and GPS units. Most required equipment will be specific to the landbird effort; therefore, few arrangements are required for sharing equipment with other SODN monitoring efforts (e.g., water quality). We will not provide housing to observers (unfortunately, this is likely to be a major impediment toward attracting qualified candidates). Prior to the beginning of each field season, we will investigate housing options at parks.

8.3 Startup costs and budget

Field-equipment costs in the first year of the project will be approximately $5,000–6,000, which assumes that each observer already owns an appropriate pair of binoculars. Additional costs may be incurred if the network purchases binoculars. There will be cost savings if some of the needed equipment is already available at the network office (e.g., GPS units). After the first year, we anticipate that field equipment costs will be approximately $750 annually to replace lost, damaged, or dated equipment.

We anticipate that landbird monitoring will cost approximately $30,000 annually for surveys conducted in each year, and an additional

Pygmy nuthatch (*Sitta pygmaea*).

$10,000 every 3–5 years for surveys in higher elevation areas. This figure excludes the cost of overseeing the project (Table 8.3). At the time of this writing (May 2007), there are no personnel at the SODN office who can conduct bird surveys; therefore, all technical expertise will be hired from outside the program. Based on our assessment of the market for qualified observers (see 7.2 Qualifications and Training), we will pay approximately $13–14 per hour. For this analysis, we are assuming that we will hire observers through the University of Arizona, which has employee-related expenses of 10.5% and overhead cost of 17.5%. Some expense may be saved if existing park staff, particularly those at ORPI, can assist with surveys.

8.4 Collaboration

We suggest expanding the spatial scope of this protocol to areas outside parks, so as to place park management and resources in a regional context. Further, considerable financial and administrative efficiencies will be gained by partnering with other agencies and organizations with similar goals. At the time of this writing, there are a number of other biological monitoring initiatives occurring in the greater Sonoran Desert region (RECON Environmental 2006). If these programs choose to monitor the same parameters as outlined in this protocol narrative, then great efficiency may be realized by implementing collective monitoring using the same field personnel and equipment, thereby saving money on administration and data collection. A good example of such collaboration is now occurring between the Northern Colorado Plateau Network and the Rocky Mountain Bird Observatory (Bennetts et al. 2005). If collaboration with outside partners occurs, it is imperative that this protocol be followed, at least on SODN lands.

9 Procedure for Revising the Protocol and Program Review

9.1 Revising the protocol

We have divided this sampling protocol into a protocol narrative and 11 separate SOPs. The protocol narrative is a general overview of the protocol that provides the history and justification for the program and an overview of sampling methods. The protocol narrative will only be revised if major changes are made to the protocol. The SOPs, in contrast, are very specific step-by-step instructions for performing a each task. They are expected to be revised more frequently than the protocol narrative.

Careful documentation of such revisions, including a library of previous versions, is essential for maintaining consistency in data collection, analyses, and reporting. To summarize changes, the monitoring database for each component contains a field to identify the protocol version used to gather and analyze data. The steps for changing any aspect of the protocol are outlined in SOP #11. Each SOP contains a revision history log that should be completed each time an SOP is revised to explain why changes were made, and to assign a new version number to the revised SOP. New versions of SOPs and the protocol narrative should be archived in the appropriate folder of the SODN protocol library.

9.2 Program review

We suggest that a thorough analysis of the data from this project be undertaken after the first 3–5 years and every 10 years thereafter. An initial 3–5-year review is essential and should involve extensive quantitative analyses to evaluate the efficiency of the program design, results, and ability to meet the stated goals and objectives. A component of the review will involve recommended revisions to the program, with explicit justification. Products from this effort will be trend assessment of population parameters, variance partitioning and power analysis (Supplement A), and an assessment of sampling methods and spatial inferences. Also, new analytical techniques or tools may become available that have important application to these data. For example, advances in multi-species and multi-year occupancy estimation procedures and both parametric and Bayesian analytical tools will certainly become more refined (Darryl MacKenzie, pers. comm.). Because the program review will take considerably more time and expertise than the network currently has, we suggest that the network contract a suitable reviewer with the appropriate skills and experience.

10 Acknowledgements

Many people contributed to writing of all aspects of this protocol. Portions of this protocol, including text and figures, were taken from McIntyre et al. (2004), Peitz et al. (2004), and Bennetts et al. (2005). Andy Hubbard has invested resources and provided unending faith in the development of this and other protocols. Cecilia Schmidt provided early technical assistance. Bob Steidl was always available for study-design assistance. Steve Garman provided assistance with power analysis, including providing the R code for power. Ed Debevec (Institute of Arctic Biology, University of Alaska, Fairbanks) generously provided R code for generating bird summary statistics. Finally, Eric W. Albrecht provided early leadership toward making this protocol a reality; we are indebted to his vision and are deeply sad that he will not see its implementation.

11 Literature Cited

Albrecht, E. W., W. L. Halvorson, P. P. Guertin, B. F. Powell, and C. A. Schmidt. 2005. A biological inventory and hydrological assessment of the Cave Springs riparian area, Tonto National Monument, Arizona. Unpublished report. USGS Southwest Biological Science Center, Sonoran Desert Research Station, University of Arizona, Tucson, Arizona.

Alcock, J. 2005. Animal behavior: An evolutionary approach. Sunderland, Mass.: Sinauer Associates.

Allen, L. S. 1996. Ecological role of fire in the Madrean province. Pages 5–10 *in* Effects of fire on Madrean Province ecosystems. General Technical Report RM-GTR-289. U.S. Department of Agriculture Forest Service, Rocky Mountain Forest and Range Experiment Station, Ft. Collins, Colorado.

Bahre, C. J. 1991. A legacy of change: Historic human impact on vegetation of the Arizona borderlands. Tucson: University of Arizona Press.

Bahre, C. J., and M. L. Shelton. 1993. Historic vegetation change, mesquite increases, and climate in Southeastern Arizona. Journal of Biogeography **20**:489–504.

Barrows, C. W., M. B. Swartz, W. L. Hodges, M. F. Allen, J. T. Rotenberry, B. L. Li, T. A. Scott, and X. W. Chen. 2005. A framework for monitoring multiple-species conservation plans. Journal of Wildlife Management **69**:1333–1345.

Bart, J. 2005. Monitoring the abundance of bird populations. Auk **122**:15–25.

Bart, J., K. P. Burnham, E. H. Dunn, C. M. Francis, and C. J. Ralph. 2004. Goals and strategies for estimating trends in landbird abundance. Journal of Wildlife Management **68**:611–626.

Bennetts, R. E., A. Schrag, and S. Wolff. 2005. Cooperative bird monitoring plan and protocol for the Greater Yellowstone Network of parks. Version 1.00. Unpublished protocol to the Greater Yellowstone Network, National Park Service, Bozeman, Montana.

Bibby, C. J, N. D. Burgess, D. A. Hill, and S. Mustoe. 2000. Bird census techniques. Second ed. London: Academic Press.

Bock, C. E., and J. H. Bock. 1984. Importance of sycamores to riparian birds in Southeastern Arizona. Journal of Field Ornithology **55**:97–103.

——. 1988. Grassland birds in southeastern Arizona: Impacts of fire, grazing, and alien vegetation. Pages 43–58 *in* P. D. Goriup, ed., Ecology and conservation of grassland birds. Cambridge, U.K.: International Council for Bird Preservation.

Bowers, J. E., T. M. Bean, and R. M. Turner. 2006. Two decades of change in distribution of exotic plants at the desert laboratory, Tucson, Arizona. Madrono **53**:252–263.

Brown, D. E., ed. 1994. Biotic communities: Southwestern United States and northwestern Mexico. Salt Lake City: University of Utah Press.

Brown, J. H., T. J. Valone, and C. G. Curtin. 1997. Reorganization of an arid ecosystem in response to recent climate change. Proceedings of the National Academy of Sciences of the United States of America **94**:9729–9733.

Brown, J. L., S. H. Li, and N. Bhagabati. 1999. Long-term trend toward earlier breeding in an American bird: A response to global warming? Proceedings of the National Academy of Sciences of the United States of America **96**:5565–5569.

Bryce, S. A., R. M. Hughes, and P. R. Kaufmann. 2002. Development of a bird integrity index: Using bird assemblages as indicators of riparian condition. Environmental Management **30**:294–310.

Buckland, S. T., D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borchers, and L. Thomas. 2001. Introduction to distance sampling: Estimating abundance of biological populations. Oxford, U.K.: Oxford University Press.

——, eds. 2004. Advanced distance sampling. Oxford, U.K.: Oxford University Press.

Burgess, T. L., J. E. Bowers, and R. M. Turner. 1991. Exotic plants at the Desert Laboratory, Tucson, Arizona. Madrońo **38**:96–114.

Caffrey, C., S. C. R. Smith, and T. J. Weston. 2005. West Nile virus devastates an American crow population. Condor **107**:128–132.

Cam, E., J. R. Sauer, J. D. Nichols, J. E. Hines, and C. H. Flather. 2000. Geographic analysis of species richness and community attributes of forest birds from survey data in the mid-Atlantic integrated assessment region. Environmental Monitoring and Assessment **63**:81–94.

Canterbury, G. E., T. E. Martin, D. R. Petit, L. J. Petit, and D. F. Bradford. 2000. Bird communities and habitat as ecological indicators of forest condition in regional monitoring. Conservation Biology **14**:544–558.

Carothers, S. W., R. R. Johnson, and S. W. Aitchison. 1974. Population structure and social-organization of southwestern riparian birds. American Zoologist **14**:97–108.

Cody, M. L. 1981. Habitat selection in birds: The roles of vegetation structure, competitors, and productivity. Bioscience **31**:107–113.

Colwell, R. K., and J. A. Coddington. 1994. Estimating terrestrial biodiversity through extrapolation. Philosophical Transactions of the Royal Society of London Series B-Biological Sciences **345**:101–118.

Corman, T. E., and C. Wise-Gervais, editors. 2005. Arizona breeding bird atlas. Albuquerque: University of New Mexico Press.

Dale, V. H., and S. C. Beyeler. 2001. Challenges in the development and use of ecological indicators. Ecological Indicators **1**:3–10.

Desante, D. F., K. M. Burton, J. F. Saracco, and B. L. Walker. 1995. Productivity indices and survival rate estimates from maps, a continent-wide programme of constant-effort mist-netting in North America. Journal of Applied Statistics **22**:935–947.

Diefenbach, D. R., D. W. Brauning, and J. A. Mattice. 2003. Variability in grassland bird counts related to observer differences and species detection rates. Auk **120**:1168–1179.

Farnsworth, G. L., K. H. Pollock, J. D. Nichols, T. R. Simons, J. E. Hines, and J. R. Sauer. 2002. A removal model for estimating detection probabilities from point-count surveys. Auk **119**:414–425.

Field, S. A., A. J. Tyre, and H. P. Possingham. 2005. Optimizing allocation of monitoring effort under economic and observational constraints. Journal of Wildlife Management **69**:473–482.

Franklin, K. A., K. Lyons, P. L. Nagler, D. Lampkin, E. P. Glenn, F. Molina-Freaner, T. Markow, and A. R. Huete. 2006. Buffelgrass (*Pennisetum ciliare*) land conversion and productivity in the plains of Sonora, Mexico. Biological Conservation **127**:62–71.

Ganey, J. L., W. M. Block, and P. F. Bouche. 1996. Effects of fire on birds in Madrean forests and woodlands. Pages 144–154 *in* Effects of fire on Madrean province ecosystems. General Technical Report RM-GTR-289. U.S. Department of Agriculture Forest Service, Rocky Mountain Forest and Range Experiment Station, Ft. Collins, Colorado.

Germaine, S. S., S. S. Rosenstock, R. E. Schweinsburg, and W. S. Richardson. 1998. Relationships among breeding birds, habitat, and residential development in greater Tucson, Arizona. Ecological Applications **8**:680–691.

Green, D. A., and M. G. Baker. 2003. Urbanization impacts on habitat and bird communities in a Sonoran Desert ecosystem. Landscape and Urban Planning **63**:225–239.

Groschupf, K. D., B. T. Brown, and R.R. Johnson. 1988. An annotated checklist of birds of Organ Pipe Cactus National Monument, Arizona. Tucson, Ariz.: Southwest Parks and Monument Association.

Holmes, R. T., and T. W. Sherry. 2001. Thirty-year bird population trends in an unfragmented temperate deciduous forest: Importance of habitat change. Auk **118**:589–609.

Hutto, R. L. 1985a. Habitat selection by nonbreeding, migratory, land birds. Pages 455–476 *in* M. L. Cody, ed., Habitat selection in birds. Orlando, Fla.: Academic Press.

——. 1985b. Seasonal changes in the habitat distribution of transient insectivorous birds in southeastern Arizona: Competition mediated? Auk **102**:120–132.

Inkley, D. B., M. G. Anderson, A. R. Blaustein, V. R. Burkett, B. Felzer, B. Griffith, J. Price, and T. L. Root. 2004. Global climate change and wildlife in North America. Wildlife Society Technical Review 04-02. Bethesda, Md.: The Wildlife Society.

James, F. C., C. E. McCullogh, and D. A. Wiedenfeld. 1996. New approaches to the analysis of population trends in land birds. Ecology **77**:13–27.

Kendall, W. L., B. G. Peterjohn, and J. R. Sauer. 1996. First-time observer effects in the North American breeding bird survey. Auk **113**:823–829.

Kepler, C. B., and J. M. Scott. 1981. Reducing bird count variability by training observers. Studies in Avian Biology **6**:366–371.

Kery, M., and H. Schmid. 2006. Estimating species richness: Calibrating a large avian monitoring programme. Journal of Applied Ecology **43**:101–110.

Knopf, F. L. 1994. Avian assemblages on altered grasslands. Studies in Avian Biology **15**:247–257.

Kou, Z., F. M. Lei, J. Yu, Z. J. Fan, Z. H. Yin, C. X. Jia, K. J. Xiong, Y. H. Sun, X. W. Zhang, X. M. Wu, X. B. Gao, and T. X. Li. 2005. New genotype of avian influenza H5N1 viruses isolated from tree sparrows in China. Journal of Virology **79**:15460–15466.

Krueper, D., J. Bart, and T. D. Rich. 2003. Response of vegetation and breeding birds to the removal of cattle on the San Pedro River, Arizona (USA). Conservation Biology **17**:607–615.

Lancia, R. A., J. D. Nichols, and K. H. Pollock. 1996. Estimating the number of animals in wildlife populations. Pages 215–253 *in* T. A. Bookhout, ed., Research and management techniques for wildlife and habitats. Lawrence, Kansas: Allen Press.

Link, W. A., and J. R. Sauer. 1998. Estimating population change from count data: Application to the North American breeding bird survey. Ecological Applications **8**:258–268.

MacArthur, R., and J. W. MacArthur. 1961. On bird species diversity. Ecology **42**:594–598.

Mackenzie, D. I., and J. A. Royle. 2005. Designing occupancy studies: General advice and allocating survey effort. Journal of Applied Ecology **42**:1105–1114.

MacKenzie, D. I., J. D. Nichols, G. B. Lachman, S. Droege, J. A. Royle, and C. A. Langtimm. 2002. Estimating site occupancy rates when detection probabilities are less than one. Ecology **83**:2248–2255.

MacKenzie, D. I., J. D. Nichols, J. A. Royle, K. H. Pollock, L. L. Bailey, and J. E. Hines. 2006. Occupancy estimation and modeling: Inferring patterns and dynamics of species. Burlington, Mass.: Elsevier Press.

MacKenzie, D. I., J. D. Nichols, J. E. Hines, M. G. Knutson, and A. B. Franklin. 2003. Estimating site occupancy, colonization, and local extinction when a species is detected imperfectly. Ecology **84**:2200–2207.

Manley, P. N., W. J. Zielinski, M. D. Schlesinger, and S. R. Mori. 2004. Evaluation of a multiple-species approach to monitoring species at the ecoregional scale. Ecological Applications **14**:296–310.

Marshall, R. M., S. Anderson, M. Batcher, P. Comer, S. Cornelius, R. Cox, A. Gondor, D. Gori, J. Humke, R. Paredes Aguilar, I. E. Parra, and S. Schwartz. 2000. An ecological analysis of conservation priorities in the Sonoran Desert Ecoregion. Prepared by The Nature Conservancy Arizona Chapter, Sonoran Institute, and Instituto del Medio Ambiente y el Desarrollo Sustentable del Estado de Sonora with support from Department of Defense Legacy Program.

Martinez, G., and A. Hubbard. 2003. Monitoring avian productivity: Analysis of MAPS data for Sonoran Desert Network Parks. Unpublished report to the National Park Service, Sonoran Desert Network Inventory and Monitoring Program, Tucson, Arizona.

Mau-Crimmins, T., A. Hubbard, D. Angell, C. Filippone, and K. Kline. 2005. Sonoran Desert Network vital signs monitoring plan. Technical Report NPS/IMR/SODN-003. National Park Service, Denver, Colorado.

McDonald, T. L. 2003. Review of environmental monitoring methods: Survey designs. Environmental Monitoring and Assessment **85**:277–292.

McIntyre, C. L., R. Drum, K. Oakley, E. Debevec, T. McDonald, and N. Guldager. 2004. Passerine bird monitoring protocol for the Central Alaska Monitoring Network. Draft Version 1.00. Unpublished protocol to the National Park Service, Central Alaska Inventory and Monitoring Network, Fairbanks, Alaska.

McLaughlin, S. P. 1986. A floristic analysis of the southwestern United States. Great Basin Naturalist **46**:46–55.

Nabhan, G. P., and A. R. Holdsworth. 1999. State of the biome: Uniqueness, biodiversity, threats, and the adequacy of protection in the Sonoran Bioregion. Tucson, Ariz.: The Wildlands Project.

National Park Service (NPS). 1992. NPS-75: Natural resources inventory and monitoring guidelines. Washington, D.C.: U.S. Department of Interior.

——. 2003. Resource issues in southern U.S. border parks from drug trafficking and undocumented alien activity. Washington, D.C.: U.S. Department of Interior.

Nelson, J. T., and S. G. Fancy. 1999. A test of the variable circular-plot method where exact density of a bird population was known. Pacific Conservation Biology **5**:139–143.

Nichols, J. D., M. J. Conroy, P. Jarman, A. P. Smith, C. Southwell, J. W. Bishir, and C. R. Dickman. 1996. Techniques for estimating abundance and species richness. Pages 177–234 *in* D. E. Wilson, F. R. Cole, J. D. Nichols, R. Rudran, and M. S. Foster, eds., Measuring and monitoring biological diversity: Standard methods for mammals. Washington, D.C.: Smithsonian Institution Press.

Nichols, J. D., T. Boulinier, J. E. Hines, K. H. Pollock, and J. R. Sauer. 1998. Inference methods for spatial variation in species richness and community composition when not all species are detected. Conservation Biology **12**:1390–1398.

Norvell, R. E., F. P. Howe, and J. R. Parrish. 2003. A seven-year comparison of relative-abundance and distance-sampling methods. Auk **120**:1013–1028.

Oakley, K. L., L. P. Thomas, and S. G. Fancy. 2003. Guidelines for long-term monitoring protocols. Wildlife Society Bulletin

31:1000–1003.

Peitz, D. G., S. G. Fancy, L. P. Thomas, G. A. Rowell, and M. D. Debacker. 2004. Bird monitoring protocol for Agate Fossil Beds National Monument, Nebraska and Tallgrass Prairie National Preserve, Kansas. Unpublished protocol to the Prairie Cluster Prototype Monitoring Program, National Park Service.

Perkins, L. and D. Swayne. 2002. Comparative susceptibility of selected avian and mammalian species to a Hong Kong H5N1 high-pathogenicity avian influenza virus. Avian Diseases **47**:956–977 (Suppl.).

Powell, B. F. 2000. Results of yellow-billed cuckoo surveys at Tumacácori National Historical Park, Arizona. Unpublished report to the Sonoran Desert Network Inventory and Monitoring Program, Tucson, Arizona.

——. 2004. Assessment of the bird community along the Middle Reach of Rincon Creek, Saguaro National Park. Unpublished report to Saguaro National Park, Tucson, Arizona.

Powell, B. F., and R. J. Steidl. 2000. Nesting habitat and reproductive success of southwestern riparian birds. Condor **102**:823–831.

Powell, B. F., C. A. Schmidt, and W. L. Halvorson. 2005. Vascular plant and vertebrate inventory of Coronado National Memorial. Unpublished report. USGS Southwest Biological Science Center, Sonoran Desert Research Station, University of Arizona, Tucson, Arizona.

——. 2006. Vascular plant and vertebrate inventory of Saguaro National Park, Rincon Mountain District. USGS OFR 2006-1075. USGS, Southwest Biological Science Center, Sonoran Desert Research Station, University of Arizona, Tucson, Arizona.

Powell, B. F., C. A. Schmidt, W. L. Halvorson, and P. Anning. 2005a. Vascular plant and vertebrate inventory of Fort Bowie National Historic Site. USGS OFR 2005-1167. USGS Southwest Biological Science Center, Sonoran Desert Research Station, University of Arizona, Tucson, Arizona.

Powell, B. F., E. W. Albrecht, C. A. Schmidt, W. L. Halvorson, P. Anning, and K. Docherty. 2005b. Vascular plant and vertebrate inventory of Casa Grande Ruins National Monument. USGS OFR 2005-1185. USGS, Southwest Biological Science Center, Sonoran Desert Research Station, University of Arizona, Tucson, Arizona.

Powell, B. F., E. W. Albrecht, W. L. Halvorson, C. A. Schmidt, K. Docherty, and P. Anning. 2005c. Vascular plant and vertebrate inventory of Gila Cliff Dwellings National Monument. USGS OFR 2005-1187. USGS, Southwest Biological Science Center, Sonoran Desert Research Station, University of Arizona, Tucson, Arizona.

Powell, B. F., E. W. Albrecht, W. L. Halvorson, C. A. Schmidt, P. Anning, and K. Docherty. 2005d. Vascular plant and vertebrate inventory of Tumacácori National Historical Park. USGS OFR 2005-1142. USGS, Southwest Biological Science Center, Sonoran Desert Research Station, University of Arizona, Tucson, Arizona.

Powell, B. F., C. A. Schmidt, and W. L. Halvorson. 2007. Vascular plant and vertebrate inventory of Fort Bowie National Historic Site. USGS OFR 2005-1167. U.S. Geological Survey, Southwest Biological Science Center, Sonoran Desert Research Station, University of Arizona, Tucson, Arizona. http://sbsc.wr.usgs.gov/files/pdfs/ofr_2005-1167.pdf.

Pyne, S. J. 2001. Fire: A brief history. Seattle: University of Washington Press.

Ralph, C. J., S. Droege, and J. R. Sauer. 1995. Managing and monitoring birds using point counts: Standards and applications. General Technical Report PSW-GTR-149. U.S. Department of Agriculture Forest Service, Pacific Southwest Research Station, Albany, California.

Ramsey, F. L., and J. M. Scott. 1981. Tests of hearing ability. Studies in Avian Biology **6**:341–345.

Rappole, J. H. 1995. The ecology of migrant birds: A neotropical perspective. Washington, D.C.: Smithsonian Institution Press.

Rappole, J. H., and Z. Hubalek. 2003. Migratory birds and West Nile virus. Journal of Applied Microbiology **94**:47S–58S.

RECON Environmental. 2006. Draft Pima County multi-species conservation plan. Report to the Pima County Board of Supervisors. Tucson, Arizona.

Reynolds, R. T., J. M. Scott, and R. N. Nussbaum. 1980. A variable circular-plot method for estimating bird numbers. Condor **82**:309–313.

Rice, J., B. W. Anderson, and R. D. Ohmart. 1984. Comparison of the importance of different habitat attributes to avian community organization. Journal of Wildlife Management **48**:895–911.

Rice, J., R. D. Ohmart, and B. W. Anderson. 1983. Turnovers in species composition of avian communities in contiguous riparian habitats. Ecology **64**:1444–1455.

Ringold, P. L., J. Alegria, R. L. Czaplewski, B. S. Mulder, T. Tolle, and K. Burnett. 1996. Adaptive monitoring design for ecosystem management. Ecological Applications **6**:745–747.

Robbins, C. S., J. R. Sauer, R. S. Greenburg, and S. Droege. 1989. Population declines in North American birds that migrate to the Neotropics. Proceeding of the National Academy of Sciences, USA **86**:7658–7662.

Rosenberg, K. V., R. D. Ohmart, W. C. Hunter, and B. W. Anderson. 1991. Birds of the lower Colorado River Valley. Tucson: University of Arizona Press.

Rosenstock, S. S., D. R. Anderson, K. M. Giesen, T. Leukering, and M. F. Carter. 2002. Landbird counting techniques: Current practices and an alternative. Auk **119**:46–53.

Royle, J. A. 2004. Generalized estimators of avian abundance from count survey data. Animal Biodiversity and Conservation **27**:375–386.

Royle, J. A., J. D. Nichols, and M. Kery. 2005. Modeling occurrence and abundance of species when detection is imperfect. Oikos **110**:353–359.

Royle, J. A., and W. A. Link. 2006. Generalized site occupancy models allowing for false positive and false negative errors. Ecology **87**:835–841.

Sauer, J. R. 1993. Monitoring goals and programs of the U.S. Fish and Wildlife Service. Pages 245–251 *in* D. M. Finch and P. W. Stangel, eds., Status and management of neotropical migratory birds. General Technical Report RM-229. U.S. Department of Agriculture Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

Sauer, J. R., B. G. Peterjohn, and W. A. Link. 1994. Observer differences in the North American breeding bird survey. Auk **111**:50–62.

Schmidt, C., B. F. Powell, and W. L. Halvorson. 2006. Plant and vertebrate inventory of Organ Pipe Cactus National Monument. USGS Open File Report 2006-1076. USGS Southwest Biological Science Center, Sonoran Desert Research Station, University of Arizona.

Schmidt, C. A., B. F. Powell, W. L. Halvorson, and P. Anning. 2005. Vascular plant and vertebrate inventory of Chiricahua National Monument. Unpublished Report. USGS Southwest Biological Science Center, Sonoran Desert Research Station, University of Arizona, Tucson, Arizona.

Schmidt, C. A., B. F. Powell, and W. L. Halvorson. 2005. Vascular plant and vertebrate inventory of Tuzigoot National Monument. USGS OFR 2005-1347. USGS Southwest Biological Science Center, Sonoran Desert Research Station, University of Arizona, Tucson, Arizona. http://sbsc.wr.usgs.gov/files/pdfs/ofr_2005-1347.pdf.

———. 2005b. Vascular plant and vertebrate inventory of Chiricahua National Monument. Unpublished report to the Sonoran Desert Inventory and Monitoring Program, Tucson, Arizona.

Schmidt, C. A., W. L. Halvorson, and C. A. Drost. 2006a. Vascular plant and vertebrate inventory of Montezuma Castle National Monument. Unpublished report to the Sonoran Desert Inventory and Monitoring Program, Tucson, Arizona.

Schmidt, C. A., B. F. Powell, W. L. Halvorson. 2006b. Vascular plant and vertebrate inventory of Organ Pipe Cactus National Monument. Unpublished report to the Sonoran Desert Inventory and Monitoring

Program, Tucson, Arizona.

Segee, B. P., and J. L. Neeley. 2006. One the line: The impacts of immigration policy on wildlife and habitat in the Arizona borderlands. Washington D.C.: Defenders of Wildlife.

Sekercioglu, C. H. 2002. Impacts of birdwatching on human and avian communities. Environmental Conservation **29**:282–289.

Sogge, M. K., and M. J. Johnson. 1995. Montezuma Castle avian inventory 1991–1994. Unpublished report by U.S. Geological Survey, Flagstaff, Arizona.

Stevens, D. L., Jr. 1997. Variable density grid-based sampling designs for continuous spatial populations. Enviormetrics **8**:164–195.

Stevens, D. L., Jr., and A. R. Olsen. 2000. Spatially restricted random sampling designs for design-based and model-based estimation. Pages 609–616 *in* G. B. M. Heuvelink and M. J. P. Lemmens, eds., Accuracy 2000: Proceedings of the 4th international symposium on spatial accuracy assessment in natural resources and environmental sciences. The Netherlands: Delft University Press.

Stevens, D. L., Jr., and A. R. Olsen. 2004. Spatially balanced sampling of natural resources. Journal of the American Statistical Association **99**:262–278.

Stevens, L. E., and B. D. Gold. 2003. Monitoring for adaptive management of the Colorado River Ecosystem in Glen and Grand canyons. Pages 101–134 *in* D. E. Busch and J. C. Trexler, eds., Monitoring ecosystems: Interdisciplinary approaches for evaluating ecoregional initiatives. Washington, D.C.: Island Press.

Strindberg, S., S. T. Buckland, and L. Thomas. 2004. Design of distance sampling surveys and geographic information systems. Pages 190–228 *in* S. T. Buckland, D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borshers, and L. Thomas, eds., Advanced distance sampling. Oxford, U.K.: Oxford University Press.

Stromberg, J. C., R. Tiller, and B. Richter. 1996. Effects of groundwater decline on riparian vegetation of semiarid regions: The San Pedro River, Arizona. Ecological Applications **6**:113–131.

Strong, T. R., and C. E. Bock. 1990. Bird species distribution patterns in riparian habitats in southeastern Arizona. Condor **92**:866–885.

Swetnam, T. W., C. D. Allen, and J. L. Betancourt. 1999. Applied historical ecology: Using the past to manage for the future. Ecological Applications **9**:1189–1206.

Swetnam, T. W, and C. H. Baisan. 1996. Fire histories of montane forests in Madrean borderlands. Pages 15–18 *in* Effects of fire on Madrean province ecosystems. General Technical Report RM-GTR-289. United States Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, Ft. Collins, Colorado.

Theobald, D. M., D. L. Stevens, Jr., D. White, N. S. Urquhart, and A. R. Olsen. 2005. Using GIS to generate spatially-balanced random survey designs for natural resource applications. Manuscript submitted to Environmental Management. http://www.nrel.colostate.edu/projects/starmap/download/rrqrr/theobald_etal_RRQRR20050706.pdf.

Thomas, L., J. L. Laake, S. Strindberg, F. F. C. Marques, S. T. Buckland, D. L. Borchers, D. R. Anderson, K. P. Burnham, S. L. Pollard J. H. Hedley, J. R. B. Bishop, and T. A. Marques. 2005. Distance 5.0. Release Beta 5. Research unit for wildlife population assessment, University of St. Andrews, U.K. http:/www.ruspa.st-and.ac.uk/distance.

Thompson, S. K. 2002a. Sampling. Second edition. New York: John Wiley and Sons.

Thompson, W. L. 2002b. Towards reliable bird surveys: Accounting for individuals present but not detected. Auk **119**:18–25.

Urquhart, N. S., and T. M. Kincaid. 1999. Designs for detecting trend from repeated surveys of ecological resources. Journal of Agricultural, Biological and Environmental Statistics **4**:404–414.

Van Auken, O. W. 2000. Shrub invasions of North American semiarid grasslands. Annual Review of Ecology and Systematics **31**:197–215.

Visser, M. E., A. J. Vannoordwijk, J. M. Tinbergen, and C. M. Lessells. 1998. Warmer springs lead to mistimed reproduction in Great Tits (*Parus major*). Proceedings of the Royal Society of London Series B: Biological Sciences **265**:1867–1870.

Wiens, J. A. 1985. Habitat selection in variable environments: Shrub-steppe birds. Pages 191–226 *in* M. L. Cody, ed., Habitat selection in birds. Orlando, Fla.: Academic Press.

Wiens, J. A., and J. T. Rotenberry. 1981. Habitat associations and community structure of birds in shrubsteppe environments. Ecological Monographs **51**:21–41.

Williams, B. K., J. D. Nichols, and M. J. Conroy. 2002. Analysis and management of animal populations. San Diego, Ca.: Academic Press.

Section 2
Standard Operating Procedures

SOP #1: Preparations for the Field Season and Equipment Needed

Version 1.02 (May 4, 2007)

Revision History Log

Previous Version #	Revision date	Author	Changes made	Section and paragraph	Reason for change	New Version #
1.01	May 4, 2007	Brian Powell	Minor to reflect test of protocol in 2007, primarily, no permanent marking of points		Difficult to obtain permission to use permanent markers and GPS units are sufficient	1.02

This SOP describes the procedures to be followed prior to when observers are hired, trained, and conducting surveys. Pre-season planning such as creating schedules and organizing equipment facilitates the completion of both bird and environmental monitoring work and allows for budget planning. All of the equipment and supplies listed in Table 1.01.1 should be organized and made ready for the field season, and copies of the field-data forms in Appendix B should be made. In early March of each year, prior to the field season, all observers should review the entire protocol, including SOPs. Review of bird identification by sight and sound is particularly important and is covered in SOP #2.

General Preparation and Review

As the person responsible for all aspects of preparations for the field season, the project manager will:

1. **Post job positions** in appropriate outlets by late November of the year prior to the field season (see SOP #2).
2. **Review protocol narrative and all SOPs.** Understand the goals and procedures of the monitoring program and begin preparations for training and field surveys. Discuss with appropriate I&M personnel any proposed or recent changes to the sampling design or survey protocol. If a change has been implemented since the last field season, be sure that all field forms, databases, and appropriate sections in relevant SOPs have been updated.
3. **Begin preparations**. Discuss the season's objective and schedules with I&M personnel. Meet in early December to discuss hiring needs and budget, to begin developing a timeline and field schedule, and to outline responsibilities of individual observers.
4. **Contact parks.** Contact appropriate park personnel to discuss any changes in their policy for researchers or specific conditions that may have changed since the last field season (e.g., fires that may have affected sites or areas may have closed). Contact with park personnel may be especially important at Organ Pipe Cactus NM and Coronado NM because of the border-security situation in those parks. Also,

Table 1.01.1. List of equipment for conducting landbird and associated surveys.

Category/ Survey type	Item	Number needed*	Description	Notes/Purpose
Bird survey	Binoculars	1	10 x 50, 8 x 40 or similar magnification	To be provided by observer
	Laser rangefinder	1	1,000-yd range	Establishing distance to birds
	Pocket weather station	1	Kestrel 3000	Measuring air temperature, relative humidity
	Garmin76S	1	GPS unit	
	Tape recorder	1	Small, handheld mini-cassette	Recording unknown bird songs and calls
	Digital watch or timer	1		
	Handheld walkie-talkie radios	1	Small units with 2–3 km range	Communication between field workers
	Clipboard	1		
	Rolls of flagging	1		Marking points and gear. One color unique to each observer
	Bird field guides	1	*Sibley's Guide to Western Birds*	
	Bird song CD/MP3 tracks	1	Contains songs and calls of most species	Available in I&M office in Tucson
	Data forms: VCP	Many		
	Notebooks	3	Small 4" x 6"	For recording notes
	Extra batteries	Many	AA type	For GPS unit
Environmental sampling	English clinometer	1		Hill slope
	Spherical densiometer	1		Estimating canopy cover
	Compass	1		Locating subplots, placing photo ID boards, locating canopy measurement sites
	1.27-cm x 1-m PVC pipe	1		Measuring slope
	1.78-m rope	1		Marking plot boundaries
	5.0-m rope	1		Marking plot boundaries
	Surveying pins for 1.78-m and 5-m rope	3		
	2-megapixel or larger digital camera with a 50-mm lens	1		Fixed focal length is ideal
	Photo point ID board	1		Photo point
	Cover pole	1		Photo point
	Small bungee cord	2		Photo point
Environmental sampling	*Plants of Arizona* field guide	1		Reference

Table 1.01.1. List of equipment for conducting landbird and associated surveys, cont.

Category/ Survey type	Item	Number needed*	Description	Notes/Purpose
General equipment	Pencils	5–10	No. 2	
	Sharpie permanent markers	2		
	Data form: Incidental observations	Many		
	Extra batteries for all equipment	Variable		At least one backup set for each piece of equipment
	Plot-descriptions sheets	1		
	First-aid kit	1		
	Flagging tape	1 roll		
Personal items**	Insect repellent			
	Sunscreen			
	Day pack			
	Sunhat or baseball hat			
	Pocketknife			
	Water bottles			

*Number needed are per observer.

**To be supplied by observers.

When preparing for the field season, each survey crew should have at least one backup of all major equipment.

discuss housing availability and needs with appropriate parks. Fill out web-based permit requests.

5. **Review field notes from previous year.** At the end of each field season, crew leaders will write a brief (3–5 page) report on the field season, which will include a discussion on the general field conditions of the year, access issues to sites, notes about observers if there were problems, and suggestions for improving the efficiency of the program. Review these reports and follow up on any proposed changes, particularly those related to access issues. Suggested changes to the protocol will be collected in each of the first five years, but substantial changes to the protocol should only be instituted after the 3–5-year review.

6. **Print and review the Sonoran Desert Network species list.** This list is included as Appendix A. Review the species most likely to be encountered in each park.

7. **Generate a list of point coordinates for all points.** See SOP #4 for a list of UTM coordinates. Include GIS-generated points for new sites and a list of the actual marker coordinates for previously sampled sites.

8. Print maps of each site and include with transect/group write-up. Ask the network data manager for assistance in printing these maps.

9. **Print and copy the field-data forms.** The field-data forms are included in Appendix B. Print approximately 5% of these forms onto Rite-in-the-Rain© paper.

10. **Upload waypoints onto the GPS units.** Waypoints (the latitude and longitude [UTM] coordinates for each survey point) should be uploaded via computer. Alternatively, they can be manually entered into GPS units before the start of the field season, or entered in the field (SOP #4). Note that manually entering coordinates introduces an extra source of error and should be avoided, if possible.

11. **Calibrate instruments** such as Kestrel pocket weather meters and laser rangefinders and replace batteries at the beginning of the season.

12. **Enroll observers in CPR/first-aid course.** Organize a one-day CPR/first-aid

and/or wilderness first-aid course for all observers. These courses are taught regularly by the Southern Arizona Chapter of the American Red Cross (http://www.saz-redcross.org). Also, observers would benefit from attending a half-day field-safety course taught by Cecil Schwalbe (cecils@srnr.arizona.edu) at the USGS/UA School of Natural Resources. This course is typically held in each March.

13. **Provide observers with training CDs or MP3s.** After formal acceptance of positions, each observer should receive a copy of the bird song/call training CDs or MP3 tracks.

Scheduling Field Work

1. Monitoring efforts at SODN parks will require a field crew of at least two observers. To ensure safety, all observers will work in the same general area each day. Observers will survey 5–10 points each morning (grouped as a transect or independently placed points, termed "sites") and sites will be surveyed four times each season. Observers will typically be asked to work a schedule consisting of five days on, two days off. However, observers will occasionally be asked to survey one extra day each week during the peak of the breeding season (mid-April to mid-May).

2. Preliminary field schedules will be drawn up prior to the beginning of surveys and observer training. Surveys at parks will be asynchronous; surveying will begin as early as March 1 in Organ Pipe Cactus NM and as late at early May at Gila Cliff Dwellings NM. Survey schedules should include some extra time for make-up surveys due to cancellation of surveys (about 5% of surveys in the Sonoran Desert region are cancelled, primarily due to wind; Brian Powell, *unpublished data*).

3. Because of the possibility for the need of a ranger escort at many parts of both Organ Pipe Cactus NM and Coronado NM, the park contact person must be notified at least four weeks prior to surveys to ensure that rangers are able to accompany observers. Scheduling that far in advance may be difficult because of inevitable changes in field surveys. Therefore, it will be imperative to maintain scheduling flexibility in parks and areas that do not require coordination with law-enforcement personnel.

4. Environmental sampling should only be done on points already sampled for birds or after the morning survey is completed. In most cases, environmental sampling can be conducted at approximately two points following each survey morning. Because our survey crews will be working in close proximity, it should be fairly easy for crews to meet up after the completion of the bird surveys to start environmental sampling. Environmental sampling will begin in 2008.

Organizing Supplies and Equipment

See Table 1.01.1. for a list of equipment needed prior to commencing field work. At least one month prior to the beginning of each field season, the project manager should tally all equipment and inspect and test it for damage and calibration. All expensive equipment (laser rangefinders and Kestrel pocket weather stations) should be painted fluorescent colors to facilitate relocation.

Suggested Readings and Audio References

These resources will be made available in the I&M office in Tucson:

Baicich, P. J., and C. J. O. Harrison. 1997. A guide to the nests, eggs, and nestlings of North American Birds. San Diego, Ca.: Academic Press.

Colver, K. J., D. Stokes, and L. Stokes. 1999. Stokes field guide to bird songs. New York: Time Warner.

Epple, A. O., and L. E. Epple. 1995. Plants of Arizona. Helena, Mont.: Falcon Press.

Keller, G. A. 2001. Bird songs of southeastern Arizona and Sonora, Mexico. Ithaca, N.Y.: Macaulay Library of Natural Sounds, Cornell Laboratory of Ornithology.

Sibley, D. A. 2003. The Sibley field guide to birds of western North America. New York: Alfred A. Knopf.

SOP #2: Hiring and Training Observers

Version 1.02 (May 4, 2007)

Revision History Log

Previous Version #	Revision date	Author	Changes made	Section and paragraph	Reason for change	New Version #

This SOP explains the procedures for hiring and training bird-survey personnel (observers). Accurate, consistent data collection begins with the hiring process, followed by a rigorous training program. Training should ensure that all observers are able to identify, by sight and sound, >90% of bird species expected to be encountered in SODN parks and >80% of bird species that have reasonable potential to occur in the area. It is also essential that observers are able to accurately and consistently estimate distances to birds and follow standard operating procedures to ensure data quality across time. Observers must be prepared both mentally and physically for the extreme heat and difficult terrain of SODN parks.

Hiring Observers

Qualifications and attributes

The most essential element for the collection of high-quality data is well-trained and experienced observers. Given the high level of variability associated with bird surveys in general, it is imperative that known sources of error, such as that related to observer skill, be minimized (Kepler and Scott 1981; Thomas 1996; Diefenbach et al. 2003). The importance of hiring well-qualified observers and training them cannot be overemphasized; excellent observers obtain species estimates within 90% of the total species known to be present and estimate abundance within 80% accuracy (Ralph et al. 1993). Hiring observers with significant field-survey experience in the Sonoran Desert region will be a challenge for the program. In our experience, there is a lack of well-qualified candidates who know all or most of the species in the region and who have experience with distance sampling.

In point-transect counts, most birds are recorded aurally. Therefore, it is important to hire observers with good hearing ability to ensure consistent data collection (Ramsey and Scott 1981). Though the analysis of distance-sampling and occupancy data can account for differences in observer skill, the ability to model these differences has limitations. Potential observers with serious hearing loss (> 20 dB) should not be hired unless they have their hearing corrected to 10 dB using hearing aids (Kepler and Scott 1981).

In addition to their skill, experience, and hearing ability, observers must be in excellent physical condition and be able to thrive in difficult field conditions. The physical and psychological demands of surveying in the extreme heat of the Sonoran Desert should not underestimated; even the most skilled observer is of no use if s/he is unable to cope with difficult field conditions. Certification as a Wilderness First Responder (or in wilderness first Aid) and in CPR is also an asset.

Hiring process

As outlined in the protocol narrative, our current assessment of the market for skilled observers in the Sonoran Desert region indicated that wages of $13–14/hr should be considered the minimum starting wage. To attract the most-qualified candidates, it will be important to disseminate job announcements by no later than early December to appropriate outlets, including physical job boards at the School of Natural Resources at the University of Arizona, e-mail listservs within the scientific community of Tucson and Phoenix, and the following websites:

- Ornithological newsletter: http://www.aou.org/jobs/
- Texas A&M Wildlife Science job board: http://www.wfsc.tamu.edu/jobboard/index.htm
- Society for Conservation Biology job database: http://www.conbio.org/jobs.

During the applicant review process, it will be important to give priority to those candidates with considerable experience conducting multispecies bird surveys in the region and, secondly, to candidates with distance-sampling experience. Our experience shows that distance estimation can be learned in a few days, but learning the songs and calls of the 200 or so species that are likely to be encountered during surveys of SODN parks takes considerably more time. We also recommend that those responsible for hiring consider candidates with excellent experience in other regions of North America, and who, based on information from past employers, have a demonstrated exceptional ability to learn songs and calls of new species.

Hiring personnel should interview all well-qualified candidates at least once and call three references. As mentioned earlier, particular attention should be paid to the experience of the observer, his/her ability to learn new calls, his/her physical abilities to withstand difficult field conditions, and his/her overall attitude. Our experience informs us that an observer with a positive and enthusiastic attitude makes a better crew member and is most adaptable to challenging field conditions.

Training Observers

This training program emphasizes correct identification of species and distance estimation and promotes accuracy and consistency in data collection among observers. In particular, we try to calibrate observers so that they have comparable skills in identifying species, are estimating the numbers seen or heard in the same way, and are recording data in a consistent format. For observers who are already competent at identifying birds by sight and sound, the need for training may be minimal; experienced observers usually recalibrate quickly. If the program is fortunate enough to hire all experienced observers for a season, then the training program that we propose will improve their skills. No observer is exempt from the training program.

The following section outlines the tasks to be completed during the five-day training period. We summarized much of this material from Peitz et al. (2004) and Bennetts et al. (2005). Future versions of this SOP may include a more detailed training program.

1. **Prepare for the training program.** The project manager or hired cooperator will act as instructor. The instructor must prepare training materials, itineraries, field gear, and set up distance courses before the training program begins. Along with the training program, a variety of other tasks will have to be completed in preparation for fieldwork. Thus, it is crucial that instructors prepare well in advance and budget their time appropriately.
2. **Send each observer bird song/call CDs or MP3s.** Once hiring paperwork is initiated, it will be important that observers receive the song/call training CDs or MP3 tracks that include the most likely species to be encountered in SODN parks. These materials have been compiled by SODN staff and are available at the I&M office in Tucson.
3. **Issue field gear before training begins.** See SOP #1 (Preparing for the Field Season and Equipment Needed) for a list of field equipment. Provide a copy of this protocol to all trainees, along with field gear and other training materials, before training begins. Ensure that observers examine the list of necessary personal gear (listed in SOP #1) and have all the appropriate equipment by the time fieldwork starts. Ensure that trainees are informed and prepared for the training and survey events; everyone should bring binoculars, warm clothing (if appropriate), pocket field guides, hats, and other appropriate equipment for each day of training. Have field technicians read Kepler and Scott (1981) for a detailed discus-

sion of training observers and Chapter 2 of Bibby et al. (2000) for a general discussion of the sources of error in bird surveys.

4. **Have all crewmembers participate in a five-day landbird-survey and distance-estimation training program.** Observers from previous seasons normally do not need as much training in bird identification skills as new observers. However, all observers must attend the entire training course each year. Experienced observers can assist with training less-experienced observers. Experienced observers also will continue practicing distance estimation, working on identification of birds by call notes and partial songs, and generally improving their identification skills.

5. **Conduct training in areas similar to those encountered during surveys.** Conduct the majority of the five-day training program in areas with similar topography and communities to those encountered during surveys. We recommend areas close to Tucson, such as Cienega Creek Preserve, Sabino Canyon, Rincon Creek, and even Tumacácori NHP. While it emphasizes distance estimation, the initial objective of the training program is to maximize the trainees' exposure to the species most likely to be encountered during the surveys. Discuss personal techniques for distance estimation, dealing with busy points, fly-overs, moving birds, potentially confusing scenarios, and bird species and behaviors that are encountered in similar areas. It is important to recognize that training sessions early in the season will fail to detect all of the species that will be encountered later in the season. This is especially true in the riparian areas, as most of the riparian-obligate species are Neotropical migrants. Therefore, it will be important to discuss common species that are likely to be encountered later in the season.

6. **Focus on distance estimation during the first days of training.** The five-day training session occurs immediately before the field season, when many landbirds are returning to their nesting grounds. Emphasize distance estimation during the first 2–3 days of training. Construct distance-estimation training courses in a variety of areas and topographical gradients. The importance of accurate distance estimation cannot be overemphasized and training has been found to improve accuracy considerably (Kepler and Scott 1981).

7. **Emphasize field safety procedures and issues.** Discuss emergency safety procedures and important safety issues for the Sonoran Desert region, most notably heat exposure. It is recommended that all field personnel take a one-day CPR/first-aid course and/or the field-safety course offered through the School of Natural Resources at the University of Arizona. A field-safety instruction booklet is currently being developed by the network.

8. **Review dominant trees and shrubs.** The environmental-characteristics component of field sampling also will be covered and it will be important to use a small portion of the time during the five-day training session to familiarize observers with the common trees and shrubs of the region.

Establishing a distance training course

Each early-morning training session should be devoted to learning the songs and calls of birds in the training area. After a few hours of general birding, we recommend setting up one or two distance-training courses. Over the five-day training period, we recommend establishing courses in a variety of field conditions, such as uplands, riparian areas, and areas with different slopes and obstructions. The first course should be set up in a flat, open area. Here are the directions for setting up a course:

1. Begin by placing flagging at 10 m, 25 m, 50 m, and 100 m from a central point and having observers estimate distances to trees, rocks, and flagging from that central point.
2. Have each observer place flagging at 4–5 locations visible from the central point, and then have everyone in the group record distances to each flag in a field book. Distances should be estimated to the nearest meter. Then, use a laser rangefinder to measure the distance to each flag, and have each person compare their initial estimate to the actual distance. Repeat this exercise at several sites until observers can consistently estimate distances to within 10–15% of the actual distance. For objects within 20

m of the station, observers should be able to accurately estimate distances to within 1 m of the true distance.

3. The majority of birds are usually heard but not seen, and estimating distances to birds that are only heard is often the greatest source of error in landbird surveys. With all observers at the central point, have each observer estimate the distance to vocalizing birds pointed out by the instructor. Horizontal distances should be estimated as if a plumb bob was lowered to the ground from the bird's location. Observers should visually identify the tree or branch where they think the bird is, and estimate the horizontal distance to an object that they can see directly below where they think the bird is vocalizing from.

4. Half of the group should place themselves at various distances away from the central point, and quietly wait until a bird vocalizes near them. Place reference markers at measured distances from the central point to help these "spotters" estimate the distance between the central point and birds that vocalize. The other half of the group should remain at the central point, and estimate the distance to any birds that vocalize. The observer closest to the bird should then indicate where the bird was vocalizing from and, if necessary, the distance to the point directly under the bird should be measured from the central point. This is a slow but important part of the training, and should be repeated until observers have experience with estimating distances to a number of different species.

5. Simultaneous counts: Divide observers into groups and have them conduct eight-minute counts from the same location. At the end of each count, have the observers compare notes and discuss any discrepancies in the species detected and the estimated distances to them. Remember that the distance to where the bird was first detected should be recorded. For example, if a bird flies towards the central point, the distance where it was first heard or seen is recorded, not the closest distance or where it lands. Continue these simultaneous counts until there is consistency among observers in species and distances recorded. If insufficiencies are discovered at the group level, they should be addressed with further training and courses. Individual observers with significant differences should be trained further.

General timeline for the training program

1. **Day 1. Begin outdoors and introduce the project.** During the first day of training, introduce trainees to the context and goals of the project; to distance-sampling techniques, including the basic assumptions and statistical theory; and to the fundamentals of our sampling design, methods, and protocol. Take the group for a walk around the immediate area and review the birds that are encountered along the way. Spend the remainder of the day in the field on the first distance-training course. This course will be visually based and topographically flat.

2. **Days 2–3. Continue working on distance estimation and incorporate auditory distance estimation.** It will be difficult to conduct more than two distance-training courses in one day, considering the time required for set-up and completion of the course. As a break between distance-training courses, walk through different areas and practice bird identification, using laser rangefinders to continually reinforce distance estimation. Continue using visual distance courses until all trainees are consistently estimating within 10–15% of the actual distance. Once this goal has been achieved, begin to estimate distances to singing birds. After trainees achieve an average of ±10% accuracy for auditory detections, incorporate distance estimation into practice counts.

3. **Days 4–5. Begin practicing counts, emphasizing exposure to unusual species or species with difficult identification.** Schedule training in a variety of areas, continuing to maximize exposure to as many species as possible. Walk through various community types and continually "quiz" trainees individually. Separate into small groups (combining experienced observers with novice trainees, if possible) and begin to practice eight-minute counts and record results on the actual field-data forms. At the end of each count, compare species lists. Reinforce identification skills and sce-

narios likely to be encountered in the field, focusing on problem species that are commonly missed or confused by the trainees. Continue estimating distances, using laser rangefinders (and pacing when necessary).

General rules and miscellaneous count issues

General rules for observers to follow during surveys:

- **Look/listen everywhere.** Be sure to look up regularly, particularly in areas with taller trees like riparian areas and especially if you are wearing a hat. Be sure to look and listen in all directions approximately equally.
- **Stand at points.** Do **not** sit or kneel, as this can reduce the number of individuals recorded by decreasing visibility and audibility.
- **No pishing.** Do not attract birds to you. Pishing is permissible after the count in order to attempt to identify an individual that was not identifiable on the count. Do not add other individuals that were otherwise not counted doing the eight-minute count period.
- **No guessing.** Never guess on the identity of a bird. Instead, use an unknown code (e.g., unidentified sparrow: UNSP) for those individuals you're not sure about. However, recording a lot of unidentified birds is an indication that you need to learn/practice more before performing surveys.
- **Practice.** Practice in the general area prior to formal counts and be familiar with the songs and calls of all species found in the area.

Miscellaneous issues to be aware of when conducting the bird counts, and how to deal with them:

- **"Listening through" window species.** It is not unusual for observers to "listen through" (not detect) a particular common species because they are habituated to it. Mourning dove is a common window species.
- **Airplane (and other) noise.** If audibility of birds is reduced by mechanical noise, observers should interrupt the count and restart when noise abates and add time to the end to make an eight-minute count. Obviously, a timepiece that permits stopping and restarting from the stop point is of great value.
- **Swamping.** There are potentially times when so many birds are detectable that the observer is unable to keep up with recording them. This happens often in riparian areas. If this occurs, it is important to recognize how distance sampling works. Estimates of density using distance sampling are quite sensitive to observations close to the point and less so at great distances from the point. Thus, if "swamping" occurs, observations close to the point should be the priority.

Collecting environmental data

Environmental sampling will take place after the end of bird sampling each morning and after the end of the bird-sampling field season in 2008. Training for collecting environmental data will take place for two days prior to the start of the bird surveys and after the five-day bird survey training session.

1. Each field personnel should read SOP #6.
2. The project manager should construct approximately three cover poles prior to the start of the field season.
3. Once in the field, observers should spend time learning the dominant trees and shrubs of riparian and upland vegetation communities and practice estimating cover classes of different vegetation types and groundcover categories.
4. The project manager should be familiar with all aspects of the protocol and be able to teach other observers how to use a clinometer and laser rangefinder, assess topographic position, identify cover types, assess horizontal vegetation cover, and assess cover using Daubenmire cover classes.
5. Because of the rather subjective nature of estimating many of the environmental variables, it is critical that observers practice estimating these variables until there is virtual consensus among group members.

Literature Cited

Bennetts, R. E., A. Schrag, and S. Wolff. 2005. Cooperative bird monitoring plan and protocol for the Greater Yellowstone Network of parks. Version 1.00. Unpublished protocol.

Bibby, C. J., N. D. Burgess, D. A. Hill, and S. Mustoe. 2000. Bird census techniques. Second edition. London, U.K.: Academic Press.

Diefenbach, D. R., D. W. Brauning, and J. A. Mattice. 2003. Variability in grassland bird counts related to observer differences and species detection rates. Auk **120**:1168–1179.

Kepler, C. B., and J. M. Scott. 1981. Reducing bird count variability by training observers. Studies in Avian Biology **6**:366–371.

Peitz, D. G., S. G. Fancy, L. P. Thomas, G. A. Rowell, and M. D. Debacker. 2004. Bird monitoring protocol for Agate Fossil Beds National Monument, Nebraska, and Tallgrass Prairie National Preserve, Kansas. Unpublished protocol to the Prairie Cluster Prototype Monitoring Program, National Park Service, U.S. Department of the Interior.

Ralph, C. J., G. R. Geupel, P. Pyle, T. E. Martin, and D. F. DeSante. 1993. Handbook of field methods for monitoring landbirds. General Technical Report PSW-GTR-144. USDA Forest Service, Pacific Southwest Research Station, Albany, California.

Ramsey, F. L., and J. M. Scott. 1981. Tests of hearing ability. Studies in Avian Biology **6**:341–345.

Thomas, L. 1996. Monitoring long-term population change: Why are there so many analysis methods? Ecology **77**:49–58.

SOP #3: GPS Unit Operation

Version 1.02 (May 4, 2007)

Revision History Log

Previous Version #	Revision date	Author	Changes made	Section and paragraph	Reason for change	New Version #
1.01	May 4, 2007	Brian Powell	Eliminate section on pocket PC		Pocket PC was not used or needed in 2007.	1.02

This SOP describes the procedures for using a Garmin 76S GPS unit, which are used to navigate to and between bird survey points.

GPS Unit Setup

Prior to going into the field, it will be necessary for all observers to read and understand the Garmin manual that accompanies the 76S GPS unit. During the five-day training session at the beginning of the field season, the project manager will be responsible for ensuring that all observers are competent in operating the unit. The following is a step-by-step guide for unit operation.

1. Confirm that GPS data output is in “NMEA” format.
2. Press **Menu** button twice on the 76S to reach main menu.
3. Select **Setup.**
4. Use rocker keypad to reach *****, confirm *** is “NMEA” and not “GARMIN”.
5. Confirm **** is “UTM”.
6. Highlight ***Coordinate System***.
7. Press **enter.** The ***Coordinate System*** screen has a listing of available projections. If UTM is not selected, select it now and press **enter. Datum** should always be set to NAD 1983 (Conus). “Zone” should be set to 12 for all parks except Gila Cliff Dwellings NM, which is Zone 13.
8. To change the Zone, highlight this option, then press the **right arrow**.
9. A menu listing all possible zones will appear.
10. Use the arrow pad to scroll to the appropriate zone. Once you have selected the proper Zone, press **enter**.
11. Upon returning to the main projection menu ensure that the Datum is still set to NAD 1983 (Conus). If this is not the case scroll down to **Datum** and press the **right arrow**. Scroll through the list until you have selected NAD 1983 (Conus). Press **enter**.
12. Scroll down to Altitude reference. This should be set to “HAE”. If all of the information is correct press **enter** a second time.

Appendix 3.01.1. Glossary of Important GPS Unit Terms

Elevation Mask: Sets cut-off elevation for satellites (the unit will not gather positions from satellites lower than the degree set). This should be a minimum of one degree above the Base Station Mask, with 15 degrees recommended. This is most important during the planning stages. If you are working in locations with obstructions, you can set the mask higher so that only those satellites higher in the sky will be used for data collection. You also can allow for these situations by checking the azimuth position of satellites in Quick Plan.

SNR Mask: Signal strength or signal-to-noise ratio. If it is too high, you will not get good data. The range is 0–99. If you raise the SNR mask, you can receive more satellites, but the data is not as good. The default is 6.

PDOP Mask: Position dilution of precision. This is an indication of the accuracy of the calculated position based on the location of the satellites in the constellation. If satellite positions do not allow the use of coordinate geometry, then accurate ground locations can not be triangulated from them. <4 = very good; 5-8 = adequate; >8 = inadequate.

Julian Date: Day of the year between the range of 1 and 365. For example, the Julian date for February 2 is #33. February 2 is the calendar date.

Feature: The units on which you collect data. Examples include buildings, woodlots, roads, trails, etc.

Attributes: Descriptive characteristics of features.

Differential Correction: Increases the accuracy of the data files by correcting errors associated with the satellites. (See Pathfinder Office help–differential GPS).

BoB: Beacon-on-a-Belt is a real-time correction receiver.

SOP #4: Establishing and Marking Bird-Survey Points

Version 1.02 (May 4, 2007)

Revision History Log

Previous Version #	Revision date	Author	Changes made	Section and paragraph	Reason for change	New Version #

This SOP explains the procedures used for designating sites and outlines a series of decision rules for establishing points and transects. The UTMs for sites are located in Table 4.01.1 (next page). Most of these sites were established in March/April 2007.

Establishing Transects and Points

The location of most transects has been established (Table 4.01.1). Observers should have the UTM coordinates loaded onto their GPS units and use them to navigate to the start of each transect. Observers should place one 40-cm piece of flagging tape at each bird-survey point along the transect. Each piece of flagging tape will remain at the point for the duration of the field season and will be taken down by the last observers to visit the point in that field season. When placing flagging, observers should identify, using a permanent marker, what point is being marked, and write: "NPS bird monitoring program."

Table 4.01.1. UTM coordinates for the location of landbird monitoring sites in Sonoran Desert Network parks.

Park	Point name	Type	UTM_X	UTM_Y	Established in 2007
Casa Grande Ruins National Monument	U-1	Upland	449799	3650680	YES
	U-10	Upland	450162	3651310	YES
	U-11	Upland	450514	3651311	YES
	U-2	Upland	450147	3650681	YES
	U-3	Upland	450492	3650686	YES
	U-6	Upland	450344	3651009	YES
	U-7	Upland	449992	3651027	YES
	U-8	Upland	449635	3651016	YES
	U-9	Upland	449812	3651310	YES
Chiricahua National Monument	BON-1	Riparian	652148	3542651	NO
	BON-2	Riparian	652380	3542746	NO
	BON-3	Riparian	652631	3542746	NO
	BON-4	Riparian	652874	3542685	NO
	BON-5	Riparian	653114	3542617	NO
	BON-6	Riparian	653359	3542663	NO
	BON-7	Riparian	653600	3542622	NO
	BON-8	Riparian	653855	3542587	NO
	U-1	Upland	654401	3540799	NO
	U-10	Upland	653164	3544346	NO
	U-11	Upland	659411	3540860	NO
	U-12	Upland	657620	3542961	NO
	U-13	Upland	654385	3543364	NO
	U-14	Upland	659523	3541933	NO
	U-15	Upland	653044	3545343	NO
	U-16	Upland	654308	3542337	NO
	U-17	Upland	658755	3542804	NO
	U-18	Upland	655327	3541711	NO
	U-19	Upland	654160	3545131	NO
	U-2	Upland	654069	3540067	NO
	U-20	Upland	654293	3542838	NO
	U-21	Upland	653712	3542573	NO
	U-22	Upland	658410	3543893	NO
	U-23	Upland	652313	3544829	NO
	U-24	Upland	654282	3541747	NO
	U-25	Upland	658450	3543497	NO
	U-26	Upland	653892	3545478	NO
	U-27	Upland	653294	3545202	NO
	U-28	Upland	658072	3542272	NO
	U-29	Upland	656280	3542291	NO
	U-3	Upland	659758	3541429	NO
	U-30	Upland	655266	3543122	NO

Table 4.01.1. UTM coordinates for the location of landbird monitoring sites in SODN parks, cont.

Park	Point name	Type	UTM_X	UTM_Y	Established in 2007
Chiricahua National Monument, cont.	U-31	Upland	653327	3543533	NO
	U-32	Upland	656656	3542306	NO
	U-33	Upland	652170	3545162	NO
	U-34	Upland	660434	3540713	NO
	U-35	Upland	658560	3543157	NO
	U-36	Upland	652162	3544335	NO
	U-37	Upland	655489	3542872	NO
	U-38	Upland	656828	3540066	NO
	U-39	Upland	652300	3543181	NO
	U-4	Upland	655080	3542206	NO
	U-40	Upland	657658	3541653	NO
	U-5	Upland	652484	3544004	NO
	U-6	Upland	658160	3541870	NO
	U-7	Upland	657097	3542776	NO
	U-8	Upland	654638	3542788	NO
	U-9	Upland	653783	3542030	NO
Coronado National Memorial	RIP-1	Riparian	570948	3468176	NO
	RIP-2	Riparian	570705	3468125	NO
	RIP-3	Riparian	570463	3468185	NO
	RIP-4	Riparian	570231	3468277	NO
	RIP-5	Riparian	569998	3468370	NO
	RIP-6	Riparian	569749	3468404	NO
	RIP-7	Riparian	569497	3468411	NO
	RIP-8	Riparian	569251	3468460	NO
	U-1	Upland	573057	3467400	NO
	U-10	Upland	572483	3467789	NO
	U-11	Upland	571953	3467380	NO
	U-12	Upland	573298	3467823	NO
	U-13	Upland	571340	3468516	NO
	U-14	Upland	573364	3468697	NO
	U-15	Upland	572174	3469329	NO
	U-16	Upland	573618	3467223	NO
	U-17	Upland	573031	3469305	NO
	U-18	Upland	571564	3468044	NO
	U-19	Upland	572622	3467322	NO
	U-2	Upland	572627	3468442	NO
	U-20	Upland	573759	3468671	NO
	U-21	Upland	571565	3469148	NO
	U-22	Upland	573602	3466938	NO
	U-23	Upland	573291	3468222	NO
	U-24	Upland	573723	3467649	NO

Table 4.01.1. UTM coordinates for the location of landbird monitoring sites in SODN parks, cont.

Park	Point name	Type	UTM_X	UTM_Y	Established in 2007
Coronado National Memorial, cont.	U-25	Upland	571250	3469756	NO
	U-3	Upland	571003	3467904	NO
	U-4	Upland	570891	3468363	NO
	U-5	Upland	570988	3466863	NO
	U-6	Upland	572264	3467292	NO
	U-7	Upland	572663	3469018	NO
	U-8	Upland	572275	3467976	NO
	U-9	Upland	571992	3467865	NO
Fort Bowie National Historic Site	SPN-1	Riparian	647071	3557641	YES
	SPN-2	Riparian	646823	3557671	YES
	SPN-3	Riparian	646596	3557774	YES
	SPN-4	Riparian	646391	3557919	YES
	SPN-5	Riparian	646372	3558168	YES
	SPN-6	Riparian	646618	3558226	YES
	SPN-7	Riparian	646846	3558332	YES
	SPN-8	Riparian	646893	3558578	YES
	Up-10	Upland	643453	3558345	YES
	Up-11	Upland	647378	3557403	YES
	Up-12	Upland	644125	3558261	YES
	Up-13	Upland	646197	3558110	YES
	Up-14	Upland	645858	3558611	YES
	Up-15	Upland	646186	3558400	YES
	Up-16	Upland	643138	3558264	YES
	Up-17	Upland	645200	3557724	YES
	Up-18	Upland	645933	3558340	YES
	Up-19	Upland	645038	3558096	YES
	Up-2	Upland	645581	3557939	YES
	Up-20	Upland	646183	3557773	YES
	Up-3	Upland	646539	3557310	YES
	Up-4	Upland	647671	3557214	YES
	Up-5	Upland	646770	3557442	YES
	Up-6	Upland	643851	3558185	YES
	Up-7	Upland	646114	3558716	YES
	Up-8	Upland	647533	3557677	YES
	Up-9	Upland	645533	3558247	YES
Gila Cliff Dwellings National Monument	RIP-1	Riparian	754838	3680090	NO
	RIP-2	Riparian	754613	3680207	NO
	RIP-3	Riparian	754426	3680354	NO
	RIP-4	Riparian	754169	3680400	NO
	RIP-5	Riparian	753964	3680632	NO
	RIP-6	Riparian	753761	3680798	NO

Table 4.01.1. UTM coordinates for the location of landbird monitoring sites in SODN parks, cont.

Park	Point name	Type	UTM_X	UTM_Y	Established in 2007
Gila Cliff Dwellings National Monument, cont.	U-1	Upland	754551	3679746	NO
	U-10	Upland	754772	3679435	NO
	U-11	Upland	754117	3680368	NO
	U-12	Upland	753846	3679886	NO
	U-13	Upland	754373	3679535	NO
	U-14	Upland	753884	3680467	NO
	U-15	Upland	754065	3679577	NO
	U-2	Upland	753724	3679291	NO
	U-3	Upland	754107	3679911	NO
	U-4	Upland	754466	3680044	NO
	U-5	Upland	754148	3679153	NO
	U-6	Upland	754734	3680187	NO
	U-7	Upland	753682	3680077	NO
	U-8	Upland	753672	3679702	NO
	U-9	Upland	754501	3679109	NO
Montezuma Castle National Monument–Castle Unit	R-1-1	Riparian	422677	3829646	YES
	R-1-2	Riparian	422589	3829892	YES
	R-1-3	Riparian	422715	3830236	YES
	R-1-4	Riparian	423012	3830219	YES
	R-1-5	Riparian	423152	3829994	YES
	R-1-6	Riparian	423365	3829846	YES
	R-2-1	Riparian	423628	3829855	YES
	R-2-2	Riparian	423850	3829999	YES
	R-2-3	Riparian	423885	3830263	YES
	R-2-4	Riparian	423681	3830431	YES
	R-2-5	Riparian	423462	3830560	YES
	R-2-6	Riparian	423278	3830787	YES
	Up-1	Upland	423008	3830906	YES
	Up-11	Upland	422480	3830393	YES
	Up-13	Upland	422603	3830612	YES
	Up-17	Upland	423550	3829737	YES
	Up-18	Upland	422418	3829734	YES
	Up-2	Upland	424023	3829693	YES
	Up-24	Upland	422739	3830376	YES
	Up-25	Upland	423318	3829619	YES
	Up-26	Upland	424020	3829942	YES
	Up-27	Upland	422785	3830789	YES
	Up-28	Upland	423777	3829627	YES
	Up-3	Upland	422965	3830521	YES
	Up-4	Upland	423164	3830359	YES
	Up-5	Upland	423081	3829742	YES

Table 4.01.1. UTM coordinates for the location of landbird monitoring sites in SODN parks, cont.

Park	Point name	Type	UTM_X	UTM_Y	Established in 2007
Montezuma Castle National Monument–Castle Unit, cont.	Up-7	Upland	422869	3829900	YES
	Up-9	Upland	423585	3830087	YES
Montezuma Castle National Monument–Well Unit	R-1	Riparian	429733	3833941	YES
	R-2	Riparian	429948	3834028	YES
	R-3	Riparian	430200	3834059	YES
	R-4	Riparian	430439	3834101	YES
	R-5	Riparian	430697	3834071	YES
	R-6	Riparian	430927	3834108	YES
	R-7	Riparian	431129	3834246	YES
	Up-1	Upland	430186	3834717	YES
	Up-10	Upland	430182	3834454	YES
	Up-2	Upland	431198	3834472	YES
	Up-3	Upland	430982	3834735	YES
	Up-4	Upland	430435	3834425	YES
	Up-5	Upland	430619	3834641	YES
	Up-7	Upland	430832	3834369	YES
	Up-8	Upland	431249	3834782	YES
	Up-9	Upland	430434	3834810	YES
Organ Pipe Cactus National Monument	R-1-1	Upland	335374	3546195	YES
	R-1-2	Upland	335465	3545874	YES
	R-1-3	Upland	335740	3545841	YES
	R-1-4	Upland	336026	3545778	YES
	R-1-5	Upland	336300	3545746	YES
	R-1-6	Upland	336592	3545699	YES
	R-1-7	Upland	336848	3545821	YES
	U-1-1	Upland	330030	3548928	YES
	U-1-2	Upland	330384	3548911	YES
	U-12-1	Upland	317577	3563115	YES
	U-12-2	Upland	317902	3562944	YES
	U-12-3	Upland	318192	3562750	YES
	U-12-4	Upland	318501	3562580	YES
	U-12-5	Upland	318784	3562369	YES
	U-12-6	Upland	319089	3562191	YES
	U-12-7	Upland	319395	3561998	YES
	U-1-3	Upland	330736	3548896	YES
	U-1-4	Upland	331088	3548882	YES
	U-1-5	Upland	331646	3548821	YES
	U-1-6	Upland	331994	3548770	YES
	U-1-7	Upland	332341	3548709	YES
	U-4-1	Upland	330311	3563892	YES

Table 4.01.1. UTM coordinates for the location of landbird monitoring sites in SODN parks, cont.

Park	Point name	Type	UTM_X	UTM_Y	Established in 2007
Organ Pipe Cactus National Monument, cont.	U-4-2	Upland	330664	3563915	YES
	U-4-3	Upland	331027	3563955	YES
	U-4-4	Upland	331359	3563850	YES
	U-4-5	Upland	331701	3563763	YES
	U-4-6	Upland	332042	3563676	YES
	U-4-7	Upland	332385	3563590	YES
	U-5-1	Upland	336188	3558806	YES
	U-5-2	Upland	335849	3558889	YES
	U-5-3	Upland	335509	3558975	YES
	U-5-4	Upland	335164	3559045	YES
	U-5-5	Upland	334824	3559131	YES
	U-5-6	Upland	334489	3559230	YES
	U-5-7	Upland	334147	3559315	YES
Saguaro National Park–Rincon Mountain District	008-1	Upland	535227	3556784	YES
	008-2	Upland	535207	3556534	YES
	008-3	Upland	535192	3556286	YES
	008-4	Upland	535173	3556038	YES
	008-5	Upland	535157	3557888	YES
	008-6	Upland	535135	3555542	YES
	008-7	Upland	535117	3555295	YES
	009-1	Upland	525016	3559243	YES
	009-2	Upland	525266	3559289	YES
	009-3	Upland	525515	3559324	YES
	009-4	Upland	525762	3559359	YES
	009-5	Upland	526010	3559402	YES
	009-6	Upland	526257	3559439	YES
	009-7	Upland	526506	3559472	YES
	112-1	Upland	526003	3558474	YES
	112-2	Upland	526193	3558324	YES
	112-3	Upland	526372	3558196	YES
	112-4	Upland	526578	3558024	YES
	112-5	Upland	526592	3557775	YES
	112-6	Upland	525808	3558630	YES
	112-7	Upland	525608	3558781	YES
	115-1	Upland	527717	3562406	YES
	115-2	Upland	527597	3562184	YES
	115-3	Upland	527512	3561964	YES
	115-4	Upland	527419	3561730	YES
	115-5	Upland	527318	3561504	YES
	115-6	Upland	527839	3562623	YES
	115-7	Upland	527964	3562840	YES

Table 4.01.1. UTM coordinates for the location of landbird monitoring sites in SODN parks, cont.

Park	Point name	Type	UTM_X	UTM_Y	Established in 2007
Saguaro National Park–Rincon Mountain District, cont.	139-1	Upland	528894	3563097	YES
	139-2	Upland	529102	3563242	YES
	139-3	Upland	529308	3563374	YES
	139-4	Upland	529517	3563516	YES
	139-5	Upland	528681	3562968	YES
	139-6	Upland	529665	3563722	YES
	LRC-1	Riparian	535856	3554747	YES
	LRC-2	Riparian	535608	3554786	YES
	LRC-3	Riparian	535347	3554872	YES
	LRC-4	Riparian	535090	3554932	YES
	LRC-5	Riparian	534861	3555038	YES
	LRC-6	Riparian	534632	3555172	YES
	LRC-7	Riparian	536100	3554809	YES
	LRC-8	Riparian	536345	3554870	YES
Saguaro National Park–Tucson Mountain District	204-1	Upland	483386	3571990	YES
	204-2	Upland	483468	3572224	YES
	204-3	Upland	483544	3572477	YES
	204-4	Upland	483616	3572710	YES
	204-5	Upland	483310	3571743	YES
	204-6	Upland	483219	3571509	YES
	204-7	Upland	483750	3572931	YES
	204-8	Upland	483948	3573098	YES
	212-1	Upland	484370	3568709	YES
	212-2	Upland	484604	3568640	YES
	212-3	Upland	484862	3568584	YES
	212-4	Upland	485105	3568534	YES
	212-5	Upland	484095	3568744	YES
	212-6	Upland	485350	3568467	YES
	213-1	Upland	480552	3571560	YES
	213-2	Upland	480785	3571494	YES
	213-3	Upland	481031	3571413	YES
	213-4	Upland	481264	3571328	YES
	213-5	Upland	481499	3571246	YES
	213-6	Upland	480328	3571673	YES
	213-7	Upland	480113	3571783	YES
	238-1	Upland	484872	3579208	YES
	238-2	Upland	485102	3579235	YES
	238-3	Upland	485358	3579254	YES
	238-4	Upland	485612	3579287	YES
	238-5	Upland	484723	3579407	YES
	238-6	Upland	484465	3579416	YES

Table 4.01.1. UTM coordinates for the location of landbird monitoring sites in SODN parks, cont.

Park	Point name	Type	UTM_X	UTM_Y	Established in 2007
Saguaro National Park–Tucson Mountain District, cont.	239-1	Upland	478263	3570188	YES
	239-2	Upland	478131	3570400	YES
	239-3	Upland	478003	3570616	YES
	239-4	Upland	477873	3570825	YES
	239-5	Upland	478396	3569974	YES
	239-6	Upland	478555	3569777	YES
	239-7	Upland	478786	3569666	YES
	239-8	Upland	479035	3569681	YES
Tonto National Monument	RIP-1	Riparian	489804	3723173	NO
	RIP-2	Riparian	489623	3722975	NO
	RIP-3	Riparian	489554	3722713	NO
	RIP-4	Riparian	489521	3722438	NO
	RIP-5	Riparian	489411	3722218	NO
	RIP-6	Riparian	489393	3721976	NO
	U-1	Upland	489226	3723217	NO
	U-10	Upland	489638	3724070	NO
	U-11	Upland	489136	3723663	NO
	U-12	Upland	489511	3723041	NO
	U-13	Upland	490509	3723317	NO
	U-14	Upland	490430	3723881	NO
	U-15	Upland	489093	3724001	NO
	U-16	Upland	489125	3724331	NO
	U-17	Upland	490327	3723537	NO
	U-18	Upland	490277	3724360	NO
	U-19	Upland	489896	3724029	NO
	U-2	Upland	490017	3723670	NO
	U-20	Upland	489667	3724335	NO
	U-3	Upland	490583	3722796	NO
	U-4	Upland	490517	3724189	NO
	U-5	Upland	489566	3723447	NO
	U-6	Upland	489825	3722985	NO
	U-7	Upland	490400	3722994	NO
	U-8	Upland	490010	3723364	NO
	U-9	Upland	489325	3724131	NO
Tumacácori National Historical Park	A-1	Upland	495418	3492600	YES
	A-2	Upland	495377	3492184	YES
	M-1	Upland	495202	3492565	YES
	M-2	Upland	495187	3493564	YES
	M-3	Upland	495326	3492964	YES
	M-4	Upland	495182	3493199	YES
	RIP-1	Riparian	495634	3493003	YES

Table 4.01.1. UTM coordinates for the location of landbird monitoring sites in SODN parks, cont.

Park	Point name	Type	UTM_X	UTM_Y	Established in 2007
Tumacácori National Historical Park, cont.	RIP-2	Riparian	495196	3493960	YES
	RIP-3	Riparian	495478	3494018	YES
	RIP-4	Riparian	495542	3493577	YES
	RIP-5	Riparian	495717	3492430	YES
	RIP-6	Riparian	495724	3492711	YES
	RIP-7	Riparian	495303	3494204	YES
	RIP-8	Riparian	495692	3493808	YES
Tuzigoot National Monument	Est-1	Riparian	406045	3847602	YES
	Est-2	Riparian	406225	3847677	YES
	Est-3	Riparian	406480	3847612	YES
	Est-4	Riparian	406634	3847796	YES
	Est-5	Riparian	406662	3848042	YES
	Est-6	Riparian	406587	3848289	YES
	Est-7	Riparian	406666	3848503	YES
	Wst-1	Riparian	406461	3848382	YES
	Wst-2	Riparian	406413	3848630	YES
	Wst-3	Riparian	406289	3848877	YES
	Wst-4	Upland	406109	3848694	YES
	Wst-5	Upland	406133	3848482	YES
	Wst-6	Upland	406192	3848255	YES
	Wst-7	Upland	406076	3848003	YES

This list does not include higher-elevation sites at Saguaro NP–Rincon Mountain District or alternative sites for monitoring in Saguaro NP and Organ Pipe Cactus NM. Those points will be established in 2006 and incorporated in later versions of the protocol.

SOP #5: Conducting the Bird Survey

Version 1.02 (May 4, 2007)

Revision History Log

Previous Version #	Revision date	Author	Changes made	Section and paragraph	Reason for change	New Version #
1.01	3/21/2007	Brian Powell	Changed information collected during count (i.e., detection type, sex)		Version 1.01 information was too onerous for observers	1.02

This SOP provides step-by-step instructions for conducting landbird counts at SODN parks using the point-transect method (Buckland et al. 2001). It describes the procedure for collecting data and filling in the data form, "SODN Point-transect Landbird Surveys" (Appendix B) and explains how to complete the "Incidental Detections" data form.

Procedures Prior to Going in the Field for a Survey Day or Trip

1. If the transect/point has been sampled previously in the season, determine the point sequence and conduct the survey in the opposite direction. The field crew leader will maintain a log of the order of survey points, so consult him/her about the correct survey order.
2. Make certain that your UTM coordinates (NAD83 datum) for that transect/points are in the GPS unit. As a backup, bring a list of UTM coordinates for each point. If necessary, UTM coordinates can be entered manually.
3. Organize equipment for the following morning's survey (see SOP #1). Prepare food and personal gear to facilitate a timely departure from camp or trailhead. Bring appropriate gear, including extra water and a first-aid kit, every day.
4. If the survey is in a remote area, make arrangements to camp near the first survey point on the previous night, or know how to get to the first point by walking in the dark (only along trails or washes).
5. Consult weather reports. Canceling surveys during the breeding season is rare in our region but strong storms can occur. Unless there are extreme conditions predicted for the morning surveys (i.e., strong winds and/or heavy rain), we recommend that observers attempt to conduct a survey. Counts should not be conducted if wind strength on the Beaufort Scale is a sustained 4 or greater (see Table 5.01.1), or if it is raining hard (rain code $\geq$4; Table 5.01.2). If you encounter these conditions, wait until the weather improves or cancel the sampling for that day and try again on another day. Consider performing vegetation sampling or data entry on days when surveys are canceled.
6. Sampling will occur in the morning, beginning as soon as it is light enough to see a distance of at least 200 m and ending no later than 3½ hours after official sunrise (Table 5.01.3). Try to arrive at the first point while it is still dark so that the count can begin as soon as it is light enough to see. Singing rate for most species is usually highest before or near official sunrise and then declines slowly over the next few hours.

Table 5.01.1. Codes (Beaufort scale) used to record wind strength during bird counts.

Wind 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	Fresh breeze, small trees sway (30–39 km/h)
6	Strong breeze, large branches moving, wind whistles (40–50 km/h)

Table 5.01.2. Codes used to record precipitation codes during bird counts.

Precipitation code	Explanation
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 5.01.3. Sunrise times for Phoenix, Arizona.

	Month				
Day	March	April	May	June	July
1	6:57	6:16	5:40	5:19	5:22
2	6:56	6:15	5:39	5:19	5:22
3	6:54	6:14	5:38	5:19	5:23
4	6:53	6:12	5:37	5:19	5:23
5	6:52	6:11	5:36	5:18	5:23
6	6:51	6:10	5:35	5:18	5:24
7	6:49	6:10	5:35	5:18	5:24
8	6:48	6:07	5:34	5:18	5:25
9	6:47	6:06	5:33	5:18	5:25
10	6:46	6:05	5:32	5:18	5:26
11	6:44	6:03	5:31	5:18	5:27
12	6:43	6:02	5:30	5:18	5:27
13	6:42	6:01	5:30	5:18	5:28
14	6:40	6:00	5:29	5:18	5:28
15	6:39	5:58	5:28	5:18	5:29
16	6:38	5:57	5:27	5:18	5:30
17	6:36	5:56	5:27	5:18	5:30
18	6:35	5:55	5:26	5:18	5:31
19	6:34	5:53	5:25	5:18	5:31
20	6:32	5:52	5:25	5:18	5:32
21	6:31	5:51	5:24	5:19	5:33
22	6:30	5:50	5:24	5:19	5:33
23	6:28	5:49	5:23	5:19	5:34
24	6:27	5:48	5:23	5:19	5:35
25	6:26	5:47	5:22	5:20	5:35
26	6:24	5:45	5:22	5:20	5:36
27	6:23	5:44	5:21	5:20	5:37
28	6:22	5:43	5:20	5:20	5:37
29	6:20	5:42	5:20	5:21	5:38
30	5:41	5:20	5:21		5:39
31	5:20				5:40

Information Recorded at the Beginning of Each Survey

7. Once you arrive at the first point, begin the count as soon as possible, but wait at least one minute to calm your heartbeat if hiking to the point was strenuous. If hiking was extremely strenuous, rest away from the point (e.g., 100 m) for a few minutes, then continue to the point. At the first point on each survey day, fill in the survey information at the top of the form. At the first and last survey points, fill in the survey condition data.

Survey information

- Park: Four-letter park code. See Table 1 in protocol narrative for park codes.
- Transect/Group (site): Unique identifier for the collection of points on the day's survey.
- Date (mm/dd/yyyy): Write in the month (2 digits), day (2 digits) and year (4 digits) in the format shown. Examples are 05/02/2006 and 06/25/2006.
- Observer initials: Fill in the three initials of the person conducting the counts using capital letters. If you do not have a middle name, then put an underscore for your middle initial. Examples would be BFP for Brian F. Powell and D_A for Debbie Angell.

Survey conditions

The following information must be filled in at the beginning and end of each survey morning. For each condition there is a "/" on the data form. Conditions at the beginning of each survey are written to the left of the dash and conditions at the end of the survey are written to the right of the dash. For example, "Temp. (^{o}C) 13/17" indicates the temperature at the beginning of the survey was 13^{o}C and the temperature at the end of the survey was 17^{o}C. To allow for the proper calibration of the weather instrument (e.g., Kestrel 3000), place it away from the ground and your body (e.g., hanging from a shrub).

- Temp(erature) (oC): Record the ambient temperature during the eight-minute count in degrees Celsius, rounded off to the nearest degree. The thermometer should be placed above the ground and allowed to adjust to ambient air temperature. Use Kestrel 3000 or similar device.
- Wind (0–6): Record the wind code (0 through 6; Table 5.01.2) as it applies to the strength of the wind during the first and last eight-minute count. Record the average wind conditions for each count, not the maximum condition (e.g., periods of gusty winds).
- Humidity (%): Record percent relative humidity as measured by Kestrel 3000 or similar device.
- Cloud cover (%): Visual estimate of the percent cloud cover, rounded off to the nearest 10%. This should be a number between 0 (no clouds) and 100 (complete overcast). If there are patches of clouds in different areas of the sky, try to picture gathering all of them together into one part of the sky and recording what percent of cloud cover that would represent.
- Precipitation (0–5): Record the appropriate code (Table 5.01.3).
- Noise (0–3): Record the noise code (Table 5.01.4) that applies to background-noise conditions during the count, as affects your ability to hear birds. Cicadas are often a considerable disturbance in our parks and are usually loud near the end of some surveys.

Table 5.01.4. 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; 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

Approaching Points and Beginning the Count

8. Navigate to the first point using the GPS unit (see SOP #3). If you observe a bird close to the point that flushes as a result of you approaching, you should record the bird's initial distance from the point on the data form. The reason for this is that a critical assumption of the distance-sampling method is that birds at or very close to (e.g., <5–10 m) the point center will always be detected, i.e., g(0) = 1. Use a separate line for each individual flushed as you would for species observed during the eight-minute active period but do not write anything in the "Minute" field.

9. Conduct the point as a "snapshot" in time. The survey results should represent the actual distribution of the birds relative to the point. The underlying theory of distance sampling requires that each point be recorded as close to a "snapshot in time" as possible. Some movement is acceptable, as long as a bird is only counted once and the observer does not cause movement. Any birds that flush upon approaching the point, or birds that seem to be attracted by the presence of the surveyors, should be noted in the comments.

10. Use a laser rangefinder to estimate distances to birds whenever possible; the closer the bird, the more accurate the distance estimation should be.

11. Use a digital watch with a timer set at eight (8) minutes. Begin the survey by starting the timer. A watch type that signals the passage of each one minute interval is ideal because you will note the minute in which the detection takes place. Stop the count at the end of the eighth minute. Observers from past surveys have had a tendency to "pack" observations made after the eighth minute into that minute (see Supplement B). This practice is not permitted by the protocol; there are opportunities to record birds observed after the eighth minute (see below).

12. Conduct the eight-minute count without interruption, being sure to fill in all the fields for each bird/flock detected. Occasionally, aircraft noise can be loud and can last for up to 30 seconds. In these instances, increase the count period by the amount of time for which the count was disturbed. If excessive noise interrupts the count for more than two minutes, then start the survey again after the disturbance has passed.

13. Once you have started your watch and begun the eight-minute counting period, record all birds heard or seen during the eight minutes, regardless of their distance from the center of the point (more on the types of detections is outlined below).

At each point, you will record the following information only once:

- Point: Unique identifier for that point.
- Start Time (hhmm): Write in the time using the hour and minute format for military time. Fill in all four digits. Examples are 0630 (6:30 am) and 0802 (8:02 am).

The following information will be recorded for each bird or group of birds observed during the eight-minute active period:

- Species: Record the four-character code for the species detected. Examples are BEVI for Bell's vireo, BHCO for brown-headed cowbird, and BHGR for black-headed grosbeak. Codes for species known to occur at Sonoran Desert Network parks are listed in Table 5.01.7 (see end of this SOP) and in Appendix A of this protocol. If no birds are detected during an eight-minute count, you should enter data for the first line of the form and record the code "ND" (No Detections) in the Species column. Birds that you can not positively identify to species should be recorded using the prefix "UN" (e.g., UNBI for unknown bird, UNSP for unknown sparrow).
- Minute (1–8): Record the minute in which the bird (or group of birds) was first detected. Minute 1 is from 0–60 seconds. By recording this information, we can compare the data to those collected by other researchers (e.g., BBS counts) that use other time intervals to conduct counts. Also, these data can be used to model detection probability (Farnsworth et al. 2002).
- Distance (m): Record the horizontal distance in meters between the point center (where you are standing), and the location

of the bird where you first detect it. Use a laser rangefinder whenever possible to get as accurate a distance as possible. Do not round off numbers to the nearest five meters; estimate the distance to the nearest meter. 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 toward you, not the distance to where it landed. For species that occur in clusters or flocks, record the distance from the observer to the center of the flock. If a bird is high in a tree, imagine dropping a plumb bob from the bird down to the ground, and measure the horizontal distance to that spot on the ground. Indicate flyovers (birds that fly 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) by writing "F" in the distance column.

- Detect(ion) type: The detection type corresponds to the first detection of that individual (Table 5.01.5). If a male was first observed visually, then later was heard singing, add "A" next to the "V" code (i.e., "V/A"). The detection type code will 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 seen versus those that are only heard.
- Flock size: For most observations, each individual bird will be treated independently as a separate observation (i.e., line on the data form), but for species that usually occur in clusters or flocks, the appropriate unit is the cluster or flock size, and not the individual bird. For example, quail almost always occur in coveys of 10–40 birds. If you observe a covey of 40 quail during a count, it is not appropriate to record 40 distances and treat them as independent observations in the analysis. For flocking species, record the distance to the center of the flock and the number of birds in the flock, rather than the distance to each individual bird.

Table 5.01.5. Codes used to record detection type during bird surveys.

Code	Description
V	Visual detection
A	Auditory detection
B or V/A	Both visual and auditory

- Sex: Most detections will be of singing males, but visual detections of birds are important to note if the species is sexually dimorphic. For auditory observations this cell will remain blank, but note gender for visual observations when it is possible to note the difference. Options: M = Male; F = Female; MF = pair. Note: there is no option for "unknown" because all observers should know the difference between male and female in sexually dimorphic species. If you see a flock in which there are multiple males and females, note in comments column.
- Age (Class): Detections are assumed to be adults, but if juveniles are observed, put Juvenile ("J"); otherwise, leave blank.
- Prev(ious) point: Place an "X" in this column if the bird was already detected at a previous point. Bias caused by repeated counting of the same individual from more than one point is usually small unless repeated counting is common during a survey (Buckland et al. 2001, 37) or in cases where a rare bird is counted from multiple points (Nelson and Fancy 1999). Recording whether a bird is thought to have been counted at a previous point allows the data to be analyzed in two different ways, depending on which is most appropriate. Some authorities say that you should not count a bird if you think it was already recorded from another point. Others argue that you should always count each bird detected, even if it was probably detected previously. By placing an "X" in this column for those cases in which you think the bird has already been counted from another point, you allow future investigators the option of analyzing data using either approach.
- Comments: Record any comments that

Table 5.01.6. Breeding behavior codes used to note breeding observations.

Code	Explanation
CN	Carrying nesting material (e.g., stick, grass, mud, cobwebs. This applies for all species except some species of wrens (cactus, Bewick's, house, marsh) and verdins.
NB	Nest building seen at actual nest site, excluding some species of wrens (see above), woodpeckers, and verdins.
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. Do not use for species that build multiple nests in a breeding season, such as cactus wrens and verdins.
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. Note: barely fledged blackbirds and swallows may fly considerable distances. Presence of young cowbirds confirms both cowbird and host.
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.

seem appropriate and might affect the quality of the data. Also record any breeding behavior that may be observed using the standard Breeding Bird Atlas Codes (Table 5.01.6). If you locate a nest, indicate what plant species it is in and note the number of eggs and the number of brown-headed cowbird eggs, if appropriate or feasible.

After the eight-minute active period

14. Observations made after the eighth minute are called outside count-period observations (OCPOs) and are noted by first drawing a short line after the end of the count. Then, record all information as you would during the count, but put an "X" through the "Minute" field.

15. Review the data form and fill in all fields on the data form before departing for the next point. Also, search the area to ensure that no equipment is left behind.

16. Navigate to the next point. Use the GPS to attain a bearing to the next point and hike to it at a reasonable pace, stopping to observe any unusual species or unknown calls or songs. We have designed the length of each survey to accommodate some OCPOs; pilot data for this project indicated that 10% more species were noted while traveling between points (see Appendix B).

17. Record observations of birds not recorded on the count but near to the point as you travel between points. For recordkeeping purposes, it is important to attribute an observation to a point. For example, if you are traveling between two points and observe a bird 50 m from the point you just left, attribute the observation to the point you just left as in step 14 above. However, if you observe a bird 200 m from the point you left and that bird is only 50 m from the point that you are approaching, make a note of this bird in the margin. If this bird was not flushed by you on your approach to the point, it may be observed during the eight-minute active period (and your note in the margin can be ignored and erased). If the bird is not observed during the active period, use the notes in the margin to note this bird at the end of the count as you would an OCPO (step 14).

18. Indicate the start of a new point by drawing a line all the way across the data form. If observations from one point span multiple pages, be sure to include ("cont.") next to the point number at the top of the next page.
19. Record observations of other notable flora and fauna (mammals, reptiles and amphibians, and fish) on a separate "Incidental Observations" data form (Appendix B).

At the End of Each Survey Day

20. Spend some time (at least 30 minutes) going back over the entire transect or parts of the transect to look for species that were not recorded during the survey. Note those species at the end of the point-transect data form and note the point and distance from the point where you made the observation. This is much like the OCPOs made while traveling between points (Step 17).
21. Review the data forms and fill in the "Page __of__" section in the upper right-hand corner of each data form.
22. Be sure to note survey conditions at the end of the survey.
23. Compare vocalizations with known bird sounds on tapes to identify all unknown bird species recorded in the field. If a species is seen in the field and you noted characteristics (in field notebook) but it was not identified, it should be identified at this time using reference materials.
24. If you are far from the transect and observe an unusual bird, note it on the data form "Incidental Observations" (see Appendix B).
25. Proof all data and update daily field notes after returning to the camp or trailhead. Contact your supervisor to indicate if you completed the transect, in what order, and to report any unusual conditions.

Recording Incidental Observations

When observers are within or near a park unit and not conducting a point-transect survey and observe a bird in an unusual location or exhibiting breeding behavior, we encourage them to record "incidental" observations. These observations are recorded onto the appropriate data form (Appendix B). Unique observations of other taxa are encouraged if the observer is confident of his/her identification skills.

The following information is recorded on each Incidental Observations data form. Many of these fields are the same as those for the point-transect count, we do not repeat the information here:

General information: to be recorded at the top of each data form only once.

1. Observer initials: three-letter initials of observer.
2. Year: Four numbers (e.g., 2007; not "07")

Individual observations: all fields should be filled out the best of the observer's ability.

1. Taxon: taxonomic class; most commonly used. Bird is assumed unless otherwise indicated (plant, fish, herp, mammal).
3. Park: four-letter park or unit code (e.g., TUMA).
4. Date: mm/dd format.
5. Time: record as 24-hour time (e.g., 3:17pm = 1517).
6. Species: use four-letter species codes (see Appendix A or Table 5.01.7) for birds or write out entire name for other groups.
7. Number of individuals: number of animals seen (of same species, sex, and age).
8. Sex: M = male or F = female (if known).
9. Age class: J = juvenile, S = subadult, or A = adult (if known).
10. UTM coordinates: using NAD83 datum.
11. Comments: Any comments unique or relevant to the detection. Include nesting codes for birds (Table 5.01.6).

Literature Cited

Buckland, S. T., D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borchers, and L. Thomas. 2001. Introduction to distance sampling: Estimating abundance of biological populations. Oxford, U.K.: Oxford University Press.

Farnsworth, G. L., K. H. Pollock, J. D. Nichols, T. R. Simons, J. E. Hines, and J. R. Sauer. 2002. A removal model for estimating detection probabilities from point-count surveys. Auk **119**:414–425.

Nelson, J. T., and S. G. Fancy. 1999. A test of the variable circular-plot method where exact density of a bird population was known. Pacific Conservation Biology **5**:139–143.

Table 5.01.7. List of four-letter codes for the most-common species in Sonoran Desert Network parks.

Code	Common name	Code	Common name
ABTO	Abert's towhee	BUOR	Bullock's oriole
ACWO	Acorn woodpecker	BUOW	Burrowing owl
AMCO	American coot	BUSH	Bushtit
AMKE	American kestrel	CACW	Cactus wren
AMPI	American pipit	CAFI	Cassin's finch
AMRO	American robin	CAGO	Canada goose
AMWI	American widgeon	CAHU	Calliope hummingbird
ANHU	Anna's hummingbird	CAKI	Cassin's kingbird
ATFL	Ash-throated flycatcher	CANT	Canyon towhee
AUWA	Audubon's warbler	CANW	Canyon wren
AZWO	Arizona woodpecker	CARW	Carolina wren
BAEA	Bald eagle	CASP	Cassin's sparrow
BANS	Bank swallow	CAVI	Cassin's vireo
BARS	Barn swallow	CBHA	Common black-hawk
BBFL	Buff-breasted flycatcher	CBTH	Curve-billed thrasher
BBLH	Broad-billed hummingbird	CEDW	Cedar waxwing
BBWD	Black-bellied whistling duck	CFPO	Cactus ferruginous pygmy-owl
BCFL	Brown-crested flycatcher	CHRA	Chihuahuan raven
BCHU	Black-chinned hummingbird	CHSP	Chipping sparrow
BCSP	Black-chinned sparrow	CITE	Cinnamon teal
BEKI	Belted kingfisher	CLNU	Clark's nutcracker
BETH	Bendire's thrasher	CLSW	Cliff swallow
BEVI	Bell's vireo	COFL	Cordilleran flycatcher
BEWR	Bewick's wren	COGD	Common ground-dove
BGGN	Blue-gray gnatcatcher	COHA	Cooper's hawk
BHCO	Brown-headed cowbird	COHU	Costa's hummingbird
BHGR	Black-headed grosbeak	COME	Common merganser
BLGR	Blue grosbeak	COMO	Common moorhen
BLPH	Black phoebe	CONI	Common nighthawk
BLVU	Black vulture	COPW	Common poorwill
BNOW	Barn owl	CORA	Common raven
BNST	Black-necked stilt	COYE	Common yellowthroat
BRBL	Brewer's blackbird	CRTH	Crissal thrasher
BRCR	Brown creeper	DCCO	Double-crested cormorant
BROC	Bronzed cowbird	DCFL	Dusky-capped flycatcher
BRSP	Brewer's sparrow	DEJU	Dark-eyed junco
BRTI	Bridled Titmouse	DUFL	Dusky flycatcher
BTGN	Black-tailed gnatcatcher	EAME	Eastern meadowlark
BTLH	Broad-tailed hummingbird	EAPH	Eastern phoebe
BTPI	Band-tailed pigeon	ELOW	Elf owl
BTSP	Black-throated sparrow	ELTR	Elegant trogon
BTYW	Black-throated gray warbler	EUST	European starling

Table 5.01.7. List of four-letter codes for the most-common species in Sonoran Desert Network parks, cont.

Code	Common name
EVGR	Evening grosbeak
FEHA	Ferruginous hawk
FLOW	Flammulated owl
FOSP	Fox sparrow
GAQU	Gambel's quail
GBHE	Great blue heron
GCSP	Golden-crowned sparrow
GHJU	Gray-headed Junco
GHOW	Great horned owl
GIFL	Gilded flicker
GIWO	Gila woodpecker
GKIN	Green kingfisher
GOEA	Golden eagle
GRCA	Gray catbird
GREG	Great egret
GRFL	Gray flycatcher
GRHA	Gray hawk
GRPE	Greater pewee
GRRO	Greater roadrunner
GRVI	Gray vireo
GRWA	Grace's warbler
GTGR	Great-tailed grackle
GTTO	Green-tailed towhee
GWTE	Green-winged teal
HAFL	Hammond's flycatcher
HAWO	Hairy woodpecker
HETA	Hepatic tanager
HETH	Hermit thrush
HEWA	Hermit warbler
HOFI	House finch
HOLA	Horned lark
HOOR	Hooded oriole
HOSP	House sparrow
HOWR	House wren
HRSH	Harris's hawk
HUVI	Hutton's vireo
INBU	Indigo bunting
INDO	Inca dove
JUTI	Juniper titmouse
KILL	Killdeer
LAGO	Lawrence's goldfinch
LARB	Lark bunting

Code	Common name
LASP	Lark sparrow
LAZB	Lazuli bunting
LBWO	Ladder-backed woodpecker
LEGO	Lesser goldfinch
LENI	Lesser nighthawk
LEOW	Long-eared owl
LEWO	Lewis's woodpecker
LISP	Lincoln's sparrow
LOSH	Loggerhead shrike
LUHU	Lucifer's hummingbird
LUWA	Lucy's warbler
MAHU	Magnificent hummingbird
MALL	Mallard
MAWR	Marsh wren
MECH	Mexican chickadee
MEJA	Mexican jay
MERL	Merlin
MGWA	MacGillivray's warbler
MOBL	Mountain bluebird
MOCH	Mountain chickadee
MODO	Mourning dove
MONQ	Montezuma quail
NAWA	Nashville warbler
NBTY	Northern beardless-tyrannulet
ND	No detections at point
NOCA	Northern cardinal
NOFL	Northern flicker
NOGO	Northern goshawk
NOHA	Northern harrier
NOMO	Northern mockingbird
NOPA	Northern parula
NOPO	Northern pygmy-owl
NOWA	Northern waterthrush
NRWS	Northern rough-winged swallow
NSWO	Northern saw-whet owl
OCWA	Orange-crowned warbler
OLWA	Olive warbler
ORJU	Oregon junco
OSFL	Olive-sided flycatcher
OSPR	Osprey
PABU	Painted bunting
PARE	Painted redstart

Table 5.01.7. List of four-letter codes for the most-common species in Sonoran Desert Network parks, cont.

Code	Common name	Code	Common name
PBGR	Pied-billed grebe	SSHA	Sharp-shinned hawk
PEFA	Peregrine falcon	STJA	Steller's jay
PHAI	Phainopepla	SUTA	Summer tanager
PIJA	Pinyon Jay	SWHA	Swainson's hawk
PISI	Pine siskin	SWTH	Swainson's thrush
PLVI	Plumbeous vireo	TOSO	Townsend's solitaire
PRFA	Prairie falcon	TOWA	Townsend's warbler
PSFL	Pacific-slope flycatcher	TRSW	Tree swallow
PSJU	Pink-sided junco	TUVU	Turkey vulture
PUMA	Purple martin	UMME	Unknown meadowlark
PYNU	Pygmy nuthatch	UNAM	Unknown Ammodramus sp.
PYRR	Pyrrhuloxia	UNBL	Unknown blackbird
RBGR	Rose-breasted grosbeak	UNBU	Unknown bunting
RBNU	Red-breasted nuthatch	UNCA	Unknown cardinal
RCKI	Ruby-crowned kinglet	UNEM	Unknown empidinax flycatcher
RCSP	Rufous-crowned sparrow	UNFL	Unknown flicker
RECR	Red crossbill	UNHU	Unknown hummingbird
RFWA	Red-faced warbler	UNMY	Unknown myiarchus
RNDU	Ring-necked duck	UNOR	Unknown oriole
RNSA	Red-naped sapsucker	UNOW	Unknown owl
RODO	Rock dove	UNPI	Unknown picoides
ROWR	Rock wren	UNPO	Unknown pygmy owl
RSFL	Red-shafted flicker	UNRA	Unknown raven
RTBE	Rose-throated becard	UNSO	Unknown screech-owl
RTHA	Red-tailed hawk	UNBI	Unknown bird
RUHU	Rufous hummingbird	UNSW	Unknown swallow spp.
RWBL	Red-winged blackbird	UNTA	Unknown tanager spp.
RWSP	Rufous-winged sparrow	UNTH	Unknown thrasher
SACR	Sandhill crane	UNTY	Unknown tyrranus
SAPH	Say's phoebe	UNWA	Unknown warbler
SASP	Sage sparrow	UNWO	Unknown woodpecker
SATH	Sage thrasher	USPA	Unknown sparrow
SBFL	Sulphur-bellied flycatcher	VABU	Varied bunting
SCOR	Scott's oriole	VASW	Vaux's swift
SCQU	Scaled quail	VEFL	Vermilion flycatcher
SNEG	Snowy egret	VERD	Verdin
SORA	Sora	VESP	Vesper sparrow
SOSP	Song sparrow	VGSW	Violet-green swallow
SOVI	Solitary vireo type	VIRA	Virginia rail
SPOW	Spotted owl	VIWA	Virginia's warbler
SPSA	Spotted sandpiper	WAVI	Warbling vireo
SPTO	Spotted towhee	WBNU	White-breasted nuthatch

Table 5.01.7. List of four-letter codes for the most-common species in Sonoran Desert Network parks, cont.

Code	Common name
WCSP	White-crowned sparrow
WEBL	Western bluebird
WEFL	Western flycatcher
WEKI	Western kingbird
WEME	Western meadowlark
WESJ	Western scrub-jay
WESO	Western screech-owl
WETA	Western tanager
WEWP	Western wood-pewee
WFIB	White-faced Ibis
WHSO	Whiskered screech-owl
WIFL	Willow flycatcher
WISA	Williamson's sapsucker
WITU	Wild turkey
WIWA	Wilson's warbler
WPWI	Whip-poor-will
WTSP	White-throated sparrow
WTSW	White-throated swift
WWDO	White-winged dove
YBCH	Yellow-breasted chat
YBCU	Yellow-billed cuckoo
YEJU	Yellow-eyed junco
YHBL	Yellow-headed blackbird
YRWA	Yellow-rumped warbler
YTVI	Yellow-throated vireo
YWAR	Yellow warbler
ZTHA	Zone-tailed hawk

SOP #6: Documenting Environmental Features at Landbird Survey Points

Version 1.02 (May 2, 2007)

Revision History Log

Previous Version #	Revision date	Author	Changes made	Section and paragraph	Reason for change	New Version #

This SOP gives step-by-step instructions for characterizing environmental features at landbird survey points in SODN parks. It describes the procedure for locating points and noting environmental features within 75 m of each bird survey point using the data form, "Bird Survey Point Location and Environmental Attributes within 75 m." This protocol also covers establishment of four subplots and explains how to measure and estimate vegetation and groundcover data at each plot using the data form, "Bird Survey Point Environmental Features: Subplots" (see Appendix B). Portions of this protocol, including text and figures, were adapted from Bennetts et al. (2005).

Overview

1. Environmental sampling will take place after the conclusion of VCP surveys each day and/or at the end of the field season. We will spend approximately two days prior to the initiation of the bird surveys in March training observers to conduct environmental sampling. Environmental sampling at the 75-m-plot level will take place in 2007; sampling at the subplots will begin in 2008.

2. Environmental features are estimated for a large (75-m-radius) plot centered on the bird survey point, as well as on four permanent subplots within each plot (Figure 6.01.1). Subplot 1 is centered on the bird survey point. The centers of subplots 2, 3, and 4 are located 36.6 m from the point, and at 120° angles from one another (i.e., Subplot 2 is at 0°, subplot 3 is at 120°, subplot 4 is at 240°). This plot layout is based on work by Herrick et al. (2005), which was in turn modified from the USFS Forest Inventory and Analysis (USFS 2003).

3. From the survey point, a number of broad-scale site attributes within 75 m are noted: slope (degrees and variability), aspect (degrees and variability), topographic position, and dominant vegetation types.

4. At each subplot, a number of vegetation features are noted or measured: canopy cover, horizontal vegetation coverage, dominant woody plant species in the overstory and understory, groundcover type, and foliar cover in the understory. The size

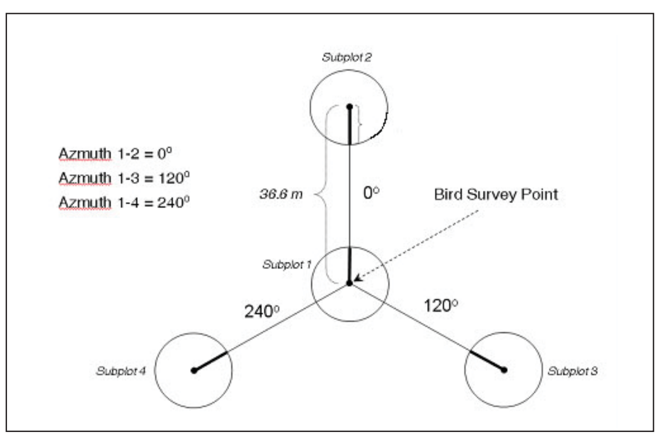


Figure 6.01.1. Layout of environmental characteristics plots at each bird survey point, Sonoran Desert Network parks.

Layout from Herrick et al. (2005) and modified from USFS (2003).

of the subplots will vary depending on the measurements or estimations, with most measurements being made within a five-meter radius of the subplot center. Photographs will be taken at each of the four subplots.

5. See SOP #1 for list of field equipment needed for conducting environmental sampling.

General Information

The following information will be entered at the top of each data form for environmental sampling ("Bird Survey Point Environmental Features: Subplots" and "Bird Survey Point Location and Environmental Features: 75-m Plots"; Appendix B).

- Park Code: A four-letter alpha code unique to each park. See Table 1 in the protocol narrative for list of park unit codes.
- Date: Month/day/year; mm/dd/yyyy.
- Observer initials: The initials for the first, middle, and last name of each person in the field crew collecting data.
- Transect/Group (site): Identification of the transect/group in which point is located.
- Point ID: The permanent identification code assigned to each bird survey point.

Plot Attributes

The following information will be recorded on the "Bird Survey Point Location and Environmental Features: 75-m Plots" data form and will be recorded only once at each point. This information gives a subjective determination of the physical characteristics within 75 m of each point. Prior to estimating these characteristics, use a laser rangefinder to determine the edge of the 75-m-radius plot.

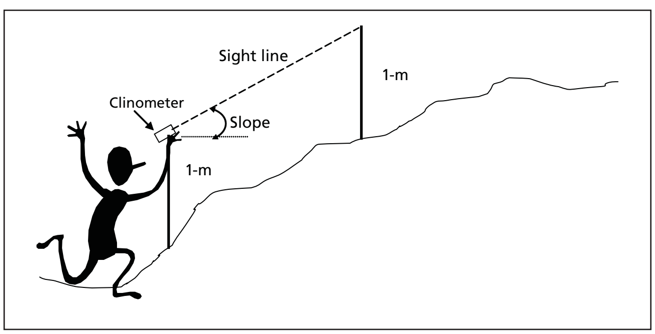


Figure 6.01.2. Diagram of how to measure slope using a clinometer and 1-m sighting poles.

Slope: Slope of the ground across the entire 75-m-radius plot is measured using an English clinometer. For slope measurements, use two poles of equal length (1 m) to sight between and read slope directly off the left-hand scale (degrees slope) of the clinometer (Figure 6.01.2). The poles should be positioned at a distance great enough to capture the average slope of the land across the 75-m-radius plot. Slope is measured in degrees the first time a plot is measured and is not recorded in subsequent years. Note: this information also can be derived from digital elevation models if the model is fine resolution (e.g., <10 m). This should be done when such products are available.

- Slope variability: Circle high, medium, or low to describe the up-and-down variability in slope across the entire 75-m-radius plot.
- Aspect: The slope direction of the 75-m-radius plot. Compass readings will be taken with the declination set at 0°. Aspect is recorded from 0° to 359°, with 360° recorded as 0°. Aspect is measured when the plot is established and is not recorded in subsequent years.
- Aspect variability: Circle high, medium, or low to describe the variability in the direction of the slope across the entire 75-m-radius plot.
- Topographic position: Describes the location of the point relative to its local position on the earth's surface. As with slope, this may be derived from digital elevation models. For this application, ArcGIS extensions such as Topographic Position Index are available (http://www.jennessent.com/arcview/tpi.htm).
    - o Level: Level top of a plateau, valley floor, or shoreline representing the former position of an alluvial plain, lake, or shore.
    - o 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.

- o Mid-slope (transportational mid-slope): Intermediate slope position.
- o Upper-slope (shoulder slope): Uppermost inclined surface at the top of a slope, typically convex in profile.
- o Escarpment/face: Sloping or vertical side of a stream bank or former steam bank.
- o Ledge (terrace, step-in slope): Nearly level shelf interrupting a steep slope or cliff face.
- o Crest (interfluve, summit, ridge): Linear top of a ridge, hill or mountain; the elevated area between two drainageways that sheds water to the drainageways.
- o Depression: Bowl-shaped or similarly depressed area.
- o Draw: Depressed, V-shaped drainage that carries water toward a stream.

Cover Type

An ocular estimate of the percent coverage of major vegetation community types and other land-cover types on the 75-m-radius plot. Use modified Daubenmire cover classes to indicate abundance (Table 6.01.1).

- Vegetation type: Six dominant vegetation communities are listed on the sheet, and space to add others is provided. You can record multiple cover classes, all of which should add up to close to 100%.
  - o Sonoran Desert upland: Palo verde and mixed cacti associations.
  - o Xeroriparian wash: Dominated by tall mesquite and netleaf hackberry along ephemeral washes. Usually little standing water. Usually bounded by Sonoran Desert upland and semi-desert grasslands.
  - o Mesic riparian wash or river: Mesic vegetation such as cottonwood, willow, Arizona sycamore, and velvet ash. Often with areas with some standing water.

Table 6.01.1. Cover is estimated using modified Daubenmire cover classes.

Cover class	Explanation
0	None present
1	0–1 % coverage of measured variable
2	2–5 % coverage of measured variable
3	6–25 % coverage of measured variable
4	26–50 % coverage of measured variable
5	51–75 % coverage of measured variable
6	76–95 % coverage of measured variable
7	96–100 % coverage of measured variable

  - o Semi-desert grassland: Perennial warm-season grasses with few shrubs, typically with oak trees in the washes at higher elevations.
  - o Oak forest and woodland: Tall oaks and pinyon pine, with some ponderosa pine in draws.
  - o Conifer Forest: Mixed conifer forest of pine, Douglas-fir, and Gambel's oak.
- Other cover types: An ocular estimate of the percent of ground covered by:
  - o Roads: paved and unpaved;
  - o Pasture: abandoned agricultural fields;
  - o Standing water: only if it is permanent (e.g., stock tank); and
  - o Stream or river: Permanent.
- Plot notes: This is the place to record your comments on the 75-m-radius plot. Indicate any recent disturbance or any feature outside the plot that you think may influence the bird community. Examples of disturbance include fire, trash, or structures. Features that you think may influence the bird community may include a riparian area, active farming or ranching, or housing development.

Subplot Information

This information will be collected at each of the four subplots and is recorded on the data form, "Bird Survey Point Environmental Features: Subplots". The size of the subplot will vary de-

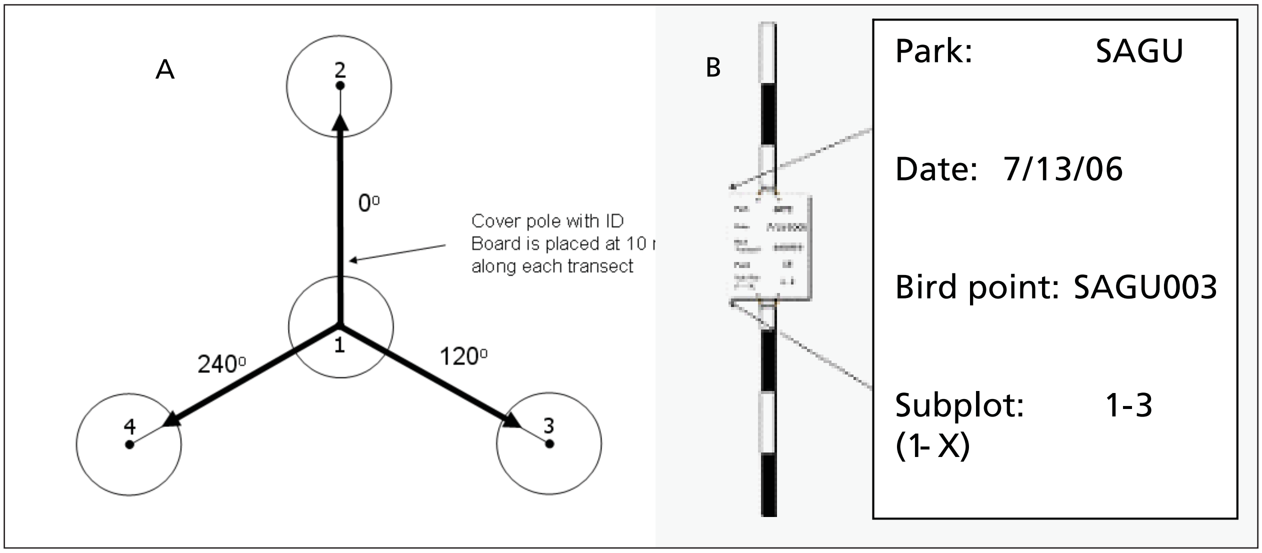


Figure 6.01.3. Location of photo points in relation to subplots (A).

Observer stands at the center of each subplot and the cover pole with ID board (B) is placed 10 m from the center of the subplot at the same azimuth as the subplot from the center of the bird point. Photo point ID board is made of erasable "white board" and is drilled with holes for bungee attachment.

pending on the type of information obtained. Once at the subplot, record the permanent identification number (1, 2, 3, or 4). Subplot 1 is positioned at the bird survey point. The remaining three subplots are located 36.6 m from the bird survey point and 120° apart, starting from 0° azimuth (see Figure 6.01.1). To navigate to each subplot, start at the center of subplot 1. Set the compass to the correct angle and walk 36.6 m. To determine the exact distance, use a 50-m tape or laser rangefinder. If using the rangefinder, obtain a distance between observers or use the photo ID board (Figure 6.01.3), which offers a good target for accurate readings.

Photographs

Photographs provide an important documentation of vegetation change at points as well as a tool for relocating subplots. Observers will take four photographs per bird survey point (one at each subplot) (Figure 6.01.3.) according the following procedures:

1) Place the "cover pole" (see Table 6.01.2; used as a reference point for scale as well as to direct the framing of the photo) 10 m from the plot center along the transect being photographed (Figure 6.01.3). The direction of the photo is the same as the line walked to get to the subplot. For subplot 1, the direction is 0°.
2) Place the completed "Photo Point ID Board" at the lowest unobstructed point on the cover pole using a small bungee cord on the top and bottom of the board.
3) Stand at the center of the subplot and center the camera's viewfinder on the 1-m marker of the cover pole. This will ensure that all photos are of similar reference (Figure 6.01.4). Take photograph.
4) Circle "Y" on data form to indicate that you have taken the photograph for that subplot.
5) At the end of each field day, download the photographs onto a laptop computer.

Canopy cover

Canopy cover is a good measure of the amount of foliage in an overstory. Canopy cover is measured using a spherical densiometer (Forestry Suppliers Spherical Crown Densiometer, concave model, Forestry Suppliers, Inc., Jackson MS) consisting of a concave mirror with 24 one-quarter-inch squares engraved on the surface (Figure 6.01.5). Take four densiometer readings 1 m from each subplot center, one in each of the cardinal directions. Hold the instrument level over the center stake, and 12–18" in front of body, at breast height, so that your head is just outside the grid area. Assume four equally-spaced dots in each square of the grid and systematically count dots equivalent to quarter-square canopy cover. Remember that there are a total of 96 quarter-squares represented on the mirror. That is, if you count canopy openings rather than canopy closure, subtract from 96 to obtain canopy coverage. The number of dots covered by canopy will be converted to percent

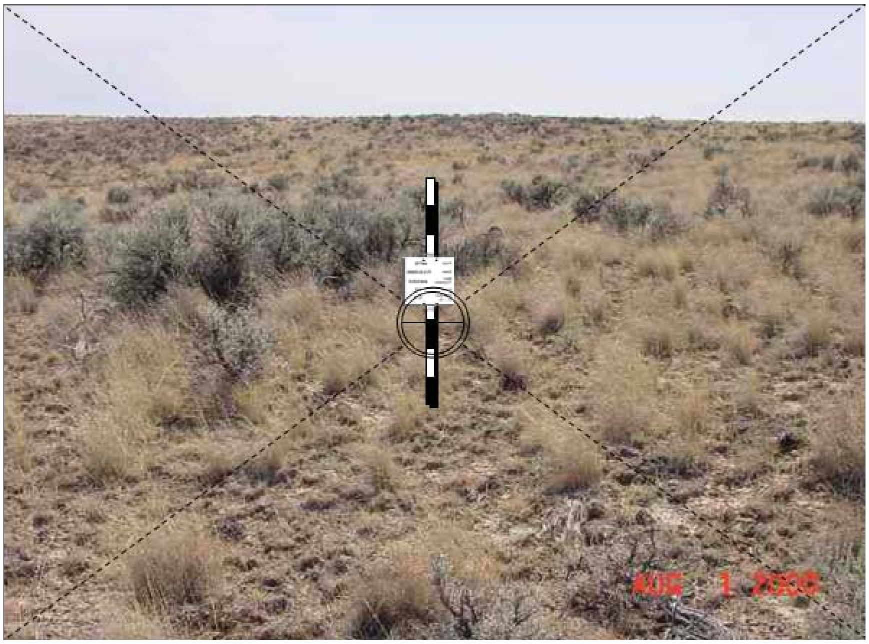
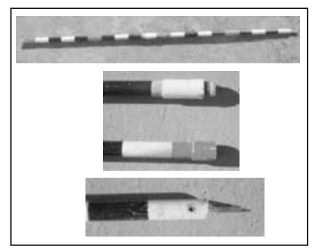


Figure 6.01.4. Centering the camera viewfinder on the 1-m marker of the cover pole.

Table 6.01.2. How to construct a cover pole for measuring horizontal vegetation coverage.

Materials	Construction
2 m (78¾ in) of 1-in (2.5-cm) diameter PVC pipe One male-threaded PVC coupling One female-threaded PVC coupling PVC pipe cleaner, primer, and glue One aluminum ¾-in (1.9-cm) wide tent stake One 1-in (2.5-cm) diameter PVC tube cap Masking tape Enamel paint (white, fluorescent orange, black) Spar-urethane glossy varnish Epoxy Drill with ¼-in (6-mm) drill bit Hacksaw	1. Cut the 1-in (2.5-cm) diameter pipe into two 1-m (39⊠-in) lengths. 2. Attach male coupling to pipe, using the cleaner, primer, and glue. 3. Repeat process with other pipe half and female coupling. 4. Connect two halves at coupling. 5. Measure and trim the connected pipe back to a 2-m (78¾-in) length 6. Drill one hole each at 1 in and at 2 in (2.5 and 5 cm) above the bottom of the pipe. Each hole should be ¼ in (6.4 mm) in diameter. 7. Cover all holes, except for the one at the 2-in (5-cm) level, using the masking tape. 8. Drill two ¼-in holes into the tent spike in the area that will be between the end of pipe and the 2-in hole. 9. Insert tent spike into the bottom of the pipe so that at least 3 in of the spike protrudes below the end of the pipe (in areas with very loose topsoil, increase protruding spike length). 10. Using masking tape, seal the bottom of the pipe to hold the spike in place and inject epoxy into one of the open holes until epoxy reaches the 2-in level. 11. Let epoxy dry, with spike straight in the pipe. 12. Using masking tape and paint, paint alternating 10-cm segments white and black, with every fifth section painted fluorescent orange. 13. Once dry, coat with spar-urethane to avoid scratches and UV degradation of paint colors.



what are these?

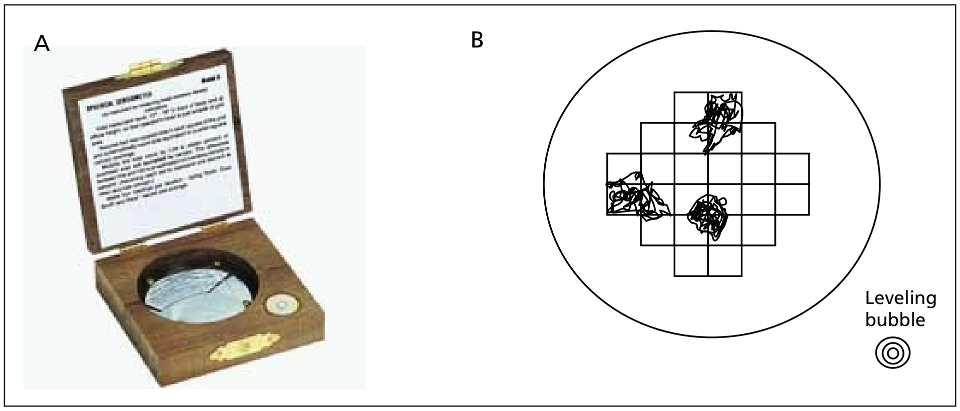


Figure 6.01.5. Spherical densiometer (A) showing a dot count of 20 (B).

Images courtesy of Forestry Suppliers, Inc.

canopy coverage during the data summary process.

Horizontal vegetation cover

The cover-pole (construction described in Table 6.01.2) method provides information on visual obstruction from foliage and is a good measure of vertical vegetation structure in the understory. The method described here is similar to methods that have been used historically for research and monitoring, such as a Robel pole, cover board, vegetation-profile board, or density board (methods from Herrick et al. 2005). An estimate of cover volume will be taken at each subplot from two observation angles using the following procedure:

1. Position the cover pole vertically at the center of the subplot (Figure 6.01.6).
2. Stand 5 m from the cover pole along the line from the transect center.
3. Using a "sighting pole" or other device to maintain a constant observation height, note whether or not each band is covered by vegetation.
4. Record the number of bands that are covered by vegetation (maximum 20). A band is considered covered by vegetation if at least 25% of the band is visually obstructed by vegetation.
5. Repeats steps 2–4, standing 5 m from the cover pole in the opposite direction along the transect.
6. Repeat steps 1–5 for each subplot.

Dominant species in the overstory

Record up to five species with individuals that are $\geq$3 m tall within 10 m of the subplot center. If there are more than five species within 10 m, record only the five most common. Species are recorded using codes from the USDA plants database (http://plants.usda.gov). If a species can not be identified in the field, observers should collect representative vegetation, take a photograph, and consult with an expert as soon as possible. The correct identification should be entered in the appropriate field as soon as possible to prevent loss of information. In addition to recording the species, you will record:

- Cover estimate: The visual estimate of the relative percent of the total overstory occupied by that species in each subplot. Estimates are projections of the amount of canopy taken by the species as if viewed from above (not to be confused with foliage volume, which takes into account the heights of the trees and the vertical size of the canopy) regardless of the density of the canopy. If more than five species are in the plot, also indicate the percent cover of all the other species combined. Cover estimates should always add to 100%, regardless of the number of species or trees.
- # trees: Number of stems of that species that originate from within 10 m of the plot center or that have >50% of their canopy within the plot center. A species with multiple stems arising from the same base (e.g., mesquite and palo verde) is recorded as only a single individual.

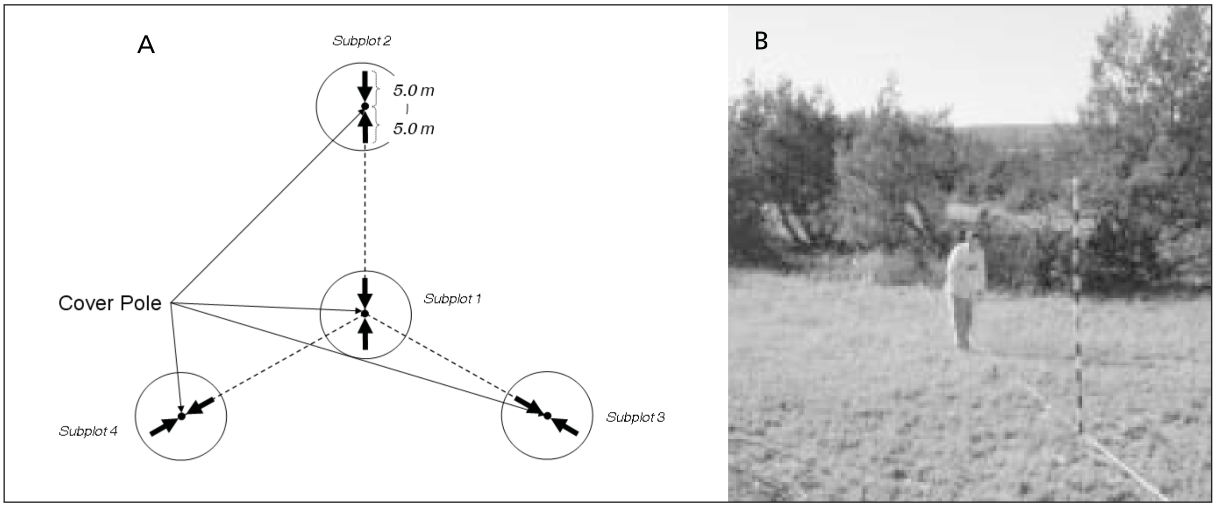


Figure 6.01.6. A cover pole is placed at each subplot center.

The number of bands covered by vegetation is recorded from a distance of 5 m at opposite directions along the transect azimuth.

Dominant species in the understory

Record up to five species of woody plants with individuals that are <3 m tall within 5 m of the subplot center. If there are more than five species within 5 m, record only the five most common. Species are recorded using codes from the USDA plants database (http://plants.usda.gov). If a species can not be identified in the field, observers should collect representative vegetation, take a photograph, and consult with an expert as soon as possible. The correct identification should be entered in the field as soon as possible to prevent loss of information. In addition to recording the species, you will record:

- Cover estimate: The visual estimate of the relative percent of the total understory occupied by that species in each subplot. Estimates are projections of the amount of canopy taken by the species as if viewed from above, regardless of the density of the shrub. For example, an acacia plant within a 1-m radius receives the same cover estimate as a prickly pear cactus of the same radius. If more than five species are in the plot, also indicate the percent cover of all the other species combined. Cover estimates should always add to 100%, regardless of the number of species or stems.
- Subplot notes: This space is provided to record your comments on a 10-m radius plot.

Ground cover

An ocular estimate of ground cover is made within 1.8 m of each subplot center. Cover of the ground surface is estimated within modified Daubenmire cover classes (Table 6.01.1). If a cover category is not present in the plot, enter a 0 for that parameter; do not leave empty records. Percent ground cover is estimated for the following parameters:

- Leaf litter: Leaf litter, excluding grasses.
- Grass litter: Grass and grass-like plant litter.
- Bare soil: Soil surface not covered by litter, plant, or rock.
- Bare rock: Visible rocks.
- Woody debris: Ground covered by woody debris including twigs and stems.
- Unvegetated: 100 minus total basal cover of the vegetation (percent).

Foliar cover

An ocular estimate of foliar cover is made within 1.8 m of each subplot center. The estimate is a vertical projection of foliar cover onto the ground surface. Cover is estimated using modified Daubenmire cover classes (Table 6.01.1). If a cover category is not present in the plot, enter a 0 for that parameter; do not leave empty records. Percent foliar cover is estimated for the following parameters:

- Perennial grasses: All grasses but annual grasses.
- Annual grasses: All grasses but perennial grasses.

- Forbs: Herbaceous vascular plants.
- Cactus: All cactus.
- Succulents: Succulents, agave, and yucca.
- Moss and fern: Mosses and ferns.
- Woody shrubs and vines: Woody shrubs and vines rooted in the plot.
- Total foliar cover: Vertical projection of total foliar cover of living vegetation (less than 1.5 m in height) onto the ground surface.

Literature Cited

Bennetts, R. E., A. Schrag, and S. Wolff. 2005. Cooperative bird monitoring plan and protocol for the Greater Yellowstone Network of parks. Version 1.00. Unpublished protocol.

Herrick, J. E., J. W. Van Zee, K. M. Havstad, L. M. Burkett, and W. G. Whitford. 2005. Monitoring manual for grassland, shrubland, and savanna ecosystem. Tucson: University of Arizona Press.

U.S. Forest Service (USFS). 2003. National core field guide volume I: Field data collection procedure for phase 2 plots, version 1.71. http://srs.fs.usda.gov/fia/manual/p2manual.htm.

SOP #7: Data Management

Version 1.02 (May 5, 2007)

Revision History Log

Previous Version #	Revision date	Author	Changes made	Section and paragraph	Reason for change	New Version #

This Standard Operating Procedure (SOP) documents the Microsoft Access database *SODN_BirdComm* and provides instructions for data entry, data verification and validation, and database administration for the data collected under the bird monitoring protocol for the Sonoran Desert Network (SODN). This SOP also documents the database tables (including lookup tables) and standardized queries (in development) used for basic data summaries. This SOP has been developed in accordance with strategies and guidance for data processing and quality assurance/quality control (QA/QC) for the SODN (Angell 2005).

Bird Monitoring Database

Metadata

Metadata for the bird monitoring database was developed using NPS Dataset Catalog Version 3 and the NPS Metadata Tools & Editor within ArcCatalog (ESRI, Inc.). For further guidance on these applications, refer to the SODN Dataset Catalog Data Entry Guidelines (in development), SODN Metadata Development Guidelines (in development), and the NPS NR-GIS Data Store instructions at http://science.nature.nps.gov/nrdata/docs/metahelp/metahelp.cfm. Appendix 7.01.3 contains a preliminary Federal Geographic Data Committee-compliant metadata file for the bird community monitoring database created with Dataset Catalog. Appendix 7.01.4 contains the HTML version of the metadata that will be made available in the NR-GIS Metadata and Data Store, which can be accessed at http://science.nature.nps.gov/nrdata//.

Data model

Microsoft Access 2002 is the primary software environment for managing data for bird communities and associated environmental features. The database comprises a front-end file and a back-end file that are linked using the Backend Linking Utility in the database. The front-end file, *SODN_BirdComm.mdb*, acts as the user interface into the back-end database and contains the forms, queries, and VBA code for the application. The back-end file, *SODN_BirdComm_be.mdb*, contains the actual data tables. This configuration facilitates improvements and revisions to the database front-end application without altering the actual data structure or any of the data records in the back-end data tables.

Figure 7.01.1 displays the primary relationships among the bird data tables in the database. The primary table for storing bird observation records is *tbl_Bird_Detections_Data*. The table contains one record for each individual bird or flock of birds recorded during an eight-minute count, including data such as species, distance from observer, age, and sex. For each eight-minute count, a single record in *tbl_Locations* stores location information (e.g., X and Y coordinates), and a single record in *tbl_Events* stores date and time information. The Locations and Events tables are standardized tables that are shared with the environmental data tables, as well as other SODN monitoring protocol databases. Figure 7.01.1 also includes *tbl_ Event_Conditions,* which has a 1:1 relationship with *tbl_Events*. For each eight-minute bird count, a single record in *tbl_Event_Conditions* stores in-

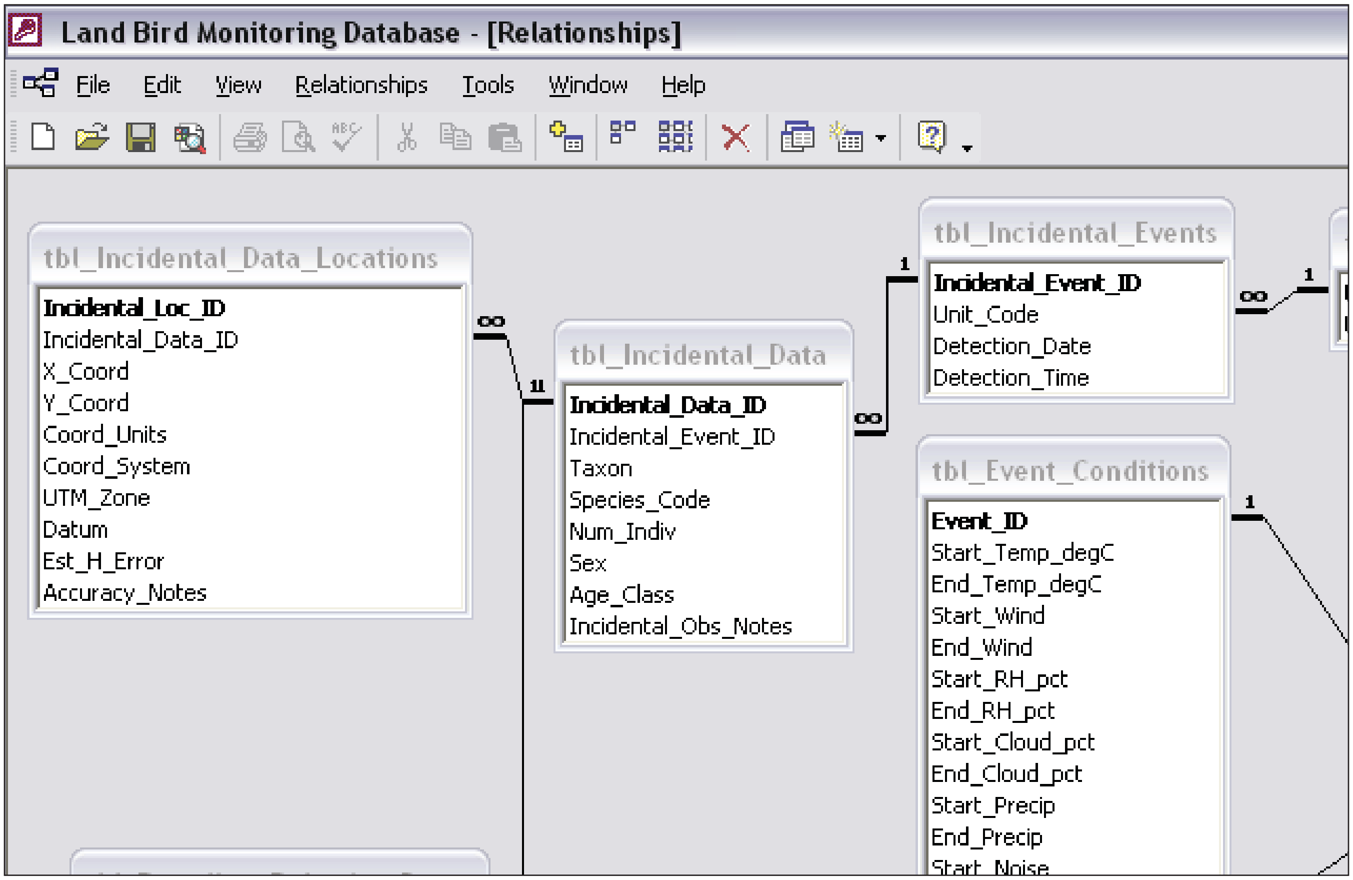


Figure 7.01.1. Data model (entity relationship diagram) for the landbird data tables in the SODN_BirdComm database.

The primary data table is tbl_Bird_Detections_Data, which stores one record for each individual or flock of birds detected. For each eight-minute count, a single record is stored in the standardized tables for locations (tbl_Locations) and events (tbl_Events), which are shared with other SODN monitoring protocol databases. (Note: Not all tables in the database are shown).

formation that is relevant to the bird monitoring protocol, such as survey-specific weather and background-noise information.

Figure 7.01.2 displays the primary relationships among the multiple tables that store environmental-features records. The table *tbl_Subplot_Veg_Data* contains general vegetative-cover information for each of the four subplots associated with each bird-survey point. This table acts as the focal point to which the other data tables containing information such as dominant overstory and understory cover are linked. As mentioned above, the Locations and Events tables are standardized tables that are shared with other monitoring protocols. Figure 7.01.2 also includes *tbl_ Land_Cover_Data*, which has a many-to-one relationship with *tbl_Locations*. Records in this table store general landcover information for each bird-survey point.

Data Entry and Handling

Data entry into the project database will be performed by the bird-survey personnel (observers), and will take place as soon as possible after it is collected—preferably, at least once each week (initiation of data entry until after the end of field season is not acceptable). Keeping current with data-entry and verification tasks helps to ensure that any errors or problems are caught and corrected as close to the time of data collection as possible, while events are still fresh in the observers' minds.

After one day (or another logical period of time) of data collection, observers will enter data into the database and verify them according to the procedures in this SOP. If the data meet overall network and protocol-specific quality requirements (as determined by the database manager

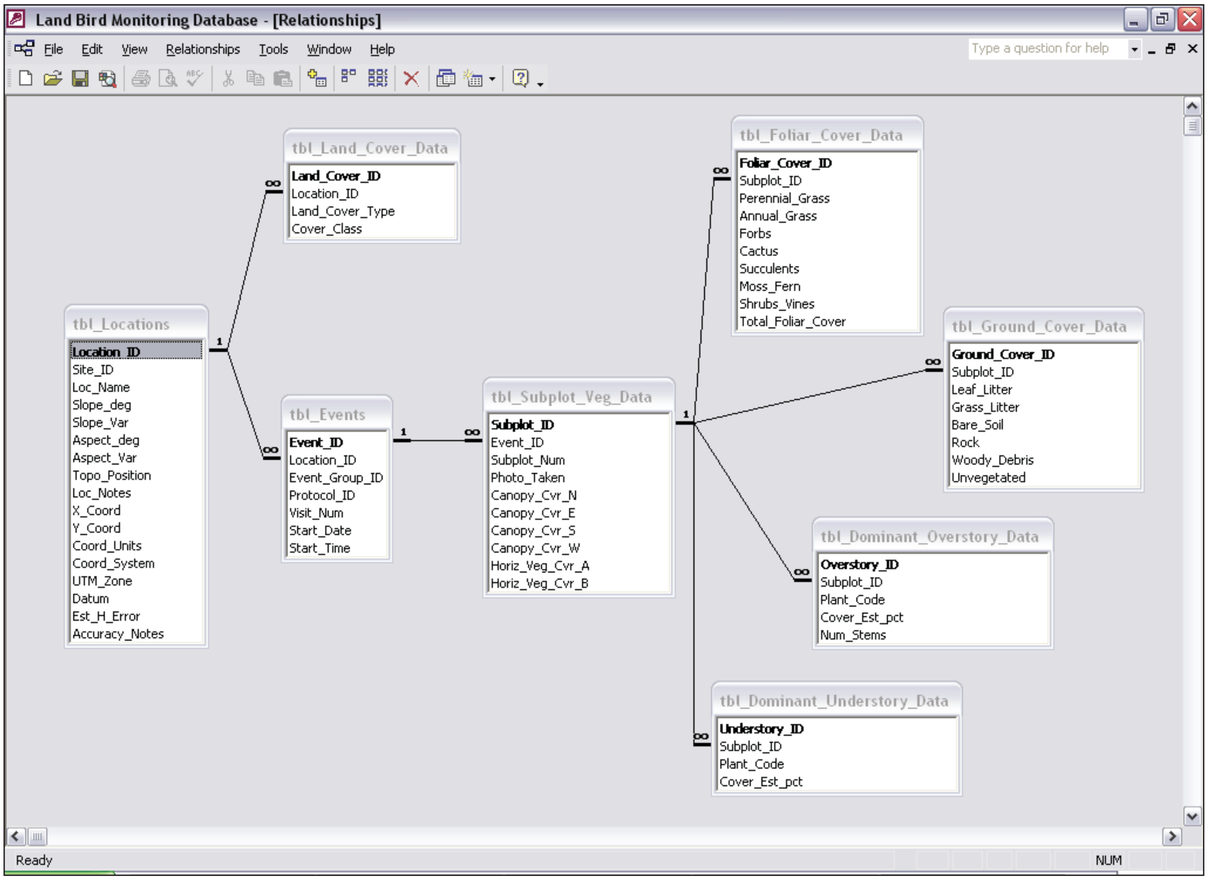


Figure 7.01.2. Data model (entity relationship diagram) for the environmental-features data tables in the SODN_BirdComm database.

The table tbl_Subplot_Veg_Data contains general vegetative-cover information and acts as the focal point to which the other habitat data tables are linked. The Locations and Events tables are standardized tables that are shared with other SODN monitoring protocols. (Note: Not all tables in the database are shown.)

or project manager), data collection will continue. If data quality is not acceptable, the project manager will provide additional training to observers and repeat the data-entry trial and quality test. If data quality does not improve to meet standards after the second trial, the project manager should examine other aspects of the protocol for factors that may be contributing to the difficulty in meeting data-quality requirements.

Data entry is accomplished using a series of forms addressing the different types of data collected during landbird surveys. The typical flow for data entry should proceed as follows:

1) Sites
2) Locations
3) Events
4) Bird data
5) Environmental data
6) Incidental observations

(Note: The front-end for the database has not yet been developed. Screenshots of the data-entry forms will be included in future versions of this SOP.)

Procedures

1) As soon as possible after returning from the field, make a copy of each original field datasheet on acid-free paper. Review each copy for clarity and completeness; ensure that all values are readable and that nothing has been cut off at the edges of the copy. Be sure the copies are dark enough. Because data will be written in pencil, you may need

to manually adjust the darkness of the copies so the values are clear. The copies will be used for data entry, so it is very important that they are clear and legible. After each datasheet is copied, date and initial the "Copied by" space provided on the **copy** using a fine-tipped blue marker.

2) Archive the original field datasheets in archival-quality folders (organized by point sequence within each park) in the file cabinet (located in the I&M office in Tucson) designated for the landbird monitoring protocol.

3) Proofread the copied datasheets, ensuring that they are filled out completely. Although all datasheets should have been reviewed for completeness in the field, some errors may still be present. Some omissions or deficiencies may not be identified until all the datasheets have been reviewed as a group.

    a) Mark any corrections or changes on the copy of the datasheet with a fine-tipped red marker. Draw a line through the incorrect value and write the correct value beside it. **Do not erase or obliterate the original entry; it must remain legible.** The reason for the correction/change should be documented in the margins or comments section of the datasheet copy.

    b) Date and initial the datasheet in the "Proofread by" space provided using a fine-tipped blue marker.

4) Enter the data using the data-entry forms in the *SODN_BirdComm.mdb* front-end database. These forms are structured to closely resemble the field datasheets, and drop-down pick lists facilitate the easy transfer of information from the datasheet to the database.

    a) Enter all information on the datasheet into the corresponding fields on the digital data-entry forms.

    b) If corrections/changes have been made in red marker, enter those values into the database instead of the original recorded values.

    c) Record any questions about data values on a separate notepad, and consult with the project manager or data manager to resolve these issues.

    d) Visually review each record immediately after input to ensure that all fields have been completed and that there are no obvious input errors.

    e) After all the information from a datasheet has been entered and visually reviewed, date and initial the "Entered by" space provided using a fine-tipped blue marker.

5) After all data (or a test group of data) have been entered into the database, proceed with data verification.

Photographs taken at the habitat subplots are downloaded at the end of each field day and stored as data photos in the Photographs folder in the Bird Community Dynamics workspace on the active network server.

Data Verification and Editing

Data verification should immediately follow data entry. Verification consists of checking the accuracy of the digital data against the original source documents (i.e., paper field-data forms). Although the goal of data entry is to achieve 100% accuracy, this is rarely accomplished. However, to minimize transcription errors in the final dataset, our policy is to verify 100% of the records to their original source. After any required corrections have been made, the project manager reviews 10% of the records a second time, and the results of that comparison are reported in the Quality section of the metadata.

Two technicians should perform data verification whenever possible, and the following procedures assume that two technicians are participating in the review.

Procedures

1) After data entry has been completed, print out all the records from the database in a format that matches the source documents as closely as possible to facilitate the comparison of values. Report forms are in development.

2) Technician #1 reads data from the source documents, and Technician #2 verifies

that the data on the printout matches the source. Note that Technician #1 **cannot** be the technician who originally entered the data, but s/he may act as Technician #2. Technician #2 should be on the lookout for duplicate records, missing records, and misspellings, as well as incorrect values.

a) When an error on the printout is found, mark the correction on the printout, **not** on the source document. Using a fine-tipped red marker, draw a line through the incorrect entry and write the correct value beside it. **Do not erase or obliterate the incorrect entry; it must remain legible.**

b) Record any notes that might be useful or questions about any data values/entries on a separate notepad, and consult with the project manager or data manager to resolve these issues.

c) After each source document is verified, Technician #1 uses a fine-tipped blue marker to date and initial the "Verified by" space provided.

d) After all source documents have been verified, Technician #2 uses a fine-tipped blue marker to date and initial the "Verified by" space provided on the first page of the printout.

3) Before making any edits to the data, create a backup copy of the database and store the copy in the appropriate folder in the project workspace. Retaining a backup copy facilitates recovery if irreparable mistakes are made during the editing process.

4) Correct the errors noted in red on the printout using the digital data-entry form(s). Make each correction separately (i.e., avoid doing a *Search and Replace* that might have unintended consequences).

5) After each correction is made, use a fine-tipped green marker to **OK** the red mark on the printout, but do not obliterate the incorrect entry. Continue until all identified errors are corrected in the digital database.

6) Double-check the printout for any errors that were missed (red mark without green OK).

7) Using a fine-tipped green marker, date and initial the "Corrected by" space provided on the first page of the printout to show that all errors have been corrected.

8) Keep the printout with the field datasheets to serve as direct evidence of completion of data entry, verification, and editing. Give the field datasheets and the printout to the project manager, who will review 10% of the data for accuracy and document the results for the metadata record.

If only one technician is available for data verification, then that technician completes all the steps above. However, note that the review **must** be performed by a technician other than the one who originally entered the data.

Data Validation and Certification

Even when data are correctly transcribed from field-data forms, they may not be accurate or logical. Data validation consists of reviewing digital data for range and logic errors. Although certain validation routines are built into the database itself via the data-entry forms and queries, the project manager or another person familiar with the data should further review the dataset for range and logic errors. Histograms, line plots, and basic statistics can reveal these types of errors. In some cases, outlying values may prove to be valid. Note any such correct but extreme values that are confirmed. Include this information in the dataset documentation to save other users from checking the same values.

After validation and final corrections, the project manager uses a blue fine-tipped marker to date and initial the "Validated by" space provided on the first page of the printout. S/he certifies the dataset by completing all sections of the Project Data Certification Form (Appendix 7.01.5) and notifies the data manager that it is ready for archiving and storage.

Procedures

(Note: Specific validation methods have not yet been determined. They will be included in the next version of this SOP.)

ESRI ArcGIS 9.*x* is used to validate spatial data residing in the digital database. UTM coordinate values stored in the database for point locations are compared to the original GPS coordinates.

Spatial-Data Procedures

These procedures were adapted from Peitz et al. (2004):

1) Open an ArcCatalog session and create a new Database Connection.
2) Select *Microsoft Jet 4.0 OLE DB* under the *Provider* tab.
3) Go to the *Connection* tab and browse to the Access database to which you are trying to link.
4) Check *Allow saving password* and select *Test connection*. If the connection succeeds, click *Okay*. All tables and queries within the Access database should now be accessible and viewable from ArcCatalog.
5) To create a coverage from the spatial coordinates stored in Access, start an ArcMap session and load the table *tbl_Locations*.
6) Go to *Tools* → *Add X,Y data*. Select *tbl_Locations* and the fields *X_Coord* and *Y_Coord* in the *Add X,Y, data* form.
7) Edit the Coordinate system by clicking the *Edit* button. Choose *Select coordinate system*, then open the *Projected Coordinate Systems* folder. Open the *UTM* folder, then open the *NAD83* folder and select UTM Zone 12N for all SODN parks except Gila Cliff Dwellings NM (Zone 13N).
8) Click *Apply;* the point locations should load into ArcMap.
9) Compare this layer to base maps (DRGs, DOQQs, etc.) and/or the original GPS data.

Database Administration

Data editing/maintenance

All data edited using this protocol are subject to the following three caveats:

1) Only make changes that improve or update the data while maintaining data integrity.
2) Once archived, document any changes made to the dataset.
3) Be prepared to recover from mistakes made during editing.

The project manager and data manager work together on any edits to archived data. After data have been archived, there will be no altering of the original or copied field data forms. Track changes in *tbl_Data_Edits_Log*. Each change will be documented in this table and be accompanied by an explanation that includes pre- and post-edit data descriptions. The data manager will print a copy of the Data Edit Report and file with the field datasheets. Field datasheets will be reconciled to the database using the edit log and reports.

Data organization

SODN monitoring projects produce large quantities of data, as well as ever-multiplying files and folders to store and manage these products. A well-organized digital-file structure is critical to avoiding confusion and potential data corruption (i.e., data that cannot be located are of no use). Each project (e.g., water quality, climate, landbirds) uses a similar folder structure on the active network server (Figure 7.01.3). The Bird_Community_Dynamics_Index document provides information on the contents of the folders and contains links to other information relevant to the project. Data collected for one year or one season are transferred following certification to a similarly structured workspace on the archive server and designated as "read-only".

Version control

Before making any major revisions to either the front- or back-end databases, the data manager will store a copy to allow tracking of changes over time and to ensure that only the most current version is used in any analyses. The file name for the bird-monitoring database includes a number appended to the file name that indicates the version of the database (e.g., SODN_BirdComm_v1-0.mdb). Versioning of archived datasets is handled by adding an eight-digit number to the file name that represents the date the copy of the dataset is made. The number is formatted as yyyymmdd (yyyy=year, mm=month, dd=day). For example, before revising *SODN_BirdComm_v1-0_be.mdb* on July 22, 2006, store a copy as *SODN_BirdComm_v1-0_be_20060722.mdb*. The current version of

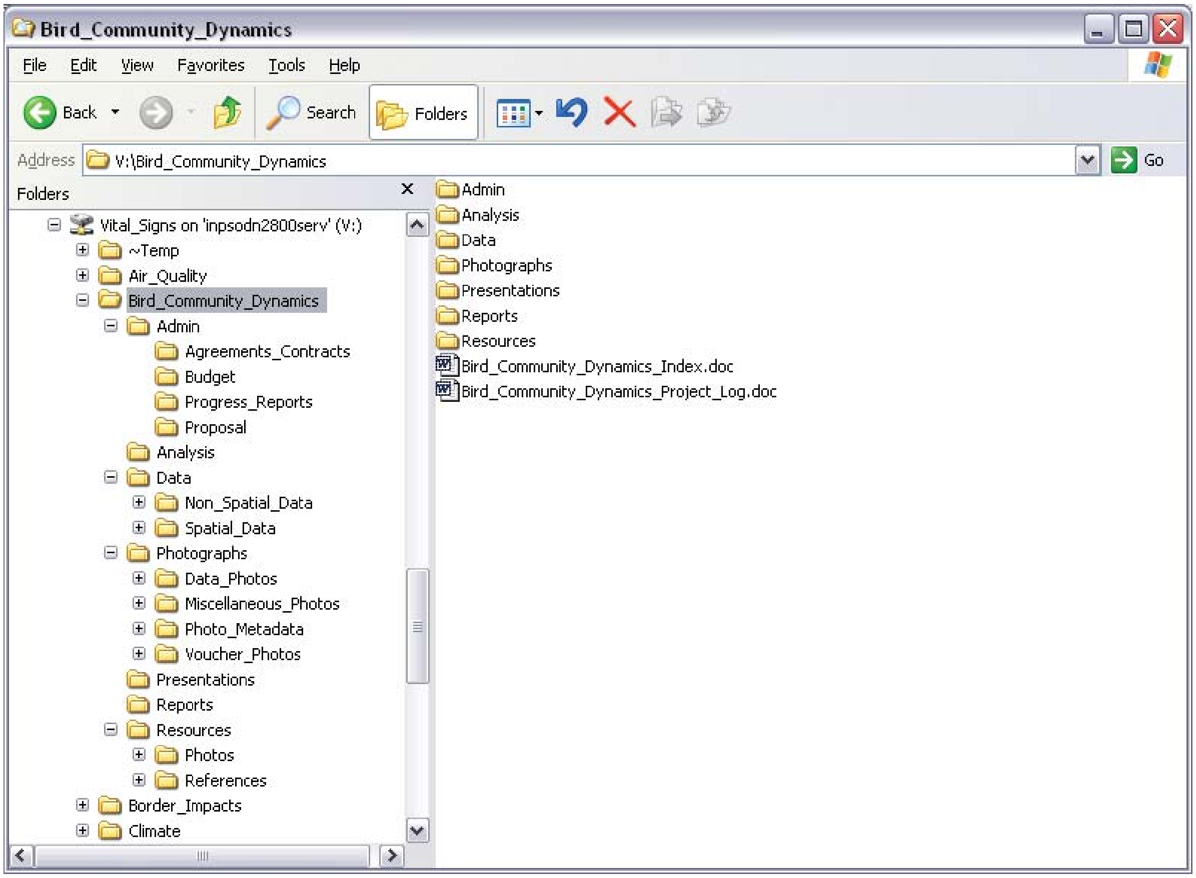


Figure 7.01.3. Recommended file organization structure for the bird-community monitoring project.

the database does **not** have the eight-digit date appended to the name. The data manager will notify frequent users of the data about the updates and provide a copy of the most recent archived version.

Data catalogs and backup

After a dataset has passed all the quality-assurance procedures specified in this SOP and has been certified by the project manager, the I&M Dataset Catalog entry is finalized and completed metadata are uploaded to the NPS NR-GIS Metadata and Data Store.

An electronic version of the dataset, in read-only format, will be maintained on the network archive server and in the NR-GIS Data Store, and a copy of the dataset stored on CD/DVD will be placed in the SODN media cabinet. External hard-drive backups of all databases on the network archive server will be made every two months and stored in a fireproof cabinet. External backups of all databases on the network active (working) server will be made daily (Monday–Friday).

Data Availability

Certified archived datasets for which all QA/QC has been completed and that do not contain sensitive information are available for research and management applications from the NR-GIS Metadata and Data Store. Metadata only are posted for datasets containing sensitive information, and any release of these data requires a signed data sharing/confidentiality agreement. A written request is required for a sensitive dataset; a data request form (in development) may be downloaded from the network website at http://www1.nature.nps.gov/im/units/sodn/data.htm. This request form (or another written format including all the required information) may be submitted via electronic or regular mail to:

Network Data Manager
NPS Sonoran Desert Network
7660 E. Broadway Blvd., Suite 303
Tucson, AZ 85710
Deborah_Angell@nps.gov

Literature Cited

Angell, Deborah L. 2005. Sonoran Desert Network data management plan. National Park Service, Inventory and Monitoring Program, Sonoran Desert Network, Tucson, Arizona. http://www.nature.nps.gov/im/units/sodn/data.htm.

Peitz, D.G., S. G. Fancy, L. P. Thomas, G. A. Rowell, and M. D. DeBacker. 2004. Bird monitoring protocol for Agate Fossil Beds National Monument, Nebraska and Tallgrass Prairie National Preserve, Kansas. Version 1.01. U.S. Department of the Interior, National Park Service, Prairie Cluster Prototype Monitoring Program.

Appendix 7.01.1. Documentation of Database Tables for the SODN Landbird Monitoring Database

The following information on database tables is provided in support of this SOP and serves as documentation of the landbird-monitoring database design.

Location and event tables

Table: tbl_Locations
Description: Sampling unit (point) locations.
Fields: 17

Field name	Data type	Field size	Field description
Location_ID	dbGUID	16	Auto-generated unique location identifier
Site_ID	dbGUID	16	Link to tbl_Sites (FK)
Loc_Name	dbText	100	Name of the location (point)
Slope_deg	dbInteger	2	Slope of ground in degrees across the entire 75-meter-radius plot
Slope_Var	dbText	10	Slope variability across the entire 75-meter-radius plot
Aspect_deg	dbInteger	2	Slope direction (aspect) of the entire 75-meter-radius plot
Aspect_Var	dbText	10	Aspect (direction of slope) variability across the entire 75-meter-radius plot
Topo_Position	dbText	25	Topographic position of the point relative to its local position on the earth's surface
Loc_Notes	dbMemo	0	General notes on the location
X_Coord	dbDouble	8	X coordinate
Y_Coord	dbDouble	8	Y coordinate
Coord_Units	dbText	10	Coordinate distance units
Coord_System	dbText	20	Coordinate system
UTM_Zone	dbText	3	UTM zone
Datum	dbText	5	Datum of mapping ellipsoid
Est_H_Error	dbSingle	4	Estimated horizontal accuracy
Accuracy_Notes	dbText	255	Positional accuracy notes

Table: tbl_Sites
Description: Location aggregations (transects and groups) of sampling point locations.
Fields: 8

Field name	Data type	Field size	Field description
Site_ID	dbGUID	16	Auto-generated unique site identifier
Unit_Code	dbText	4	Park, monument, or network code
Site_Type	dbText	25	Type of site (Transect or Group; points located along a transect are dependent; points within a group are independent)
Site_Name	dbText	100	Unique name or code for a site
Site_Desc	dbText	255	Description of a site
Site_Notes	dbMemo	0	General notes on the site
Project_Code	dbText	50	Project code; for linking information with other datasets and applications or to aggregate multiple databases for integrated analysis
Meta_MID	dbLong	4	Link to NR-GIS Metadata Database (metadata for spatial dataset)

Table: tbl_Event_Conditions
Description: Sampling event conditions.
Fields: 13

Field name	Data type	Field size	Field description
Event_ID	dbGUID	16	Link to tbl_Events (FK)
Start_Temp_degC	dbInteger	2	Temperature in degrees Celsius at the start of the sampling period
End_Temp_degC	dbInteger	2	Temperature in degrees Celsius at the end of the sampling period
Start_Wind	dbText	1	Wind speed at the start of the sampling period
End_Wind	dbText	1	Wind speed at the end of the sampling period
Start_RH_pct	dbInteger	2	Percent relative humidity at the start of the sampling period
End_RH_pct	dbInteger	2	Percent relative humidity at the end of the sampling period
Start_Cloud_pct	dbInteger	2	Percent cloud cover at the start of the sampling period
End_Cloud_pct	dbInteger	2	Percent cloud cover at the end of the sampling period
Start_Precip	dbText	1	Precipitation condition at the start of the sampling period
End_Precip	dbText	1	Precipitation condition at the end of the sampling period
Start_Noise	dbText	1	Noise level at the start of the sampling period
End_Noise	dbText	1	Noise level at the end of the sampling period

Table: tbl_Event_Groups
Description: Event aggregations (e.g., seasons, trips).
Fields: 7

Field name	Data type	Field size	Field description
Event_Group_ID	dbGUID	16	Auto-generated unique event group identifier
Start_Date	dbDate	8	Starting date of the event group
End_Date	dbDate	8	Ending date of the event group
Event_Group_Name	dbText	100	Event group (e.g., season, trip) name
Event_Group_Desc	dbText	255	Event group description
Event_Group_Notes	dbMemo	0	Event group notes
Event_Group_Report	dbText	255	Trip report, link to trip report, or trip report name

Table: tbl_Events
Description: Sampling events; unique combination of when and where (sampling point) data were collected.
Fields: 7

Field name	Data type	Field size	Field description
Event_ID	dbGUID	16	Auto-generated unique sampling event identifier
Location_ID	dbGUID	16	Link to tbl_Locations (FK)
Event_Group_ID	dbGUID	16	Link to tbl_Event_Groups (FK)
Protocol_ID	dbLong	4	Link to tbl_Protocols (FK)
Visit_Num	dbInteger	2	Number of data collection visit to this point in a year/season
Start_Date	dbDate	8	Starting date of the event
Start_Time	dbDate	8	Starting time of the event

Bird data tables

Table: tbl_Bird_Detections_Data
Description: Bird detection information.
Fields: 13

Field name	Data type	Field size	Field description
Detection_ID	dbGUID	16	Auto-generated unique bird detection identifier
Event_ID	dbGUID	16	Link to tbl_Events (FK)
AOU_Bird_Code	dbText	6	AOU (American Ornithological Union) code for the bird species; usually first two letters of first and second words in common name
Minute	dbText	1	Minute, within the eight-minute count, in which the bird(s) was first detected; 'X' indicates an incidental observation outside the eight-minute counts
Flyover	dbBoolean	1	Indicates that the bird was observed flying above the top of the vegetation canopy
Distance_m	dbInteger	2	Distance in meters between observer and the location of the bird where it was first detected; '-9999' indicates a Flyover
OCP_Obs	dbBoolean	1	Indicates that the bird(s) was observed outside of the eight-minute count period
Detection_Type	dbText	3	Type of detection corresponding to the first detection of the individual
Flock_Size	dbInteger	2	Number of individuals in a flock; enter "1" for an individual bird
Sex	dbText	2	Sex of individual(s) detected
Age_Class	dbText	2	Age class of the individual(s) detected
Previous_Point	dbBoolean	1	Indicates whether this bird was detected at a previous point
Detection_Notes	dbText	255	Additional comments made by the observer

Table: tbl_Breeding_Behavior_Data
Description: Breeding behavior(s) observed for a bird at a sampling point.
Fields: 3

Field name	Data type	Field size	Field description
Behavior_ID	dbGUID	16	Auto-generated unique breeding behavior identifier
Detection_ID	dbGUID	16	Link to tbl_Bird_Detections_Data (FK)
Behavior_Type	dbText	2	Breeding behavior(s) observed for a bird detected at a point

Habitat data tables

Table: tbl_Dominant_Overstory_Data
Description: Dominant overstory species within vegetation subplots.
Fields: 5

Field name	Data type	Field size	Field description
Overstory_ID	dbGUID	16	Auto-generated unique dominant overstory species identifier
Subplot_ID	dbGUID	16	Link to tbl_Subplot_Veg_Data (FK)
Plant_Code	dbText	50	Code for plant species greater than or equal to 3 meters tall
Cover_Est_pct	dbInteger	2	Relative percent of the total overstory cover occupied by the plant species in 10-meter subplot
Num_Stems	dbInteger	2	Number of stems of the plant species within 10-meter subplot

Table: tbl_Dominant_Understory_Data
Description: Dominant understory species within vegetation subplots.
Fields: 4

Field name	Data type	Field size	Field description
Understory_ID	dbGUID	16	Auto-generated unique dominant understory species identifier
Subplot_ID	dbGUID	16	Link to tbl_Subplot_Veg_Data (FK)
Plant_Code	dbText	50	Code for plant species less than 3 meters tall
Cover_Est_pct	dbInteger	2	Relative percent of the total understory cover occupied by the plant species in the 10-meter subplot

Table: tbl_Foliar_Cover_Data
Description: Foliar cover within vegetation subplots; based on modified Daubenmire cover classes.
Fields: 10

Field name	Data type	Field size	Field description
Foliar_Cover_ID	dbGUID	16	Auto-generated unique foliar cover identifier
Subplot_ID	dbGUID	16	Link to tbl_Subplot_Veg_Data (FK)
Perennial_Grass	dbText	1	Cover class for perennial grass in 1.8-meter subplot
Annual_Grass	dbText	1	Cover class for annual grass in 1.8-meter subplot
Forbs	dbText	1	Cover class for forbs in 1.8-meter subplot
Cactus	dbText	1	Cover class for cactus in 1.8-meter subplot
Succulents	dbText	1	Cover class for succulents in 1.8-meter subplot
Moss_Fern	dbText	1	Cover class for moss and fern in 1.8-meter subplot
Shrubs_Vines	dbText	1	Cover class for woody shrubs and vines in 1.8-meter subplot
Total_Foliar_Cover	dbText	1	Vertical projection of total foliar cover of living vegetation (less than 1.5 m in height) onto the ground surface in 1.8-meter subplot

Table: tbl_Ground_Cover_Data
Description: Ground cover within vegetation subplots; based on modified Daubenmire cover classes.
Fields: 8

Field name	Data type	Field size	Field description
Ground_Cover_ID	dbGUID	16	Auto-generated unique ground cover identifier
Subplot_ID	dbGUID	16	Link to tbl_Subplot_Veg_Data (FK)
Leaf_Litter	dbText	1	Cover class for leaf litter in 1.8-meter subplot
Grass_Litter	dbText	1	Cover class for grass litter in 1.8-meter subplot
Bare_Soil	dbText	1	Cover class for bare soil in 1.8-meter subplot
Rock	dbText	1	Cover class for rock in 1.8-meter subplot
Woody_Debris	dbText	1	Cover class for woody debris in 1.8-meter subplot
Unvegetated	dbText	1	Cover class for unvegetated ground surface in 1.8-meter subplot

Table: tbl_Land_Cover_Data
Description: Vegetation and other land cover types data for the 75-meter habitat plot.
Fields: 4

Field name	Data type	Field size	Field description
Land_Cover_ID	dbGUID	16	Auto-generated unique land cover type identifier
Location_ID	dbGUID	16	Link to tbl_Locations (FK)
Land_Cover_Type	dbText	30	Major vegetation community and other land use types on the 75-meter plot
Cover_Class	dbText	1	Modified Daubenmire cover class based on ocular estimate of percent coverage of major vegetation community and other land use types

Table: tbl_Subplot_Veg_Data
Description: Vegetation subplot data.
Fields: 10

Field name	Data type	Field size	Field description
Subplot_ID	dbGUID	16	Auto-generated unique vegetation subplot identifier
Event_ID	dbGUID	16	Link to tbl_Events (FK)
Subplot_Num	dbInteger	2	Number assigned to the subplot (1-4)
Photo_Taken	dbBoolean	1	Indicates whether a photo was taken of the subplot
Canopy_Cvr_N	dbInteger	2	Densiometer count for canopy cover facing north
Canopy_Cvr_E	dbInteger	2	Densiometer count for canopy cover facing east
Canopy_Cvr_S	dbInteger	2	Densiometer count for canopy cover facing south
Canopy_Cvr_W	dbInteger	2	Densiometer count for canopy cover facing west
Horiz_Veg_Cvr_A	dbInteger	2	Number of bands on the cover pole that are covered by vegetation (direction A)
Horiz_Veg_Cvr_B	dbInteger	2	Number of bands on the cover pole are covered by vegetation (direction B)

Incidental data tables

Table: tbl_Incidental_Data
Description: Incidental species detections data (not observed during point transect surveys).
Fields: 8

Field name	Data type	Field size	Field description
Incidental_Data_ID	dbGUID	16	Auto-generated unique incidental species detection identifier
Incidental_Event_ID	dbGUID	16	Link to tbl_Incidental_Events (FK)
Taxon	dbText	6	Taxonomic class
Species_Code	dbText	6	Code for species detected incidentally
Num_Indiv	dbInteger	2	Number of individuals of a single species detected
Sex	dbText	2	Sex of individual(s) detected
Age_Class	dbText	1	Age class of the individual(s) detected
Incidental_Obs_Notes	dbText	255	Comments about individual(s) detected

Table: tbl_Incidental_Data_Locations
Description: Incidental species detections locations.
Fields: 10

Field name	Data type	Field size	Field description
Incidental_Loc_ID	dbGUID	16	Auto-generated unique incidental data location identifier
Incidental_Data_ID	dbGUID	16	Link to tbl_Incidental_Data (FK)
X_Coord	dbDouble	8	X coordinate
Y_Coord	dbDouble	8	Y coordinate
Coord_Units	dbText	10	Coordinate distance units
Coord_System	dbText	20	Coordinate system
UTM_Zone	dbText	3	UTM zone
Datum	dbText	5	Datum of mapping ellipsoid
Est_H_Error	dbSingle	4	Estimated horizontal accuracy
Accuracy_Notes	dbText	255	Positional accuracy notes

Table: tbl_Incidental_Events
Description: Incidental species observations.
Fields: 4

Field name	Data type	Field size	Field description
Incidental_Event_ID	dbGUID	16	Auto-generated unique incidental event identifier
Unit_Code	dbText	4	Park, monument, or network code
Detection_Date	dbDate	8	Date of species detection
Detection_Time	dbDate	8	Time of species detection

Reference tables

Table: tbl_Contacts
Description: Contact data for project-related personnel.
Fields: 17

Field name	Data type	Field size	Field description
Contact_ID	dbText	50	Unique contact identifier (auto-generated concatenation of Last_Name_ First_Name)
Last_Name	dbText	25	Last name
First_Name	dbText	25	First name
Middle_Init	dbText	1	Middle initial
Organization	dbText	50	Organization or employer
Position_Title	dbText	50	Title or position description
Address_Type	dbText	8	Address (mailing, physical, both) type
Address	dbText	50	Street address
Address2	dbText	50	Address line 2, suite, apartment number
City	dbText	50	City or town
State_Code	dbText	2	State or province
Zip_Code	dbText	10	Zip code
Country	dbText	10	Country
Email_Address	dbText	50	E-mail address
Work_Phone	dbText	15	Phone number
Work_Extension	dbText	10	Phone extension
Contact_Notes	dbText	100	Contact notes

Table: tbl_ITIS_Bird_List
Description: ITIS Bird Species List.
Fields: 28

Field name	Data type	Field size	Field description
Symbol	dbText	6	Code representing a bird species. Usually first two letters of first and second words in common name. Assigned by American Ornithological Union in 2003.
Common_Name	dbText	50	Accepted common name from ITIS
Scientific_Name	dbText	50	Concatenation of the accepted Genus, Specific_Epithet, and Infrasp_Epithet (if applicable)
Genus	dbText	30	Accepted genus from ITIS
Specific_Epithet	dbText	30	Accepted specific epithet from ITIS
Authority	dbText	50	Authority for the scientific bionomial from ITIS
Infrasp_Rank	dbText	10	Subspecific taxonomic category from ITIS
Infrasp_Epithet	dbText	30	Subspecific epithet from ITIS
Infrasp_Authority	dbText	50	Authority for the subspecific epithet from ITIS
Full_Name	dbText	255	Concatenation of Genus, Specific_Epithet, Infrasp_Epithet (if applicable), and Authority
TSN	dbLong	4	Taxonomic Serial Number from ITIS
Kingdom	dbText	20	Accepted kingdom from ITIS
Order	dbText	25	Accepted order from ITIS
Family	dbText	25	Accepted family from ITIS
Neotropical_Migrant	dbBoolean	1	Species of birds, all or part of whose populations breed north of the Tropic of Cancer and winter south of that line (Rappole 1995: 173-182).
Non_Native	dbBoolean	1	Indicates if a species is not native to the area in which it was found.
ESA	dbText	50	Endangered Species Act conservation listing.
ESA_Date	dbDate	8	Date of ESA listing.
Crit_Hab	dbText	50	Indicates whether there is a Critical Habitat designation by the ESA.
BLM	dbText	50	Bureau of Land Management conservation listing.
USFS	dbText	50	U.S. Forest Service conservation listing.
NESL	dbLong	4	Navajo Endangered Species List listing.
Mex_Fed	dbText	50	Mexican Federal Endangered Species List listing.
WSCA	dbText	50	Wildlife of Special Concern in Arizona listing.
APF	dbText	50	Arizona Partners in Flight listing.
USFWS	dbText	50	U.S. Fish and Wildlife Service; BCC - Bird of Conservation Concern
G_Rank	dbText	50	Global Ranking
S_Rank	dbText	50	State Ranking

Table: tbl_ITIS_Veg_List
Description: ITIS Vegetation Species List.
Fields: 27

Field name	Data type	Field size	Field description
Symbol	dbText	50	USDA Plants database four-letter code
Common_Name	dbText	255	Accepted common name from ITIS
Scientific_Name	dbText	50	Concatenation of the accepted Genus, Specific_Epithet, Infrasp_Rank, and Infrasp_Epithet
Genus	dbText	30	Accepted genus from ITIS
Specific_Epithet	dbText	30	Accepted specific epithet from ITIS
Authority	dbText	50	Authority for the scientific bionomial from ITIS
Infrasp_Rank	dbText	10	Subspecific taxonomic category from ITIS
Infrasp_Epithet	dbText	30	Subspecific epithet from ITIS
Infrasp_Authority	dbText	50	Authority for the subspecific epithet from ITIS
Full_Name	dbText	255	Concatenation of Genus, Specific_Epithet, Authority, Infrasp_Rank, Infrasp_Epithet, and Infrasp_Authority
TSN	dbLong	4	Taxonomic Serial Number from ITIS
Kingdom	dbText	20	Accepted kingdom from ITIS
Family	dbText	40	Accepted family name from ITIS
Nativity	dbText	10	Plant's nativity status in the United States from the USDA PLANTS database
Growth_Habit	dbText	50	Plant growth form as defined by the USDA PLANTS database
Duration	dbText	10	Plant's normal life span by the USDA PLANTS database
ESA	dbText	50	Endangered Species Status
ESA_Date	dbDate	8	Date of listing
Crit_Hab	dbText	50	Critical Habitat
BLM	dbText	50	Bureau of Land Management
USFS	dbText	50	U.S. Forest Service
NESL	dbText	50	Navajo Endangered Species List
Mex_Fed	dbText	50	Mexican Status
WSCA	dbText	50	Wildlife Species of Special Concern: AZ Game and Fish
NPL	dbText	50	Arizona Native Plant Law
G_Rank	dbText	50	Global Ranking
S_Rank	dbText	50	State Ranking

Table: tbl_Parks
Description: Parks and management subunits within the Sonoran Desert Network.
Fields: 2

Field name	Data type	Field size	Field description
Unit_Code	dbText	4	Park, monument, or network code
Unit_Name	dbText	100	Park, monument, or network full name

Table: tbl_Protocols
Description: Monitoring protocols that govern sampling events.
Fields: 4

Field name	Data type	Field size	Field description
Protocol_ID	dbLong	4	Auto-generated unique protocol identifier
Protocol_Name	dbText	100	Name of the protocol governing the event
Protocol_Version	dbText	10	Version of the protocol governing the event
Effective_Date	dbDate	8	Date the protocol version was adopted for network use

Metadata tables

Table: tbl_Data_Edits_Log
Description: History of edits to data values.
Fields: 9

Field name	Data type	Field size	Field description
Data_Edit_ID	dbGUID	16	Auto-generated unique data edit identifier
Db_Meta_ID	dbGUID	16	Link to tbl_DB_Meta (FK)
Edit_Date	dbDate	8	Date of data edit
Edit_Type	dbText	12	Type of edit performed on the data
Edit_Reason	dbMemo	0	Reason for the data edit
Table_Edited	dbText	30	Name of table in which data were edited
Fields_Edited	dbText	255	Names of fields in which data were edited
Records_Edited	dbText	255	Description of the records that were edited
Edit_Details	dbMemo	0	Edit details

Table: tbl_Db_Meta
Description: Database description and links to I&M metadata tools.
Fields: 5

Field name	Data type	Field size	Field description
Db_Meta_ID	dbGUID	16	Auto-generated unique database identifier
Db_Name	dbText	50	Name of the database
Db_Desc	dbMemo	0	Description of the database purpose
Meta_MID	dbLong	4	Link to NR-GIS Metadata Database
DSC_GUID	dbLong	4	Link to I&M Dataset Catalog desktop metadata tool

Table: tbl_Db_Revisions
Description: Database revision history data.
Fields: 5

Field name	Data type	Field size	Field description
Revision_ID	dbText	10	Database revision (version) number
Db_Meta_ID	dbGUID	16	Link to tbl_DB_Meta (FK)
Revision_Date	dbDate	8	Database revision date
Revision_Reason	dbMemo	0	Reason for the database revision
Revision_Desc	dbMemo	0	Revision description

Look-up tables

Table: tlu_Breeding_Behaviors
Description: Breeding behaviors.
Fields: 2

Field name	Data type	Field size	Field description
Behavior_Code	dbText	2	Code indicating a breeding behavior
Behavior_Desc	dbText	35	Breeding behavior description

Table: tlu_Cover_Classes
Description: Modified Daubenmire cover classes.
Fields: 2

Field name	Data type	Field size	Field description
Cover_Code	dbText	1	Code indicating modified Daubenmire cover class
Cover_Class	dbText	12	Cover class percentage range

Table: tlu_Detection_Types
Description: Types of bird detections.
Fields: 2

Field name	Data type	Field size	Field description
Detection_Code	dbText	3	Code indicating type of bird detection
Detection_Desc	dbText	50	Detection type description

Table: tlu_Edit_Types
Description: Types of data edits.
Fields: 2

Field name	Data type	Field size	Field description
Data_Edit_Type	dbText	12	Type of edit made
Edit_Type_Desc	dbText	50	Data edit type description

Table: tlu_Growth_Habits
Description: Plant growth habits.
Fields: 2

Field name	Data type	Field size	Field description
Growth_Habit	dbText	15	Plant growth habit
Habit_Definition	dbText	200	Growth habit definition

Table: tlu_Land_Cover_Types
Description: Land cover types.
Fields: 2

Field name	Data type	Field size	Field description
Land_Cover_Type	dbText	30	Type of land cover
Land_Cover_Desc	dbText	125	Land cover type description

Table: tlu_Noise_Levels
Description: Background noise levels.
Fields: 2

Field name	Data type	Field size	Field description
Noise_Level_Code	dbText	1	Code indicating noise level
Noise_Level_Desc	dbText	75	Noise level description

Table: tlu_Precipitation_Types
Description: Precipitation types.
Fields: 2

Field name	Data type	Field size	Field description
Precip_Code	dbText	1	Code indicating precipitation type
Precip_Desc	dbText	60	Precipitation description

Table: tlu_Topo_Positions
Description: Topographic positions.
Fields: 2

Field name	Data type	Field size	Field description
Topo_Position	dbText	25	Topographic position
Topo_Position_Desc	dbText	255	Topographic position description

Table: tlu_Wind_Speeds
Description: Wind speeds.
Fields: 2

Field name	Data type	Field size	Field description
Wind_Code	dbText	1	Code indicating wind speed
Wind_Speed	dbText	75	Wind speed description based on Beaufort scale

Cross-reference tables

Table: xref_Edits_Contacts
Description: Cross-reference table between data edits and contacts.
Fields: 3

Field name	Data type	Field size	Field description
Data_Edit_ID	dbGUID	16	Link to tbl_Data_Edits_Log
Contact_ID	dbText	50	Link to tbl_Contacts
Edit_Role	dbText	16	The contact's role in the data edit

Table: xref_Events_Contacts
Description: Cross-reference table between events and contacts.
Fields: 4

Field name	Data type	Field size	Field description
Event_ID	dbGUID	16	Link to tbl_Events or tbl_Incidental_Events
Contact_ID	dbText	50	Link to tbl_Contacts
Contact_Role	dbText	30	The contact's role in the sampling event
Experience_Level	dbText	6	The contact's level of experience or confidence related to their role in the sampling event

Table: xref_Revisions_Contacts
Description: Cross-reference table between database revisions and contacts.
Fields: 3

Field name	Data type	Field size	Field description
Revision_ID	dbText	50	Link to tbl_Db_Revisions
Contact_ID	dbText	50	Link to tbl_Contacts
Revision_Role	dbText	18	The contact's role in the revision

Appendix 7.01.2. Documentation of Database Queries for the SODN Landbird Monitoring Database

The following information on standardized database queries that extract basic data summaries is provided in support of this SOP.

Query:
Description:
SQL:

[Front-end database is under development]

Appendix 7.01.3. Text FGDC Metadata for the SODN Landbird Monitoring Database
(text created using NPS Dataset Catalog Version 3).

NPS_Information:
 Metadata_Purpose: NPS
 Metadata_Purpose: DataCat
 NPS_Unit_Information:
  NPS_Unit_AlphaCode: SODN
  NPS_Unit_Type: Network
  NPS_Organization_Code:
 Datacat_Information:
  Dataset_GUID: {guid {D7D4BCE0-56E7-4D77-ABCD-14F9E4FFEE9A}}
  Dataset_Extent:
   Extent_Description: Coverage: IN , LOCATION: Sonoran Desert Network
   UTMBound:
    UTMWest:
    UTMEast:
    UTMNorth:
    UTMSouth:
    UTMZone: 11
    UTMDatum: Other
  Subject:
  Priority: High
  Dataset_Quality_Code:
  Data_Type: DIGDB
  Data_At_Park: No
  File_Location: V:\Bird_Community_Dynamics\Data\Non_Spatial_Data\Processed_Data\SODN_BirdComm.mdb
  Dataset_Catalog_URI:
   DSC_Link:
   LinkType:
   LinkDesc:
 Program_Information:
  Related_Information:
   Related_Name: Dataset Catalog Project ID
   Related_Contact:
    Contact_Information:
     Contact_Person_Primary:
      Contact_Person: Angell, Deborah
      Contact_Organization: National Park Service, Sonoran Desert Inventory & Monitoring Network
     Contact_Position: Network Data Manager
     Contact_Address:
      Address_Type: mailing and physical
      Address: 7660 E. Broadway Blvd., Suite 303
      City: Tucson
      State_or_Province: AZ
      Postal_Code: 85710
      Country: USA
     Contact_Voice_Telephone: (520) 731-3420, Ext. 1#
     Contact_Facsimile_Telephone: (520) 546-7601
     Contact_Electronic_Mail_Address: Deborah_Angell@nps.gov
     Hours_of_Service: 8:00 am - 4:30 pm, Monday - Friday
     Contact_Instructions: Please use e-mail when possible.
   Related_Short_Name:
   Related_Description: The Project ID value from the NPS Dataset Catalog desktop application.
   Related_Key:
    Related_Key_Name: ProjectID
    Related_Key_Value: Project ID = WM-BirdComm
Identification_Information:
 Citation:
  Citation_Information:
   Originator: NPS, Sonoran Desert Network
   Publication_Date:
   Title: Bird Community Dynamics Monitoring Database for Sonoran Desert Network Parks
   Edition: 1.00
   Geospatial_Data_Presentation_Form: Database
   Online_Linkage:
   NatureBib_Key_ID:
 Description:
  Abstract: The database contains bird community monitoring data and associated habitat data for parks in the Sonoran Desert Network. Bird communities are monitored at permanent sampling locations using the point transect method (formerly known as the variable circular plot, or VCP, method). Information on each bird or flock of birds detected includes species, distance from observer, age, sex, and flock size. Associated habitat data are collected in a 75-m radius plot centered on the bird survey point, with additional vegetative measurements made on 4 subplots within the larger plot.
  Purpose: To determine annual changes in species composition, abundance, and productivity of land birds in grassland, riparian, and upland communities in Sonoran Desert Network parks.
  Language_of_Dataset:
  Supplemental_Information: Back-end database for bird community dynamics monitoring.
 Time_Period_of_Content:
  Time_Period_Information:
   Range_of_Dates/Times:
    Beginning_Date: 2007
  Currentness_Reference: New
 Status:
  Progress: In Work

Maintenance_and_Update_Frequency: As Needed
Spatial_Domain:
Description_of_Geographic_Extent:
Bounding_Coordinates:
West_Bounding_Coordinate: -116.997
East_Bounding_Coordinate: -121.646
North_Bounding_Coordinate: 41.3885
South_Bounding_Coordinate: 34.9317
Keywords:
Theme:
Theme_Keyword_Thesaurus: None
Theme_Keyword: Animal Studies
Theme_Keyword: point transect method
Theme_Keyword: monitoring
Theme_Keyword: birds
Place:
Place_Keyword_Thesaurus: National Park System Unit Code Thesaurus
Place_Keyword: TUZI
Place_Keyword: ORPI
Place_Keyword: CAGR
Place_Keyword: CHIR
Place_Keyword: SODN
Place_Keyword: CORO
Place_Keyword: FOBO
Place_Keyword: GICL
Place_Keyword: MOCA
Place_Keyword: SAGU
Place_Keyword: TONT
Place_Keyword: TUMA
Place:
Place_Keyword_Thesaurus: National Park System Unit Name Thesaurus
Place_Keyword: Chiricahua National Monument
Place_Keyword: Organ Pipe Cactus National Monument
Place_Keyword: Coronado National Memorial
Place_Keyword: Fort Bowie National Historic Site
Place_Keyword: Gila Cliff Dwellings National Monument
Place_Keyword: Montezuma Castle National Monument
Place_Keyword: Saguaro National Park
Place_Keyword: Tonto National Monument
Place_Keyword: Tumacacori National Historical Park
Place_Keyword: Tuzigoot National Monument
Place_Keyword: Sonoran Desert Network
Place_Keyword: Casa Grande Ruins National Monument
Access_Constraints: Public access denied
Use_Constraints: Yes, T&E Species
Point_of_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Angell, Deborah
Contact_Organization: National Park Service, Sonoran Desert Inventory & Monitoring Network
Contact_Position: Network Data Manager
Contact_Address:
Address_Type: mailing and physical
Address: 7660 E. Broadway Blvd., Suite 303
City: Tucson
State_or_Province: AZ
Postal_Code: 85710
Country: USA
Contact_Voice_Telephone: (520) 731-3420, Ext. 1#
Contact_Facsimile_Telephone: (520) 546-7601
Contact_Electronic_Mail_Address: Deborah_Angell@nps.gov
Hours_of_Service: 8:00 am - 4:30 pm, Monday - Friday
Contact_Instructions: Please use e-mail when possible.
Security_Information:
Security_Classification_System: Dataset Catalog Security Classification
Security_Classification: Sensitive
Security_Handling_Description: Public access denied
Cross_Reference:
Citation_Information:
Originator: Powell, B.F. et al.
Publication_Date: 2006
Title: Bird Monitoring Protocol for Sonoran Desert Network Parks
Edition: 1.00
Publication_Information:
Publication_Place: Tucson, AZ
Publisher: NPS, Sonoran Desert Network
Online_Linkage:
NatureBib_Key_ID:
NPS_Citation_Type: doc
Native_Dataset_Format:
Data_Quality_Information:
Attribute_Accuracy:
Attribute_Accuracy_Report:
Quantitative_Attribute_Accuracy_Assessment:
Attribute_Accuracy_Value: Not defined
Attribute_Accuracy_Explanation:
Logical_Consistency_Report:
Completeness_Report: No monitoring data have been collected yet.
Lineage:
Spatial_Data_Organization_Information:
Direct_Spatial_Reference_Method:
Entity_and_Attribute_Information:
Detailed_Description:
Entity_Type:
Entity_Type_Label: tbl_Bird_Detections_Data IN SODN_BirdComm_be.mdb , (N/A)

Entity_Type_Definition: Bird detection information., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Detection_ID
Attribute_Definition: Auto-generated unique bird detection identifier; Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Event_ID
Attribute_Definition: Link to tbl_Events (FK); Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: AOU_Bird_Code
Attribute_Definition: AOU (American Ornithological Union) code for the bird species; usually first two letters of first and second words in common name; Field Type= dbText, Field Size= 6.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Minute
Attribute_Definition: Minute, within the 8-minute count, in which the bird(s) was first detected; 'X' indicates an incidental observation outside the 8-minute counts; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Flyover
Attribute_Definition: Indicates that the bird was observed flying above the top of the vegetation canopy; Field Type= dbBoolean, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Distance_m
Attribute_Definition: Distance in meters between observer and the location of the bird where it was first detected; '-9999' indicates a Flyover; Field Type= dbInteger, Field Size= 2.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: OCP_Obs
Attribute_Definition: Indicates that the bird(s) was observed outside of the 8-minute count period; Field Type= dbBoolean, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Detection_Type
Attribute_Definition: Type of detection corresponding to the first detection of the individual; Field Type= dbText, Field Size= 3.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Flock_Size
Attribute_Definition: Number of individuals in a flock; enter "1" for an individual bird detection; Field Type= dbInteger, Field Size= 2.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Sex
Attribute_Definition: Sex of individual(s) detected; Field Type= dbText, Field Size= 2.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Age_Class
Attribute_Definition: Age class of the individual(s) detected; Field Type= dbText, Field Size= 2.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Previous_Point
Attribute_Definition: Indicates whether this bird was detected at a previous point; Field Type= dbBoolean, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Detection_Notes
Attribute_Definition: Additional comments made by the observer; Field Type= dbText, Field Size= 255.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tbl_Breeding_Behavior_Data IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Breeding behavior(s) observed for a bird at a sampling point., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Behavior_ID
Attribute_Definition: Auto-generated unique breeding behavior identifier; Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Detection_ID
Attribute_Definition: Link to tbl_Bird_Detections_Data (FK); Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Behavior_Type
Attribute_Definition: Breeding behavior(s) observed for a bird detected at a point; Field Type= dbText, Field Size= 2.
Attribute_Definition_Source: Not Defined

Detailed_Description:
Entity_Type:
Entity_Type_Label: tbl_Contacts IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Contact data for project-related personnel., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Contact_ID
Attribute_Definition: Unique contact identifier (auto-generated concatenation of Last_Name_First_Name); Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Last_Name
Attribute_Definition: Last name; Field Type= dbText, Field Size= 25.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: First_Name
Attribute_Definition: First name; Field Type= dbText, Field Size= 25.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Middle_Init
Attribute_Definition: Middle initial; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Organization
Attribute_Definition: Organization or employer; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Position_Title
Attribute_Definition: Title or position description; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Address_Type
Attribute_Definition: Address (mailing, physical, both) type; Field Type= dbText, Field Size= 8.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Address
Attribute_Definition: Street address; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Address2
Attribute_Definition: Address line 2, suite, apartment number; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: City
Attribute_Definition: City or town; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: State_Code
Attribute_Definition: State or province; Field Type= dbText, Field Size= 2.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Zip_Code
Attribute_Definition: Zip code; Field Type= dbText, Field Size= 10.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Country
Attribute_Definition: Country; Field Type= dbText, Field Size= 10.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Email_Address
Attribute_Definition: E-mail address; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Work_Phone
Attribute_Definition: Phone number; Field Type= dbText, Field Size= 15.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Work_Extension
Attribute_Definition: Phone extension; Field Type= dbText, Field Size= 10.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Contact_Notes
Attribute_Definition: Contact notes; Field Type= dbText, Field Size= 100.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tbl_Data_Edits_Log IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: History of edits to data values., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Data_Edit_ID
Attribute_Definition: Auto-generated unique data edit identifier; Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:

Attribute_Label: Db_Meta_ID
Attribute_Definition: Link to tbl_DB_Meta (FK); Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Edit_Date
Attribute_Definition: Date of data edit; Field Type= dbDate, Field Size= 8.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Edit_Type
Attribute_Definition: Type of edit performed on the data; Field Type= dbText, Field Size= 12.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Edit_Reason
Attribute_Definition: Reason for the data edit; Field Type= dbMemo, Field Size= 0.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Table_Edited
Attribute_Definition: Name of table in which data were edited; Field Type= dbText, Field Size= 30.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Fields_Edited
Attribute_Definition: Names of fields in which data were edited; Field Type= dbText, Field Size= 255.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Records_Edited
Attribute_Definition: Description of the records that were edited; Field Type= dbText, Field Size= 255.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Edit_Details
Attribute_Definition: Edit details; Field Type= dbMemo, Field Size= 0.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tbl_Db_Meta IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Database description and links to I&M metadata tools., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Db_Meta_ID
Attribute_Definition: Auto-generated unique database identifier; Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Db_Name
Attribute_Definition: Name of the database; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Db_Desc
Attribute_Definition: Description of the database purpose; Field Type= dbMemo, Field Size= 0.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Meta_MID
Attribute_Definition: Link to NR-GIS Metadata Database; Field Type= dbLong, Field Size= 4.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: DSC_GUID
Attribute_Definition: Link to I&M Dataset Catalog desktop metadata tool; Field Type= dbLong, Field Size= 4.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tbl_Db_Revisions IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Database revision history data., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Revision_ID
Attribute_Definition: Database revision (version) number; Field Type= dbText, Field Size= 10.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Db_Meta_ID
Attribute_Definition: Link to tbl_DB_Meta (FK); Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Revision_Date
Attribute_Definition: Database revision date; Field Type= dbDate, Field Size= 8.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Revision_Reason
Attribute_Definition: Reason for the database revision; Field Type= dbMemo, Field Size= 0.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Revision_Desc
Attribute_Definition: Revision description; Field Type= dbMemo, Field Size= 0.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:

Entity_Type_Label: tbl_Dominant_Overstory_Data IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Dominant overstory species within vegetation subplots., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Overstory_ID
Attribute_Definition: Auto-generated unique dominant overstory species identifier; Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Subplot_ID
Attribute_Definition: Link to tbl_Subplot_Veg_Data (FK); Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Plant_Code
Attribute_Definition: Code for plant species greater than or equal to 3 meters tall; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Cover_Est_pct
Attribute_Definition: Relative percent of the total overstory cover occupied by the plant species in 10-meter subplot; Field Type= dbInteger, Field Size= 2.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Num_Stems
Attribute_Definition: Number of stems of the plant species within 10-meter subplot; Field Type= dbInteger, Field Size= 2.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tbl_Dominant_Understory_Data IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Dominant understory species within vegetation subplots., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Understory_ID
Attribute_Definition: Auto-generated unique dominant understory species identifier; Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Subplot_ID
Attribute_Definition: Link to tbl_Subplot_Veg_Data (FK); Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Plant_Code
Attribute_Definition: Code for plant species less than 3 meters tall; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Cover_Est_pct
Attribute_Definition: Relative percent of the total understory cover occupied by the plant species in the 10-meter subplot; Field Type= dbInteger, Field Size= 2.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tbl_Event_Conditions IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Sampling event conditions., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Event_ID
Attribute_Definition: Link to tbl_Events (FK); Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Start_Temp_degC
Attribute_Definition: Temperature in degrees Celsius at the start of the sampling period; Field Type= dbInteger, Field Size= 2.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: End_Temp_degC
Attribute_Definition: Temperature in degrees Celsius at the end of the sampling period; Field Type= dbInteger, Field Size= 2.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Start_Wind
Attribute_Definition: Wind speed at the start of the sampling period; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: End_Wind
Attribute_Definition: Wind speed at the end of the sampling period; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Start_RH_pct
Attribute_Definition: Percent relative humidity at the start of the sampling period; Field Type= dbInte-

ger, Field Size= 2.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: End_RH_pct
Attribute_Definition: Percent relative humidity at the end of the sampling period; Field Type= dbInteger, Field Size= 2.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Start_Cloud_pct
Attribute_Definition: Percent cloud cover at the start of the sampling period; Field Type= dbInteger, Field Size= 2.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: End_Cloud_pct
Attribute_Definition: Percent cloud cover at the end of the sampling period; Field Type= dbInteger, Field Size= 2.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Start_Precip
Attribute_Definition: Precipitation condition at the start of the sampling period; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: End_Precip
Attribute_Definition: Precipitation condition at the end of the sampling period; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Start_Noise
Attribute_Definition: Noise level at the start of the sampling period; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: End_Noise
Attribute_Definition: Noise level at the end of the sampling period; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tbl_Event_Groups IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Event aggregations (e.g., seasons, trips)., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Event_Group_ID
Attribute_Definition: Auto-generated unique event group identifier; Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Start_Date
Attribute_Definition: Starting date of the event group; Field Type= dbDate, Field Size= 8.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: End_Date
Attribute_Definition: Ending date of the event group; Field Type= dbDate, Field Size= 8.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Event_Group_Name
Attribute_Definition: Event group (e.g., season, trip) name; Field Type= dbText, Field Size= 100.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Event_Group_Desc
Attribute_Definition: Event group description; Field Type= dbText, Field Size= 255.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Event_Group_Notes
Attribute_Definition: Event group notes; Field Type= dbMemo, Field Size= 0.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Event_Group_Report
Attribute_Definition: Trip report, link to trip report, or trip report name; Field Type= dbText, Field Size= 255.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tbl_Events IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Sampling events; unique combination of when and where (sampling point) data were collected., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Event_ID
Attribute_Definition: Auto-generated unique sampling event identifier; Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Location_ID
Attribute_Definition: Link to tbl_Locations (FK); Field Type= dbGUID, Field Size= 16.

Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Event_Group_ID
Attribute_Definition: Link to tbl_Event_Groups (FK); Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Protocol_ID
Attribute_Definition: Link to tbl_Protocols (FK); Field Type= dbLong, Field Size= 4.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Visit_Num
Attribute_Definition: Number of data collection visit to this point in a year/season; Field Type= dbInteger, Field Size= 2.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Start_Date
Attribute_Definition: Starting date of the event; Field Type= dbDate, Field Size= 8.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Start_Time
Attribute_Definition: Starting time of the event; Field Type= dbDate, Field Size= 8.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tbl_Foliar_Cover_Data IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Foliar cover within vegetation subplots; based on modified Daubenmire cover classes., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Foliar_Cover_ID
Attribute_Definition: Auto-generated unique foliar cover identifier; Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Subplot_ID
Attribute_Definition: Link to tbl_Subplot_Veg_Data (FK); Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Perennial_Grass
Attribute_Definition: Cover class for perennial grass in 1.8-meter subplot; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Annual_Grass
Attribute_Definition: Cover class for annual grass in 1.8-meter subplot; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Forbs
Attribute_Definition: Cover class for forbs in 1.8-meter subplot; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Cactus
Attribute_Definition: Cover class for cactus in 1.8-meter subplot; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Succulents
Attribute_Definition: Cover class for succulents in 1.8-meter subplot; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Moss_Fern
Attribute_Definition: Cover class for moss and fern in 1.8-meter subplot; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Shrubs_Vines
Attribute_Definition: Cover class for woody shrubs and vines in 1.8-meter subplot; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Total_Foliar_Cover
Attribute_Definition: Vertical projection of total foliar cover of living vegetation (less than 1.5 m in height) onto the ground surface in 1.8-meter subplot; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tbl_Ground_Cover_Data IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Ground cover within vegetation subplots; based on modified Daubenmire cover classes., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Ground_Cover_ID
Attribute_Definition: Auto-generated unique ground cover identifier; Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined

Attribute:
Attribute_Label: Subplot_ID
Attribute_Definition: Link to tbl_Subplot_Veg_Data (FK); Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Leaf_Litter
Attribute_Definition: Cover class for leaf litter in 1.8-meter subplot; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Grass_Litter
Attribute_Definition: Cover class for grass litter in 1.8-meter subplot; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Bare_Soil
Attribute_Definition: Cover class for bare soil in 1.8-meter subplot; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Rock
Attribute_Definition: Cover class for rock in 1.8-meter subplot; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Woody_Debris
Attribute_Definition: Cover class for woody debris in 1.8-meter subplot; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Unvegetated
Attribute_Definition: Cover class for unvegetated ground surface in 1.8-meter subplot; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tbl_Incidental_Data IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Incidental species detections data (not observed during point transect surveys)., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Incidental_Data_ID
Attribute_Definition: Auto-generated unique incidental species detection identifier; Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Incidental_Event_ID
Attribute_Definition: Link to tbl_Incidental_Events (FK); Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Taxon
Attribute_Definition: Taxonomic class; Field Type= dbText, Field Size= 6.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Species_Code
Attribute_Definition: Code for species detected incidentally; Field Type= dbText, Field Size= 6.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Num_Indiv
Attribute_Definition: Number of individuals of a single species detected; Field Type= dbInteger, Field Size= 2.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Sex
Attribute_Definition: Sex of individual(s) detected; Field Type= dbText, Field Size= 2.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Age_Class
Attribute_Definition: Age class of the individual(s) detected; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Incidental_Obs_Notes
Attribute_Definition: Comments about individual(s) detected; Field Type= dbText, Field Size= 255.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tbl_Incidental_Data_Locations IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Incidental species detections locations., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Incidental_Loc_ID
Attribute_Definition: Auto-generated unique incidental data location identifier; Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Incidental_Data_ID
Attribute_Definition: Link to tbl_Incidental_Data (FK); Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:

Attribute_Label: X_Coord
Attribute_Definition: X coordinate; Field Type= dbDouble, Field Size= 8.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Y_Coord
Attribute_Definition: Y coordinate; Field Type= dbDouble, Field Size= 8.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Coord_Units
Attribute_Definition: Coordinate distance units; Field Type= dbText, Field Size= 10.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Coord_System
Attribute_Definition: Coordinate system; Field Type= dbText, Field Size= 20.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: UTM_Zone
Attribute_Definition: UTM Zone; Field Type= dbText, Field Size= 3.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Datum
Attribute_Definition: Datum of mapping ellipsoid; Field Type= dbText, Field Size= 5.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Est_H_Error
Attribute_Definition: Estimated horizontal accuracy; Field Type= dbSingle, Field Size= 4.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Accuracy_Notes
Attribute_Definition: Positional accuracy notes; Field Type= dbText, Field Size= 255.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tbl_Incidental_Events IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Incidental species observations., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Incidental_Event_ID
Attribute_Definition: Auto-generated unique incidental event identifier; Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Unit_Code
Attribute_Definition: Park, monument, or network code; Field Type= dbText, Field Size= 4.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Detection_Date
Attribute_Definition: Date of species detection; Field Type= dbDate, Field Size= 8.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Detection_Time
Attribute_Definition: Time of species detection; Field Type= dbDate, Field Size= 8.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tbl_ITIS_Bird_List IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: ITIS Bird Species List., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Symbol
Attribute_Definition: Code representing a bird species. Usually first two letters of first and second words in common name. Assigned by American Ornithological Union in 2003.; Field Type= dbText, Field Size= 6.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Common_Name
Attribute_Definition: Accepted common name from ITIS; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Scientific_Name
Attribute_Definition: Concatenation of the accepted genus specific epithet (and infrasp epithet if applicable); Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Genus
Attribute_Definition: Accepted genus from ITIS; Field Type= dbText, Field Size= 30.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Specific_Epithet
Attribute_Definition: Accepted specific epithet from ITIS; Field Type= dbText, Field Size= 30.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Authority
Attribute_Definition: Authority for the scientific

bionomial from ITIS; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Infrasp_Rank
Attribute_Definition: Subspecific taxonomic category from ITIS; Field Type= dbText, Field Size= 10.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Infrasp_Epithet
Attribute_Definition: Subspecific epithet from ITIS; Field Type= dbText, Field Size= 30.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Infrasp_Authority
Attribute_Definition: Authority for the subspecific epithet from ITIS; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Full_Name
Attribute_Definition: Concatenation of genus, specific epithet (infrasp epithet) authority; Field Type= dbText, Field Size= 255.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: TSN
Attribute_Definition: Taxonomic Serial Number from ITIS; Field Type= dbLong, Field Size= 4.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Kingdom
Attribute_Definition: Accepted kingdom from ITIS; Field Type= dbText, Field Size= 20.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Order
Attribute_Definition: Accepted oder from ITIS; Field Type= dbText, Field Size= 25.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Family
Attribute_Definition: Accepted family from ITIS; Field Type= dbText, Field Size= 25.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Neotropical_Migrant
Attribute_Definition: Species of birds, all or part of whose populations breed north of the Tropic of Cancer and winter south of that line (Rappole 1995: 173-182).; Field Type= dbBoolean, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Non_Native
Attribute_Definition: Indicates if a species is not native to the area it was found.; Field Type= dbBoolean, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: ESA
Attribute_Definition: Endangered Species Act conservation listing.; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: ESA_Date
Attribute_Definition: Date of ESA listing.; Field Type= dbDate, Field Size= 8.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Crit_Hab
Attribute_Definition: Indicates whether there is a Critical Habitat designation by the ESA.; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: BLM
Attribute_Definition: Bureau of Land Management conservation listing.; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: USFS
Attribute_Definition: U.S. Forest Service conservation listing.; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: NESL
Attribute_Definition: Navajo Endangered Species List listing.; Field Type= dbLong, Field Size= 4.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Mex_Fed
Attribute_Definition: Mexican Federal Endangered Species List listing.; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: WSCA
Attribute_Definition: Wildlife of Special Concern in Arizona listing.; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: APF
Attribute_Definition: Arizona Partners in Fight listing.; Field Type= dbText, Field Size= 50.

Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: USFWS
Attribute_Definition: U.S. Fish and Wildlife Service; BCC - Bird of Conservation Concern; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: G_Rank
Attribute_Definition: Global Ranking; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: S_Rank
Attribute_Definition: State Ranking; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tbl_ITIS_Veg_List IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: ITIS Vegetation Species List., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Symbol
Attribute_Definition: USDA Plants database four letter code; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Common_Name
Attribute_Definition: Accepted common name from ITIS; Field Type= dbText, Field Size= 255.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Scientific_Name
Attribute_Definition: Concatenation of the accepted genus specific epithet (and infrasp rank and epithet if applicable); Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Genus
Attribute_Definition: Accepted genus from ITIS; Field Type= dbText, Field Size= 30.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Specific_Epithet
Attribute_Definition: Accepted specific epithet from ITIS; Field Type= dbText, Field Size= 30.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Authority
Attribute_Definition: Authority for the scientific bionomial from ITIS; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Infrasp_Rank
Attribute_Definition: Subspecific taxonomic category from ITIS; Field Type= dbText, Field Size= 10.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Infrasp_Epithet
Attribute_Definition: Subspecific epithet from ITIS; Field Type= dbText, Field Size= 30.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Infrasp_Authority
Attribute_Definition: Authority for the subspecific epithet from ITIS; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Full_Name
Attribute_Definition: Concatenation of genus, specific epithet, authority, infrasp_rank, infrasp_epithet, infrasp_authority; Field Type= dbText, Field Size= 255.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: TSN
Attribute_Definition: Taxonomic Serial Number from ITIS; Field Type= dbLong, Field Size= 4.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Kingdom
Attribute_Definition: Accepted kingdom from ITIS; Field Type= dbText, Field Size= 20.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Family
Attribute_Definition: Accepeted family name from ITIS; Field Type= dbText, Field Size= 40.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Nativity
Attribute_Definition: Plant's nativity status in the United States by the USDA PLANTS database; Field Type= dbText, Field Size= 10.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Growth_Habit
Attribute_Definition: Plant growth form as defined by the USDA PLANTS database; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined

Attribute:
Attribute_Label: Duration
Attribute_Definition: Plant's normal life span by the USDA PLANTS database; Field Type= dbText, Field Size= 10.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: ESA
Attribute_Definition: Endangered Species Status; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: ESA_Date
Attribute_Definition: Date of Listing; Field Type= dbDate, Field Size= 8.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Crit_Hab
Attribute_Definition: Critical Habitat; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: BLM
Attribute_Definition: Bureau of Land Management; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: USFS
Attribute_Definition: U.S. Forest Service; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: NESL
Attribute_Definition: Navajo Endangered Species List; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Mex_Fed
Attribute_Definition: Mexican Status; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: WSCA
Attribute_Definition: Wildlife Species of Special Concern: AZ Game and Fish; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: NPL
Attribute_Definition: Arizona Native Plant Law; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: G_Rank
Attribute_Definition: Global Ranking; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: S_Rank
Attribute_Definition: State Ranking; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tbl_Land_Cover_Data IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Vegetation and other land cover types data for the 75-meter habitat plot., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Land_Cover_ID
Attribute_Definition: Auto-generated unique land cover type identifier; Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Location_ID
Attribute_Definition: Link to tbl_Locations (FK); Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Land_Cover_Type
Attribute_Definition: Major vegetation community and other land use types on the 75-meter plot; Field Type= dbText, Field Size= 30.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Cover_Class
Attribute_Definition: Modified Daubenmire cover class based on ocular estimate of percent coverage of major vegetation community and other land use types; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tbl_Locations IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Sampling unit (point) locations., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Location_ID
Attribute_Definition: Auto-generated unique location identifier; Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined

Attribute:
 Attribute_Label: Site_ID
 Attribute_Definition: Link to tbl_Sites (FK); Field Type= dbGUID, Field Size= 16.
 Attribute_Definition_Source: Not Defined
Attribute:
 Attribute_Label: Loc_Name
 Attribute_Definition: Name of the location (point); Field Type= dbText, Field Size= 100.
 Attribute_Definition_Source: Not Defined
Attribute:
 Attribute_Label: Slope_deg
 Attribute_Definition: Slope of ground in degrees across the entire 75-meter-radius plot; Field Type= dbInteger, Field Size= 2.
 Attribute_Definition_Source: Not Defined
Attribute:
 Attribute_Label: Slope_Var
 Attribute_Definition: Slope variability across the entire 75-meter-radius plot; Field Type= dbText, Field Size= 10.
 Attribute_Definition_Source: Not Defined
Attribute:
 Attribute_Label: Aspect_deg
 Attribute_Definition: Slope direction (aspect) of the entire 75-meter-radius plot; Field Type= dbInteger, Field Size= 2.
 Attribute_Definition_Source: Not Defined
Attribute:
 Attribute_Label: Aspect_Var
 Attribute_Definition: Aspect (direction of slope) variability across the entire 75-meter-radius plot; Field Type= dbText, Field Size= 10.
 Attribute_Definition_Source: Not Defined
Attribute:
 Attribute_Label: Topo_Position
 Attribute_Definition: Topographic position of the point relative to its local position on the earth's surface; Field Type= dbText, Field Size= 25.
 Attribute_Definition_Source: Not Defined
Attribute:
 Attribute_Label: Loc_Notes
 Attribute_Definition: General notes on the location; Field Type= dbMemo, Field Size= 0.
 Attribute_Definition_Source: Not Defined
Attribute:
 Attribute_Label: X_Coord
 Attribute_Definition: X coordinate; Field Type= dbDouble, Field Size= 8.
 Attribute_Definition_Source: Not Defined
Attribute:
 Attribute_Label: Y_Coord
 Attribute_Definition: Y coordinate; Field Type= dbDouble, Field Size= 8.
 Attribute_Definition_Source: Not Defined
Attribute:
 Attribute_Label: Coord_Units
 Attribute_Definition: Coordinate distance units; Field Type= dbText, Field Size= 10.
 Attribute_Definition_Source: Not Defined
Attribute:
 Attribute_Label: Coord_System
 Attribute_Definition: Coordinate system; Field Type= dbText, Field Size= 20.
 Attribute_Definition_Source: Not Defined
Attribute:
 Attribute_Label: UTM_Zone
 Attribute_Definition: UTM Zone; Field Type= dbText, Field Size= 3.
 Attribute_Definition_Source: Not Defined
Attribute:
 Attribute_Label: Datum
 Attribute_Definition: Datum of mapping ellipsoid; Field Type= dbText, Field Size= 5.
 Attribute_Definition_Source: Not Defined
Attribute:
 Attribute_Label: Est_H_Error
 Attribute_Definition: Estimated horizontal accuracy; Field Type= dbSingle, Field Size= 4.
 Attribute_Definition_Source: Not Defined
Attribute:
 Attribute_Label: Accuracy_Notes
 Attribute_Definition: Positional accuracy notes; Field Type= dbText, Field Size= 255.
 Attribute_Definition_Source: Not Defined
Detailed_Description:
 Entity_Type:
 Entity_Type_Label: tbl_Parks IN SODN_BirdComm_be.mdb , (N/A)
 Entity_Type_Definition: Parks and management subunits within the Sonoran Desert Network., Microsoft Access
 Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
 Attribute:
 Attribute_Label: Unit_Code
 Attribute_Definition: Park, monument, or network code; Field Type= dbText, Field Size= 4.
 Attribute_Definition_Source: Not Defined
 Attribute:
 Attribute_Label: Unit_Name
 Attribute_Definition: Park, monument, or network full name; Field Type= dbText, Field Size= 100.
 Attribute_Definition_Source: Not Defined
Detailed_Description:
 Entity_Type:
 Entity_Type_Label: tbl_Protocols IN SODN_BirdComm_be.mdb , (N/A)

Entity_Type_Definition: Monitoring protocols that govern sampling events., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Protocol_ID
Attribute_Definition: Auto-generated unique protocol identifier; Field Type= dbLong, Field Size= 4.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Protocol_Name
Attribute_Definition: Name of the protocol governing the event; Field Type= dbText, Field Size= 100.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Protocol_Version
Attribute_Definition: Version of the protocol governing the event; Field Type= dbText, Field Size= 10.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Effective_Date
Attribute_Definition: Date the protocol version was adopted for network use; Field Type= dbDate, Field Size= 8.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tbl_Sites IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Location aggregations (transects and groups) of sampling point locations., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Site_ID
Attribute_Definition: Auto-generated unique site identifier; Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Unit_Code
Attribute_Definition: Park, monument, or network code; Field Type= dbText, Field Size= 4.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Site_Type
Attribute_Definition: Type of site (Transect or Group; points located along a transect are dependent; points within a group are independent); Field Type= dbText, Field Size= 25.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Site_Name
Attribute_Definition: Unique name or code for a site; Field Type= dbText, Field Size= 100.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Site_Desc
Attribute_Definition: Description of a site; Field Type= dbText, Field Size= 255.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Site_Notes
Attribute_Definition: General notes on the site; Field Type= dbMemo, Field Size= 0.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Project_Code
Attribute_Definition: Project code; for linking information with other data sets and applications or to aggregate multiple databases for integrated analysis; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Meta_MID
Attribute_Definition: Link to NR-GIS Metadata Database (metadata for spatial data set); Field Type= dbLong, Field Size= 4.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tbl_Subplot_Veg_Data IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Vegetation subplot data., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Subplot_ID
Attribute_Definition: Auto-generated unique vegetation subplot identifier; Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Event_ID
Attribute_Definition: Link to tbl_Events (FK); Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Subplot_Num
Attribute_Definition: Number assigned to the subplot (1-4); Field Type= dbInteger, Field Size= 2.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Photo_Taken
Attribute_Definition: Indicates whether a photo was taken of the subplot; Field Type= dbBoolean, Field Size= 1.

Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Canopy_Cvr_N
Attribute_Definition: Densiometer count for canopy cover facing north; Field Type= dbInteger, Field Size= 2.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Canopy_Cvr_E
Attribute_Definition: Densiometer count for canopy cover facing east; Field Type= dbInteger, Field Size= 2.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Canopy_Cvr_S
Attribute_Definition: Densiometer count for canopy cover facing south; Field Type= dbInteger, Field Size= 2.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Canopy_Cvr_W
Attribute_Definition: Densiometer count for canopy cover facing west; Field Type= dbInteger, Field Size= 2.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Horiz_Veg_Cvr_A
Attribute_Definition: Number of bands on the cover pole that are covered by vegetation (direction A); Field Type= dbInteger, Field Size= 2.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Horiz_Veg_Cvr_B
Attribute_Definition: Number of bands on the cover pole that are covered by vegetation (direction B); Field Type= dbInteger, Field Size= 2.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tlu_Breeding_Behaviors IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Breeding behaviors., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Behavior_Code
Attribute_Definition: Code indicating a breeding behavior; Field Type= dbText, Field Size= 2.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Behavior_Desc
Attribute_Definition: Breeding behavior description; Field Type= dbText, Field Size= 35.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tlu_Cover_Classes IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Modified Daubenmire cover classes., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Cover_Code
Attribute_Definition: Code indicating modified Daubenmire cover class; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Cover_Class
Attribute_Definition: Cover class percentage range; Field Type= dbText, Field Size= 12.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tlu_Detection_Types IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Types of bird detections., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Detection_Code
Attribute_Definition: Code indicating type of bird detection; Field Type= dbText, Field Size= 3.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Detection_Desc
Attribute_Definition: Detection type description; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tlu_Edit_Types IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Types of data edits., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Data_Edit_Type
Attribute_Definition: Type of edit made; Field Type= dbText, Field Size= 12.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Edit_Type_Desc
Attribute_Definition: Data edit type description; Field

Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tlu_Growth_Habits IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Plant growth habits., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Growth_Habit
Attribute_Definition: Plant growth habit; Field Type= dbText, Field Size= 15.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Habit_Definition
Attribute_Definition: Growth habit definition; Field Type= dbText, Field Size= 200.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tlu_Land_Cover_Types IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Land cover types., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Land_Cover_Type
Attribute_Definition: Type of land cover; Field Type= dbText, Field Size= 30.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Land_Cover_Desc
Attribute_Definition: Land cover type description; Field Type= dbText, Field Size= 125.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tlu_Noise_Levels IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Background noise levels., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Noise_Level_Code
Attribute_Definition: Code indicating noise level; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Noise_Level_Desc
Attribute_Definition: Noise level description; Field Type= dbText, Field Size= 75.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tlu_Precipitation_Types IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Precipitation types., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Precip_Code
Attribute_Definition: Code indicating precipitation type; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Precip_Desc
Attribute_Definition: Precipitation description; Field Type= dbText, Field Size= 60.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tlu_Topo_Positions IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Topographic positions., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Topo_Position
Attribute_Definition: Topographic position; Field Type= dbText, Field Size= 25.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Topo_Position_Desc
Attribute_Definition: Topographic position description; Field Type= dbText, Field Size= 255.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tlu_Wind_Speeds IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Wind speeds., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Wind_Code
Attribute_Definition: Code indicating wind speed; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Wind_Speed
Attribute_Definition: Wind speed description based

on Beaufort scale; Field Type= dbText, Field Size= 75.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: xref_Edits_Contacts IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Cross-reference table between data edits and contacts., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Data_Edit_ID
Attribute_Definition: Link to tbl_Data_Edits_Log (FK); Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Contact_ID
Attribute_Definition: Link to tbl_Contacts (FK); Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Edit_Role
Attribute_Definition: The contact's role in the data edit; Field Type= dbText, Field Size= 16.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: xref_Events_Contacts IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Cross-reference table between events and contacts., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Event_ID
Attribute_Definition: Link to tbl_Events or tbl_Incidental_Events; Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Contact_ID
Attribute_Definition: Link to tbl_Contacts; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Contact_Role
Attribute_Definition: The contact's role in the sampling event; Field Type= dbText, Field Size= 30.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Experience_Level
Attribute_Definition: The contact's level of experience or confidence related to their role in the sampling event; Field Type= dbText, Field Size= 6.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: xref_Revisions_Contacts IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Cross-reference table between database revisions and contacts., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Revision_ID
Attribute_Definition: Link to tbl_Db_Revisions; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Contact_ID
Attribute_Definition: Link to tbl_Contacts; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Revision_Role
Attribute_Definition: The contact's role in the revision; Field Type= dbText, Field Size= 18.
Attribute_Definition_Source: Not Defined
Distribution_Information:
Distributor:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Angell, Deborah
Contact_Organization: National Park Service, Sonoran Desert Inventory & Monitoring Network
Contact_Position: Network Data Manager
Contact_Address:
Address_Type: mailing and physical
Address: 7660 E. Broadway Blvd., Suite 303
City: Tucson
State_or_Province: AZ
Postal_Code: 85710
Country: USA
Contact_Voice_Telephone: (520) 731-3420, Ext. 1#
Contact_Facsimile_Telephone: (520) 546-7601
Contact_Electronic_Mail_Address: Deborah_Angell@nps.gov
Hours_of_Service: 8:00 am - 4:30 pm, Monday - Friday
Contact_Instructions: Please use e-mail when possible.
Resource_Description: SODN, WM-BirdComm Bird Community Dynamics Monitoring Database for Sonoran Desert Network Parks
Distribution_Liability: The National Park Service shall not be held liable for improper or incorrect use of the data described and/or contained herein.

These data and related graphics (if available) are not legal documents and are not intended to be used as such. The information contained in these data is dynamic and may change over time. The data are not better than the original sources from which they were derived. It is the responsibility of the data user to use the data appropriately and consistent within the limitations of geospatial data in general and these data in particular. Any related graphics (if available) are intended to aid the data user in acquiring relevant data; it is not appropriate to use related graphics as data. The National Park Service gives no warranty, expressed or implied, as to the accuracy, reliability, or completeness of these data. It is strongly recommended that these data are directly acquired from an NPS server and not indirectly through other sources which may have changed the data in some way. Although these data have been processed successfully on a computer system at the National Park Service, no warranty expressed or implied is made regarding the utility of the data on another system or for general or scientific purposes, nor shall the act of distribution constitute any such warranty. This disclaimer applies both to individual use of the data and aggregate use with other data. All World Wide Web addresses were valid when this metadata was created.

Standard_Order_Process:
Digital_Form:
Digital_Transfer_Information:
Format_Name: Microsoft Access 2002 database (mdb file)
Transfer_Size: 1.91
Digital_Transfer_Option:
Online_Option:
Computer_Contact_Information:
Network_Address:
Network_Resource_Name:
Fees: Free
Ordering_Instructions: I&M (Contact Name)
Technical_Prerequisites: Does data need to be converted? None
Metadata_Reference_Information:
Metadata_Date: 20060626
Metadata_Review_Date: 20060626
Metadata_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Angell, Deborah
Contact_Organization: National Park Service, Sonoran Desert Inventory & Monitoring Network
Contact_Position: Network Data Manager
Contact_Address:
Address_Type: mailing and physical
Address: 7660 E. Broadway Blvd., Suite 303
City: Tucson
State_or_Province: AZ
Postal_Code: 85710
Country: USA
Contact_Voice_Telephone: (520) 731-3420, Ext. 1#
Contact_Facsimile_Telephone: (520) 546-7601
Contact_Electronic_Mail_Address: Deborah_Angell@nps.gov
Hours_of_Service: 8:00 am - 4:30 pm, Monday - Friday
Contact_Instructions: Please use e-mail when possible.
Metadata_Standard_Name: FGDC
Metadata_Standard_Version: FGDC-STD-001-1998
Metadata_Extensions:
Online_Linkage: http://nrdata.nps.gov/profiles/NPS_Profile.xml
Profile_Name: NPS NR and GIS Metadata Profile

Appendix 7.01.4. HTML Version of FGDC Metadata File for the SODN Landbird Monitoring Database

Metadata also available as - [Parseable text] - [XML]

Metadata

- NPS_Information
- Identification_Information
- Data_Quality_Information
- Spatial_Data_Organization_Information
- Entity_and_Attribute_Information
- Distribution_Information
- Metadata_Reference_Information

NPS_Information:
Metadata_Purpose: NPS
Metadata_Purpose: DataCat
NPS_Unit_Information:
NPS_Unit_AlphaCode: SODN
NPS_Unit_Type: Network
NPS_Organization_Code:
Datacat_Information:
Dataset_GUID: {guid {D7D4BCE0-56E7-4D77-ABCD-14F9E4FFEE9A}}
Dataset_Extent:
Extent_Description: Coverage: IN , LOCATION: Sonoran Desert Network
UTMBound:
UTMWest:
UTMEast:
UTMNorth:
UTMSouth:
UTMZone: 11
UTMDatum: Other
Subject:
Priority: High
Dataset_Quality_Code:
Data_Type: DIGDB
Data_At_Park: No
File_Location: V:\Bird_Community_Dynamics\Data\Non_Spatial_Data\Processed_Data\SODN_BirdComm.mdb
Dataset_Catalog_URI:
DSC_Link:
LinkType:
LinkDesc:
Program_Information:
Related_Information:
Related_Name: Dataset Catalog Project ID
Related_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Angell, Deborah
Contact_Organization: National Park Service, Sonoran Desert Inventory & Monitoring Network
Contact_Position: Network Data Manager
Contact_Address:
Address_Type: mailing and physical
Address: 7660 E. Broadway Blvd., Suite 303
City: Tucson
State_or_Province: AZ
Postal_Code: 85710
Country: USA
Contact_Voice_Telephone: (520) 731-3420, Ext. 1#
Contact_Facsimile_Telephone: (520) 546-7601
Contact_Electronic_Mail_Address: Deborah_Angell@nps.gov
Hours_of_Service: 8:00 am - 4:30 pm, Monday - Friday
Contact_Instructions: Please use e-mail when possible.
Related_Short_Name:
Related_Description: The Project ID value from the NPS Dataset Catalog desktop application.
Related_Key:
Related_Key_Name: ProjectID
Related_Key_Value: Project ID = WM-BirdComm

Identification_Information:
Citation:
Citation_Information:
Originator: NPS, Sonoran Desert Network
Publication_Date:
Title: Bird Community Dynamics Monitoring Database for Sonoran Desert Network Parks
Edition: 1.00
Geospatial_Data_Presentation_Form: Database
Online_Linkage:
NatureBib_Key_ID:
Description:
Abstract: The database contains bird community monitoring data and associated habitat data for parks in the Sonoran Desert Network. Bird communities are monitored at permanent sampling locations using the point transect method (formerly known as the variable circular plot, or VCP, method). Information on each bird or flock of birds detected includes species, distance from observer, age, sex, and flock size. Associated habitat data are collected in a 75-m radius plot centered on the bird survey point, with additional vegetative measurements made on 4 subplots within the larger plot.
Purpose: To determine annual changes in species composition, abundance, and productivity of land birds in grassland, riparian, and upland communities in

Sonoran Desert Network parks.
Language_of_Dataset:
Supplemental_Information: Back-end database for bird community dynamics monitoring.
Time_Period_of_Content:
Time_Period_Information:
Range_of_Dates/Times:
Beginning_Date: 2007
Currentness_Reference: New
Status:
Progress: In Work
Maintenance_and_Update_Frequency: As Needed
Spatial_Domain:
Description_of_Geographic_Extent:
Bounding_Coordinates:
West_Bounding_Coordinate: -116.997
East_Bounding_Coordinate: -121.646
North_Bounding_Coordinate: 41.3885
South_Bounding_Coordinate: 34.9317
Keywords:
Theme:
Theme_Keyword_Thesaurus: None
Theme_Keyword: Animal Studies
Theme_Keyword: point transect method
Theme_Keyword: monitoring
Theme_Keyword: birds
Place:
Place_Keyword_Thesaurus: National Park System Unit Code Thesaurus
Place_Keyword: TUZI
Place_Keyword: ORPI
Place_Keyword: CAGR
Place_Keyword: CHIR
Place_Keyword: SODN
Place_Keyword: CORO
Place_Keyword: FOBO
Place_Keyword: GICL
Place_Keyword: MOCA
Place_Keyword: SAGU
Place_Keyword: TONT
Place_Keyword: TUMA
Place:
Place_Keyword_Thesaurus: National Park System Unit Name Thesaurus
Place_Keyword: Chiricahua National Monument
Place_Keyword: Organ Pipe Cactus National Monument
Place_Keyword: Coronado National Memorial
Place_Keyword: Fort Bowie National Historic Site
Place_Keyword: Gila Cliff Dwellings National Monument
Place_Keyword: Montezuma Castle National Monument
Place_Keyword: Saguaro National Park
Place_Keyword: Tonto National Monument
Place_Keyword: Tumacacori National Historical Park
Place_Keyword: Tuzigoot National Monument
Place_Keyword: Sonoran Desert Network
Place_Keyword: Casa Grande Ruins National Monument
Access_Constraints: Public access denied
Use_Constraints: Yes, T&E Species
Point_of_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Angell, Deborah
Contact_Organization: National Park Service, Sonoran Desert Inventory & Monitoring Network
Contact_Position: Network Data Manager
Contact_Address:
Address_Type: mailing and physical
Address: 7660 E. Broadway Blvd., Suite 303
City: Tucson
State_or_Province: AZ
Postal_Code: 85710
Country: USA
Contact_Voice_Telephone: (520) 731-3420, Ext. 1#
Contact_Facsimile_Telephone: (520) 546-7601
Contact_Electronic_Mail_Address: Deborah_Angell@nps.gov
Hours_of_Service: 8:00 am - 4:30 pm, Monday - Friday
Contact_Instructions: Please use e-mail when possible.
Security_Information:
Security_Classification_System: Dataset Catalog Security Classification
Security_Classification: Sensitive
Security_Handling_Description: Public access denied
Cross_Reference:
Citation_Information:
Originator: Powell, B.F. et al.
Publication_Date: 2006
Title: Bird Monitoring Protocol for Sonoran Desert Network Parks
Edition: 1.00
Publication_Information:
Publication_Place: Tucson, AZ
Publisher: NPS, Sonoran Desert Network
Online_Linkage:
NatureBib_Key_ID:
NPS_Citation_Type: doc
Native_Dataset_Format:

Data_Quality_Information:
Attribute_Accuracy:
Attribute_Accuracy_Report:
Quantitative_Attribute_Accuracy_Assessment:
Attribute_Accuracy_Value: Not defined
Attribute_Accuracy_Explanation:
Logical_Consistency_Report:
Completeness_Report: No monitoring data have been collected yet.

Lineage:

Spatial_Data_Organization_Information:
Direct_Spatial_Reference_Method:
Entity_and_Attribute_Information:
Detailed_Description:
Entity_Type:
Entity_Type_Label: tbl_Bird_Detections_Data IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Bird detection information., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Detection_ID
Attribute_Definition: Auto-generated unique bird detection identifier; Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Event_ID
Attribute_Definition: Link to tbl_Events (FK); Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: AOU_Bird_Code
Attribute_Definition: AOU (American Ornithological Union) code for the bird species; usually first two letters of first and second words in common name; Field Type= dbText, Field Size= 6.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Minute
Attribute_Definition: Minute, within the 8-minute count, in which the bird(s) was first detected; 'X' indicates an incidental observation outside the 8-minute counts; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Flyover
Attribute_Definition: Indicates that the bird was observed flying above the top of the vegetation canopy; Field Type= dbBoolean, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Distance_m
Attribute_Definition: Distance in meters between observer and the location of the bird where it was first detected; '-9999' indicates a Flyover; Field Type= dbInteger, Field Size= 2.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: OCP_Obs
Attribute_Definition: Indicates that the bird(s) was observed outside of the 8-minute count period; Field Type= dbBoolean, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Detection_Type
Attribute_Definition: Type of detection corresponding to the first detection of the individual; Field Type= dbText, Field Size= 3.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Flock_Size
Attribute_Definition: Number of individuals in a flock; enter "1" for an individual bird detection; Field Type= dbInteger, Field Size= 2.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Sex
Attribute_Definition: Sex of individual(s) detected; Field Type= dbText, Field Size= 2.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Age_Class
Attribute_Definition: Age class of the individual(s) detected; Field Type= dbText, Field Size= 2.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Previous_Point
Attribute_Definition: Indicates whether this bird was detected at a previous point; Field Type= dbBoolean, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Detection_Notes
Attribute_Definition: Additional comments made by the observer; Field Type= dbText, Field Size= 255.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tbl_Breeding_Behavior_Data IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Breeding behavior(s) observed for a bird at a sampling point., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Behavior_ID
Attribute_Definition: Auto-generated unique breeding behavior identifier; Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Detection_ID
Attribute_Definition: Link to tbl_Bird_Detections_Data

(FK); Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Behavior_Type
Attribute_Definition: Breeding behavior(s) observed for a bird detected at a point; Field Type= dbText, Field Size= 2.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tbl_Contacts IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Contact data for project-related personnel., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Contact_ID
Attribute_Definition: Unique contact identifier (auto-generated concatenation of Last_Name_First_Name); Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Last_Name
Attribute_Definition: Last name; Field Type= dbText, Field Size= 25.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: First_Name
Attribute_Definition: First name; Field Type= dbText, Field Size= 25.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Middle_Init
Attribute_Definition: Middle initial; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Organization
Attribute_Definition: Organization or employer; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Position_Title
Attribute_Definition: Title or position description; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Address_Type
Attribute_Definition: Address (mailing, physical, both) type; Field Type= dbText, Field Size= 8.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Address
Attribute_Definition: Street address; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Address2
Attribute_Definition: Address line 2, suite, apartment number; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: City
Attribute_Definition: City or town; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: State_Code
Attribute_Definition: State or province; Field Type= dbText, Field Size= 2.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Zip_Code
Attribute_Definition: Zip code; Field Type= dbText, Field Size= 10.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Country
Attribute_Definition: Country; Field Type= dbText, Field Size= 10.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Email_Address
Attribute_Definition: E-mail address; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Work_Phone
Attribute_Definition: Phone number; Field Type= dbText, Field Size= 15.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Work_Extension
Attribute_Definition: Phone extension; Field Type= dbText, Field Size= 10.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Contact_Notes
Attribute_Definition: Contact notes; Field Type= dbText, Field Size= 100.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tbl_Data_Edits_Log IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: History of edits to data values., Microsoft Access

Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Data_Edit_ID
Attribute_Definition: Auto-generated unique data edit identifier; Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Db_Meta_ID
Attribute_Definition: Link to tbl_DB_Meta (FK); Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Edit_Date
Attribute_Definition: Date of data edit; Field Type= dbDate, Field Size= 8.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Edit_Type
Attribute_Definition: Type of edit performed on the data; Field Type= dbText, Field Size= 12.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Edit_Reason
Attribute_Definition: Reason for the data edit; Field Type= dbMemo, Field Size= 0.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Table_Edited
Attribute_Definition: Name of table in which data were edited; Field Type= dbText, Field Size= 30.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Fields_Edited
Attribute_Definition: Names of fields in which data were edited; Field Type= dbText, Field Size= 255.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Records_Edited
Attribute_Definition: Description of the records that were edited; Field Type= dbText, Field Size= 255.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Edit_Details
Attribute_Definition: Edit details; Field Type= dbMemo, Field Size= 0.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tbl_Db_Meta IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Database description and links to I&M metadata tools., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Db_Meta_ID
Attribute_Definition: Auto-generated unique database identifier; Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Db_Name
Attribute_Definition: Name of the database; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Db_Desc
Attribute_Definition: Description of the database purpose; Field Type= dbMemo, Field Size= 0.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Meta_MID
Attribute_Definition: Link to NR-GIS Metadata Database; Field Type= dbLong, Field Size= 4.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: DSC_GUID
Attribute_Definition: Link to I&M Dataset Catalog desktop metadata tool; Field Type= dbLong, Field Size= 4.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tbl_Db_Revisions IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Database revision history data., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Revision_ID
Attribute_Definition: Database revision (version) number; Field Type= dbText, Field Size= 10.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Db_Meta_ID
Attribute_Definition: Link to tbl_DB_Meta (FK); Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Revision_Date
Attribute_Definition: Database revision date; Field Type= dbDate, Field Size= 8.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Revision_Reason
Attribute_Definition: Reason for the database revision; Field Type= dbMemo, Field Size= 0.

Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Revision_Desc
Attribute_Definition: Revision description; Field Type= dbMemo, Field Size= 0.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tbl_Dominant_Overstory_Data IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Dominant overstory species within vegetation subplots., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Overstory_ID
Attribute_Definition: Auto-generated unique dominant overstory species identifier; Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Subplot_ID
Attribute_Definition: Link to tbl_Subplot_Veg_Data (FK); Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Plant_Code
Attribute_Definition: Code for plant species greater than or equal to 3 meters tall; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Cover_Est_pct
Attribute_Definition: Relative percent of the total overstory cover occupied by the plant species in 10-meter subplot; Field Type= dbInteger, Field Size= 2.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Num_Stems
Attribute_Definition: Number of stems of the plant species within 10-meter subplot; Field Type= dbInteger, Field Size= 2.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tbl_Dominant_Understory_Data IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Dominant understory species within vegetation subplots., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Understory_ID
Attribute_Definition: Auto-generated unique dominant understory species identifier; Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Subplot_ID
Attribute_Definition: Link to tbl_Subplot_Veg_Data (FK); Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Plant_Code
Attribute_Definition: Code for plant species less than 3 meters tall; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Cover_Est_pct
Attribute_Definition: Relative percent of the total understory cover occupied by the plant species in the 10-meter subplot; Field Type= dbInteger, Field Size= 2.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tbl_Event_Conditions IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Sampling event conditions., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Event_ID
Attribute_Definition: Link to tbl_Events (FK); Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Start_Temp_degC
Attribute_Definition: Temperature in degrees Celsius at the start of the sampling period; Field Type= dbInteger, Field Size= 2.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: End_Temp_degC
Attribute_Definition: Temperature in degrees Celsius at the end of the sampling period; Field Type= dbInteger, Field Size= 2.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Start_Wind
Attribute_Definition: Wind speed at the start of the sampling period; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: End_Wind
Attribute_Definition: Wind speed at the end of the sampling period; Field Type= dbText, Field Size= 1.

Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Start_RH_pct
Attribute_Definition: Percent relative humidity at the start of the sampling period; Field Type= dbInteger, Field Size= 2.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: End_RH_pct
Attribute_Definition: Percent relative humidity at the end of the sampling period; Field Type= dbInteger, Field Size= 2.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Start_Cloud_pct
Attribute_Definition: Percent cloud cover at the start of the sampling period; Field Type= dbInteger, Field Size= 2.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: End_Cloud_pct
Attribute_Definition: Percent cloud cover at the end of the sampling period; Field Type= dbInteger, Field Size= 2.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Start_Precip
Attribute_Definition: Precipitation condition at the start of the sampling period; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: End_Precip
Attribute_Definition: Precipitation condition at the end of the sampling period; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Start_Noise
Attribute_Definition: Noise level at the start of the sampling period; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: End_Noise
Attribute_Definition: Noise level at the end of the sampling period; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tbl_Event_Groups IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Event aggregations (e.g., seasons, trips)., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Event_Group_ID
Attribute_Definition: Auto-generated unique event group identifier; Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Start_Date
Attribute_Definition: Starting date of the event group; Field Type= dbDate, Field Size= 8.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: End_Date
Attribute_Definition: Ending date of the event group; Field Type= dbDate, Field Size= 8.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Event_Group_Name
Attribute_Definition: Event group (e.g., season, trip) name; Field Type= dbText, Field Size= 100.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Event_Group_Desc
Attribute_Definition: Event group description; Field Type= dbText, Field Size= 255.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Event_Group_Notes
Attribute_Definition: Event group notes; Field Type= dbMemo, Field Size= 0.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Event_Group_Report
Attribute_Definition: Trip report, link to trip report, or trip report name; Field Type= dbText, Field Size= 255.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tbl_Events IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Sampling events; unique combination of when and where (sampling point) data were collected., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Event_ID
Attribute_Definition: Auto-generated unique sampling event identifier; Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Location_ID

Attribute_Definition: Link to tbl_Locations (FK); Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Event_Group_ID
Attribute_Definition: Link to tbl_Event_Groups (FK); Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Protocol_ID
Attribute_Definition: Link to tbl_Protocols (FK); Field Type= dbLong, Field Size= 4.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Visit_Num
Attribute_Definition: Number of data collection visit to this point in a year/season; Field Type= dbInteger, Field Size= 2.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Start_Date
Attribute_Definition: Starting date of the event; Field Type= dbDate, Field Size= 8.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Start_Time
Attribute_Definition: Starting time of the event; Field Type= dbDate, Field Size= 8.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tbl_Foliar_Cover_Data IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Foliar cover within vegetation subplots; based on modified Daubenmire cover classes., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Foliar_Cover_ID
Attribute_Definition: Auto-generated unique foliar cover identifier; Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Subplot_ID
Attribute_Definition: Link to tbl_Subplot_Veg_Data (FK); Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Perennial_Grass
Attribute_Definition: Cover class for perennial grass in 1.8-meter subplot; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Annual_Grass
Attribute_Definition: Cover class for annual grass in 1.8-meter subplot; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Forbs
Attribute_Definition: Cover class for forbs in 1.8-meter subplot; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Cactus
Attribute_Definition: Cover class for cactus in 1.8-meter subplot; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Succulents
Attribute_Definition: Cover class for succulents in 1.8-meter subplot; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Moss_Fern
Attribute_Definition: Cover class for moss and fern in 1.8-meter subplot; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Shrubs_Vines
Attribute_Definition: Cover class for woody shrubs and vines in 1.8-meter subplot; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Total_Foliar_Cover
Attribute_Definition: Vertical projection of total foliar cover of living vegetation (less than 1.5 m in height) onto the ground surface in 1.8-meter subplot; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tbl_Ground_Cover_Data IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Ground cover within vegetation subplots; based on modified Daubenmire cover classes., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Ground_Cover_ID
Attribute_Definition: Auto-generated unique ground cover identifier; Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Subplot_ID
Attribute_Definition: Link to tbl_Subplot_Veg_Data (FK);

Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Leaf_Litter
Attribute_Definition: Cover class for leaf litter in 1.8-meter subplot; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Grass_Litter
Attribute_Definition: Cover class for grass litter in 1.8-meter subplot; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Bare_Soil
Attribute_Definition: Cover class for bare soil in 1.8-meter subplot; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Rock
Attribute_Definition: Cover class for rock in 1.8-meter subplot; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Woody_Debris
Attribute_Definition: Cover class for woody debris in 1.8-meter subplot; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Unvegetated
Attribute_Definition: Cover class for unvegetated ground surface in 1.8-meter subplot; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tbl_Incidental_Data IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Incidental species detections data (not observed during point transect surveys)., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Incidental_Data_ID
Attribute_Definition: Auto-generated unique incidental species detection identifier; Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Incidental_Event_ID
Attribute_Definition: Link to tbl_Incidental_Events (FK); Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Taxon
Attribute_Definition: Taxonomic class; Field Type= dbText, Field Size= 6.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Species_Code
Attribute_Definition: Code for species detected incidentally; Field Type= dbText, Field Size= 6.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Num_Indiv
Attribute_Definition: Number of individuals of a single species detected; Field Type= dbInteger, Field Size= 2.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Sex
Attribute_Definition: Sex of individual(s) detected; Field Type= dbText, Field Size= 2.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Age_Class
Attribute_Definition: Age class of the individual(s) detected; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Incidental_Obs_Notes
Attribute_Definition: Comments about individual(s) detected; Field Type= dbText, Field Size= 255.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tbl_Incidental_Data_Locations IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Incidental species detections locations., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Incidental_Loc_ID
Attribute_Definition: Auto-generated unique incidental data location identifier; Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Incidental_Data_ID
Attribute_Definition: Link to tbl_Incidental_Data (FK); Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: X_Coord
Attribute_Definition: X coordinate; Field Type= dbDouble, Field Size= 8.
Attribute_Definition_Source: Not Defined

Attribute:
Attribute_Label: Y_Coord
Attribute_Definition: Y coordinate; Field Type= dbDouble, Field Size= 8.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Coord_Units
Attribute_Definition: Coordinate distance units; Field Type= dbText, Field Size= 10.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Coord_System
Attribute_Definition: Coordinate system; Field Type= dbText, Field Size= 20.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: UTM_Zone
Attribute_Definition: UTM Zone; Field Type= dbText, Field Size= 3.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Datum
Attribute_Definition: Datum of mapping ellipsoid; Field Type= dbText, Field Size= 5.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Est_H_Error
Attribute_Definition: Estimated horizontal accuracy; Field Type= dbSingle, Field Size= 4.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Accuracy_Notes
Attribute_Definition: Positional accuracy notes; Field Type= dbText, Field Size= 255.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tbl_Incidental_Events IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Incidental species observations., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Incidental_Event_ID
Attribute_Definition: Auto-generated unique incidental event identifier; Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Unit_Code
Attribute_Definition: Park, monument, or network code; Field Type= dbText, Field Size= 4.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Detection_Date
Attribute_Definition: Date of species detection; Field Type= dbDate, Field Size= 8.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Detection_Time
Attribute_Definition: Time of species detection; Field Type= dbDate, Field Size= 8.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tbl_ITIS_Bird_List IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: ITIS Bird Species List., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Symbol
Attribute_Definition: Code representing a bird species. Usually first two letters of first and second words in common name. Assigned by American Ornithological Union in 2003.; Field Type= dbText, Field Size= 6.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Common_Name
Attribute_Definition: Accepted common name from ITIS; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Scientific_Name
Attribute_Definition: Concatenation of the accepted genus specific epithet (and infrasp epithet if applicable); Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Genus
Attribute_Definition: Accepted genus from ITIS; Field Type= dbText, Field Size= 30.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Specific_Epithet
Attribute_Definition: Accepted specific epithet from ITIS; Field Type= dbText, Field Size= 30.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Authority
Attribute_Definition: Authority for the scientific bionomial from ITIS; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Infrasp_Rank

Attribute_Definition: Subspecific taxonomic category from ITIS; Field Type= dbText, Field Size= 10.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Infrasp_Epithet
Attribute_Definition: Subspecific epithet from ITIS; Field Type= dbText, Field Size= 30.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Infrasp_Authority
Attribute_Definition: Authority for the subspecific epithet from ITIS; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Full_Name
Attribute_Definition: Concatenation of genus, specific epithet (infrasp epithet) authority; Field Type= dbText, Field Size= 255.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: TSN
Attribute_Definition: Taxonomic Serial Number from ITIS; Field Type= dbLong, Field Size= 4.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Kingdom
Attribute_Definition: Accepted kingdom from ITIS; Field Type= dbText, Field Size= 20.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Order
Attribute_Definition: Accepted oder from ITIS; Field Type= dbText, Field Size= 25.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Family
Attribute_Definition: Accepted family from ITIS; Field Type= dbText, Field Size= 25.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Neotropical_Migrant
Attribute_Definition: Species of birds, all or part of whose populations breed north of the Tropic of Cancer and winter south of that line (Rappole 1995: 173-182).; Field Type= dbBoolean, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Non_Native
Attribute_Definition: Indicates if a species is not native to the area it was found.; Field Type= dbBoolean, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: ESA
Attribute_Definition: Endangered Species Act conservation listing.; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: ESA_Date
Attribute_Definition: Date of ESA listing.; Field Type= dbDate, Field Size= 8.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Crit_Hab
Attribute_Definition: Indicates whether there is a Critical Habitat designation by the ESA.; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: BLM
Attribute_Definition: Bureau of Land Management conservation listing.; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: USFS
Attribute_Definition: U.S. Forest Service conservation listing.; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: NESL
Attribute_Definition: Navajo Endangered Species List listing.; Field Type= dbLong, Field Size= 4.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Mex_Fed
Attribute_Definition: Mexican Federal Endangered Species List listing.; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: WSCA
Attribute_Definition: Wildlife of Special Concern in Arizona listing.; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: APF
Attribute_Definition: Arizona Partners in Fight listing.; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: USFWS
Attribute_Definition: U.S. Fish and Wildlife Service; BCC - Bird of Conservation Concern; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: G_Rank
Attribute_Definition: Global Ranking; Field Type= dbText,

Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: S_Rank
Attribute_Definition: State Ranking; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tbl_ITIS_Veg_List IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: ITIS Vegetation Species List., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Symbol
Attribute_Definition: USDA Plants database four letter code; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Common_Name
Attribute_Definition: Accepted common name from ITIS; Field Type= dbText, Field Size= 255.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Scientific_Name
Attribute_Definition: Concatenation of the accepted genus specific epithet (and infrasp rank and epithet if applicable); Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Genus
Attribute_Definition: Accepted genus from ITIS; Field Type= dbText, Field Size= 30.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Specific_Epithet
Attribute_Definition: Accepted specific epithet from ITIS; Field Type= dbText, Field Size= 30.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Authority
Attribute_Definition: Authority for the scientific bionomial from ITIS; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Infrasp_Rank
Attribute_Definition: Subspecific taxonomic category from ITIS; Field Type= dbText, Field Size= 10.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Infrasp_Epithet
Attribute_Definition: Subspecific epithet from ITIS; Field Type= dbText, Field Size= 30.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Infrasp_Authority
Attribute_Definition: Authority for the subspecific epithet from ITIS; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Full_Name
Attribute_Definition: Concatenation of genus, specific epithet, authority, infrasp_rank, infrasp_epithet, infrasp_authority; Field Type= dbText, Field Size= 255.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: TSN
Attribute_Definition: Taxonomic Serial Number from ITIS; Field Type= dbLong, Field Size= 4.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Kingdom
Attribute_Definition: Accepted kingdom from ITIS; Field Type= dbText, Field Size= 20.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Family
Attribute_Definition: Accepeted family name from ITIS; Field Type= dbText, Field Size= 40.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Nativity
Attribute_Definition: Plant's nativity status in the United States by the USDA PLANTS database; Field Type= dbText, Field Size= 10.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Growth_Habit
Attribute_Definition: Plant growth form as defined by the USDA PLANTS database; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Duration
Attribute_Definition: Plant's normal life span by the USDA PLANTS database; Field Type= dbText, Field Size= 10.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: ESA
Attribute_Definition: Endangered Species Status; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: ESA_Date

Attribute_Definition: Date of Listing; Field Type= dbDate, Field Size= 8.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Crit_Hab
Attribute_Definition: Critical Habitat; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: BLM
Attribute_Definition: Bureau of Land Management; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: USFS
Attribute_Definition: U.S. Forest Service; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: NESL
Attribute_Definition: Navajo Endangered Species List; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Mex_Fed
Attribute_Definition: Mexican Status; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: WSCA
Attribute_Definition: Wildlife Species of Special Concern: AZ Game and Fish; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: NPL
Attribute_Definition: Arizona Native Plant Law; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: G_Rank
Attribute_Definition: Global Ranking; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: S_Rank
Attribute_Definition: State Ranking; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tbl_Land_Cover_Data IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Vegetation and other land cover types data for the 75-meter habitat plot., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Land_Cover_ID
Attribute_Definition: Auto-generated unique land cover type identifier; Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Location_ID
Attribute_Definition: Link to tbl_Locations (FK); Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Land_Cover_Type
Attribute_Definition: Major vegetation community and other land use types on the 75-meter plot; Field Type= dbText, Field Size= 30.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Cover_Class
Attribute_Definition: Modified Daubenmire cover class based on ocular estimate of percent coverage of major vegetation community and other land use types; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tbl_Locations IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Sampling unit (point) locations., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Location_ID
Attribute_Definition: Auto-generated unique location identifier; Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Site_ID
Attribute_Definition: Link to tbl_Sites (FK); Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Loc_Name
Attribute_Definition: Name of the location (point); Field Type= dbText, Field Size= 100.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Slope_deg
Attribute_Definition: Slope of ground in degrees across the

entire 75-meter-radius plot; Field Type= dbInteger, Field Size= 2.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Slope_Var
Attribute_Definition: Slope variability across the entire 75-meter-radius plot; Field Type= dbText, Field Size= 10.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Aspect_deg
Attribute_Definition: Slope direction (aspect) of the entire 75-meter-radius plot; Field Type= dbInteger, Field Size= 2.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Aspect_Var
Attribute_Definition: Aspect (direction of slope) variability across the entire 75-meter-radius plot; Field Type= dbText, Field Size= 10.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Topo_Position
Attribute_Definition: Topographic position of the point relative to its local position on the earth's surface; Field Type= dbText, Field Size= 25.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Loc_Notes
Attribute_Definition: General notes on the location; Field Type= dbMemo, Field Size= 0.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: X_Coord
Attribute_Definition: X coordinate; Field Type= dbDouble, Field Size= 8.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Y_Coord
Attribute_Definition: Y coordinate; Field Type= dbDouble, Field Size= 8.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Coord_Units
Attribute_Definition: Coordinate distance units; Field Type= dbText, Field Size= 10.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Coord_System
Attribute_Definition: Coordinate system; Field Type= dbText, Field Size= 20.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: UTM_Zone
Attribute_Definition: UTM Zone; Field Type= dbText, Field Size= 3.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Datum
Attribute_Definition: Datum of mapping ellipsoid; Field Type= dbText, Field Size= 5.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Est_H_Error
Attribute_Definition: Estimated horizontal accuracy; Field Type= dbSingle, Field Size= 4.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Accuracy_Notes
Attribute_Definition: Positional accuracy notes; Field Type= dbText, Field Size= 255.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tbl_Parks IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Parks and management subunits within the Sonoran Desert Network., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Unit_Code
Attribute_Definition: Park, monument, or network code; Field Type= dbText, Field Size= 4.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Unit_Name
Attribute_Definition: Park, monument, or network full name; Field Type= dbText, Field Size= 100.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tbl_Protocols IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Monitoring protocols that govern sampling events., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Protocol_ID
Attribute_Definition: Auto-generated unique protocol identifier; Field Type= dbLong, Field Size= 4.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Protocol_Name
Attribute_Definition: Name of the protocol governing the event; Field Type= dbText, Field Size= 100.

Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Protocol_Version
Attribute_Definition: Version of the protocol governing the event; Field Type= dbText, Field Size= 10.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Effective_Date
Attribute_Definition: Date the protocol version was adopted for network use; Field Type= dbDate, Field Size= 8.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tbl_Sites IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Location aggregations (transects and groups) of sampling point locations., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Site_ID
Attribute_Definition: Auto-generated unique site identifier; Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Unit_Code
Attribute_Definition: Park, monument, or network code; Field Type= dbText, Field Size= 4.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Site_Type
Attribute_Definition: Type of site (Transect or Group; points located along a transect are dependent; points within a group are independent); Field Type= dbText, Field Size= 25.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Site_Name
Attribute_Definition: Unique name or code for a site; Field Type= dbText, Field Size= 100.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Site_Desc
Attribute_Definition: Description of a site; Field Type= dbText, Field Size= 255.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Site_Notes
Attribute_Definition: General notes on the site; Field Type= dbMemo, Field Size= 0.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Project_Code
Attribute_Definition: Project code; for linking information with other data sets and applications or to aggregate multiple databases for integrated analysis; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Meta_MID
Attribute_Definition: Link to NR-GIS Metadata Database (metadata for spatial data set); Field Type= dbLong, Field Size= 4.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tbl_Subplot_Veg_Data IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Vegetation subplot data., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Subplot_ID
Attribute_Definition: Auto-generated unique vegetation subplot identifier; Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Event_ID
Attribute_Definition: Link to tbl_Events (FK); Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Subplot_Num
Attribute_Definition: Number assigned to the subplot (1-4); Field Type= dbInteger, Field Size= 2.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Photo_Taken
Attribute_Definition: Indicates whether a photo was taken of the subplot; Field Type= dbBoolean, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Canopy_Cvr_N
Attribute_Definition: Densiometer count for canopy cover facing north; Field Type= dbInteger, Field Size= 2.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Canopy_Cvr_E
Attribute_Definition: Densiometer count for canopy cover facing east; Field Type= dbInteger, Field Size= 2.
Attribute_Definition_Source: Not Defined
Attribute:

Attribute_Label: Canopy_Cvr_S
Attribute_Definition: Densiometer count for canopy cover facing south; Field Type= dbInteger, Field Size= 2.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Canopy_Cvr_W
Attribute_Definition: Densiometer count for canopy cover facing west; Field Type= dbInteger, Field Size= 2.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Horiz_Veg_Cvr_A
Attribute_Definition: Number of bands on the cover pole that are covered by vegetation (direction A); Field Type= dbInteger, Field Size= 2.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Horiz_Veg_Cvr_B
Attribute_Definition: Number of bands on the cover pole that are covered by vegetation (direction B); Field Type= dbInteger, Field Size= 2.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tlu_Breeding_Behaviors IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Breeding behaviors., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Behavior_Code
Attribute_Definition: Code indicating a breeding behavior; Field Type= dbText, Field Size= 2.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Behavior_Desc
Attribute_Definition: Breeding behavior description; Field Type= dbText, Field Size= 35.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tlu_Cover_Classes IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Modified Daubenmire cover classes., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Cover_Code
Attribute_Definition: Code indicating modified Daubenmire cover class; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Cover_Class
Attribute_Definition: Cover class percentage range; Field Type= dbText, Field Size= 12.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tlu_Detection_Types IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Types of bird detections., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Detection_Code
Attribute_Definition: Code indicating type of bird detection; Field Type= dbText, Field Size= 3.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Detection_Desc
Attribute_Definition: Detection type description; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tlu_Edit_Types IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Types of data edits., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Data_Edit_Type
Attribute_Definition: Type of edit made; Field Type= dbText, Field Size= 12.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Edit_Type_Desc
Attribute_Definition: Data edit type description; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tlu_Growth_Habits IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Plant growth habits., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Growth_Habit
Attribute_Definition: Plant growth habit; Field Type= dbText, Field Size= 15.
Attribute_Definition_Source: Not Defined

Attribute:
Attribute_Label: Habit_Definition
Attribute_Definition: Growth habit definition; Field Type= dbText, Field Size= 200.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tlu_Land_Cover_Types IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Land cover types., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Land_Cover_Type
Attribute_Definition: Type of land cover; Field Type= dbText, Field Size= 30.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Land_Cover_Desc
Attribute_Definition: Land cover type description; Field Type= dbText, Field Size= 125.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tlu_Noise_Levels IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Background noise levels., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Noise_Level_Code
Attribute_Definition: Code indicating noise level; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Noise_Level_Desc
Attribute_Definition: Noise level description; Field Type= dbText, Field Size= 75.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tlu_Precipitation_Types IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Precipitation types., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Precip_Code
Attribute_Definition: Code indicating precipitation type; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Precip_Desc
Attribute_Definition: Precipitation description; Field Type= dbText, Field Size= 60.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tlu_Topo_Positions IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Topographic positions., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Topo_Position
Attribute_Definition: Topographic position; Field Type= dbText, Field Size= 25.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Topo_Position_Desc
Attribute_Definition: Topographic position description; Field Type= dbText, Field Size= 255.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: tlu_Wind_Speeds IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Wind speeds., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Wind_Code
Attribute_Definition: Code indicating wind speed; Field Type= dbText, Field Size= 1.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Wind_Speed
Attribute_Definition: Wind speed description based on Beaufort scale; Field Type= dbText, Field Size= 75.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: xref_Edits_Contacts IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Cross-reference table between data edits and contacts., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Data_Edit_ID
Attribute_Definition: Link to tbl_Data_Edits_Log (FK); Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined

Attribute:
Attribute_Label: Contact_ID
Attribute_Definition: Link to tbl_Contacts (FK); Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Edit_Role
Attribute_Definition: The contact's role in the data edit; Field Type= dbText, Field Size= 16.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: xref_Events_Contacts IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Cross-reference table between events and contacts., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Event_ID
Attribute_Definition: Link to tbl_Events or tbl_Incidental_Events; Field Type= dbGUID, Field Size= 16.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Contact_ID
Attribute_Definition: Link to tbl_Contacts; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Contact_Role
Attribute_Definition: The contact's role in the sampling event; Field Type= dbText, Field Size= 30.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Experience_Level
Attribute_Definition: The contact's level of experience or confidence related to their role in the sampling event; Field Type= dbText, Field Size= 6.
Attribute_Definition_Source: Not Defined
Detailed_Description:
Entity_Type:
Entity_Type_Label: xref_Revisions_Contacts IN SODN_BirdComm_be.mdb , (N/A)
Entity_Type_Definition: Cross-reference table between database revisions and contacts., Microsoft Access
Entity_Type_Definition_Source: IN SODN_BirdComm_be.mdb
Attribute:
Attribute_Label: Revision_ID
Attribute_Definition: Link to tbl_Db_Revisions; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Contact_ID
Attribute_Definition: Link to tbl_Contacts; Field Type= dbText, Field Size= 50.
Attribute_Definition_Source: Not Defined
Attribute:
Attribute_Label: Revision_Role
Attribute_Definition: The contact's role in the revision; Field Type= dbText, Field Size= 18.
Attribute_Definition_Source: Not Defined

Distribution_Information:
Distributor:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Angell, Deborah
Contact_Organization: National Park Service, Sonoran Desert Inventory & Monitoring Network
Contact_Position: Network Data Manager
Contact_Address:
Address_Type: mailing and physical
Address: 7660 E. Broadway Blvd., Suite 303
City: Tucson
State_or_Province: AZ
Postal_Code: 85710
Country: USA
Contact_Voice_Telephone: (520) 731-3420, Ext. 1#
Contact_Facsimile_Telephone: (520) 546-7601
Contact_Electronic_Mail_Address: Deborah_Angell@nps.gov
Hours_of_Service: 8:00 am - 4:30 pm, Monday - Friday
Contact_Instructions: Please use e-mail when possible.
Resource_Description: SODN, WM-BirdComm Bird Community Dynamics Monitoring Database for Sonoran Desert Network Parks
Distribution_Liability: The National Park Service shall not be held liable for improper or incorrect use of the data described and/or contained herein. These data and related graphics (if available) are not legal documents and are not intended to be used as such. The information contained in these data is dynamic and may change over time. The data are not better than the original sources from which they were derived. It is the responsibility of the data user to use the data appropriately and consistent within the limitations of geospatial data in general and these data in particular. Any related graphics (if available) are intended to aid the data user in acquiring relevant data; it is not appropriate to use related graphics as data. The National Park Service gives no warranty, expressed or implied, as to the accuracy, reliability, or completeness of these data. It is strongly recommended that these data are directly acquired from an NPS server and not indirectly through

other sources which may have changed the data in some way. Although these data have been processed successfully on a computer system at the National Park Service, no warranty expressed or implied is made regarding the utility of the data on another system or for general or scientific purposes, nor shall the act of distribution constitute any such warranty. This disclaimer applies both to individual use of the data and aggregate use with other data. All World Wide Web addresses were valid when this metadata was created.
Standard_Order_Process:
Digital_Form:
Digital_Transfer_Information:
Format_Name: Microsoft Access 2002 database (mdb file)
Transfer_Size: 1.91
Digital_Transfer_Option:
Online_Option:
Computer_Contact_Information:
Network_Address:
Network_Resource_Name:
Fees: Free
Ordering_Instructions: I&M (Contact Name)
Technical_Prerequisites: Does data need to be converted? None

---

Metadata_Reference_Information:
Metadata_Date: 20060626
Metadata_Review_Date: 20060626
Metadata_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Angell, Deborah
Contact_Organization: National Park Service, Sonoran Desert Inventory & Monitoring Network
Contact_Position: Network Data Manager
Contact_Address:
Address_Type: mailing and physical
Address: 7660 E. Broadway Blvd., Suite 303
City: Tucson
State_or_Province: AZ
Postal_Code: 85710
Country: USA
Contact_Voice_Telephone: (520) 731-3420, Ext. 1#
Contact_Facsimile_Telephone: (520) 546-7601
Contact_Electronic_Mail_Address: Deborah_Angell@nps.gov
Hours_of_Service: 8:00 am - 4:30 pm, Monday - Friday
Contact_Instructions: Please use e-mail when possible.
Metadata_Standard_Name: FGDC
Metadata_Standard_Version: FGDC-STD-001-1998
Metadata_Extensions:
Online_Linkage: <http://nrdata.nps.gov/profiles/NPS_Profile.xml>
Profile_Name: NPS NR and GIS Metadata Profile

Generated by `mp` version

Appendix 7.01.5. SODN Project Data Certification Form for the SODN Landbird Monitoring Database

Project Data Certification Form

Data certification is the stage in project data management confirming that the data: 1) have undergone and passed quality-assurance checks; 2) are complete for the period of record; and 3) are fully documented and ready for archiving, posting, and distribution as appropriate. Certification is **not** intended to and **does not** imply that the data are completely free of errors or inconsistencies that may or may not have been detected during quality assurance reviews.

1) Certification date:

2) Certified by:

Title:

Affiliation:

3) Project code:

Project title:

4) Range of dates for certified data:

Description of data being certified:

5) List the parks included in the certified data set, and provide any park-specific details about this certification:

Park	Details

6) This certification refers to data in accompanying files. Check all that apply, and indicate file names and current locations to the right:

Database file(s):

Spatial data layer(s):

Other (specify):

Certified data are already in the master version of a park, SODN, or NPS database.

Please indicate the database system(s):

7) Do the certified data include any sensitive information (*e.g.*, southwestern willow flycatcher nest sites, cave locations, rare plant locations) that may put resources at greater risk if released to the public?

No Yes

Details:

8) Description of data processing and quality assurance measures. (Note: These may be cut and pasted from corresponding sections of the protocol and/or SOPs.)

9) Results and summary of quality assurance reviews, explain the steps taken to resolve problems encountered during data processing and quality reviews.

SOP #8: Data Summary and Analysis

Version 1.02 (May 5, 2007)

Revision History Log

Previous Version #	Revision date	Author	Changes made	Section and paragraph	Reason for change	New Version #

This SOP provides an overview of the procedures to be used for analyzing point-transect and associated environmental data for landbird monitoring in SODN parks. Annual reports will include species lists as well as information on species richness and relative abundance of each bird species in each park. This SOP also reviews approaches and tools to be used during a program-review process that will occur every five years and involve density, occupancy, and trend estimation.

Annual Data Summary and Analysis

Parameters that we have selected for annual summary will provide simple descriptive information on the occurrence and distribution of birds. The most basic statistics to be included in annual reports will summarize survey effort, relative abundance of each species, and community-level parameters such as species richness. In the future, we will incorporate automated functions into the database to allow data summaries at various spatial scales for several applications. Annual reports will conform to the standards outlined in SOP #9.

Survey effort

An appendix to each annual report will summarize the number of points and transects surveyed within each park and the number of visits to each (see Supplement B, Table 1, for example). Annual reports will also contain a table within the text that summarizes total survey effort within each park and across the network. We will also include a map detailing the location of all points that we survey.

Population and community parameters

In annual reports, we will summarize the following parameters:

- Relative abundance: the total number of individuals observed of each species scaled by survey effort. Survey effort will equal the number of points multiplied by the number of visits.
- Observed species richness: the number of species observed during surveys during a specific time period.
- Estimated species richness: corrects for species that are present but undetected by modeling detections with use of a capture–recapture model (Williams et al. 2002) and thereby can improve naïve estimates of observed species richness. We will estimate species richness using a bootstrap method in which points are resampled with replacement. The model output provides an estimate of the mean number of species present, standard errors, and 95% confidence intervals.

Automated report functions: Birds

We will summarize data with use of a database script called BirdMonitoring that is currently under construction. Once opened, BirdMonitoring will display a number of automated analytical tools to calculate survey effort and the parameters discussed above. All of the automated functions will use all data collected at a point (i.e., regardless of the distance from the point) except those birds that were not identified to species. Summaries will be performed at various spatial scales. Ed Debevec (Institute of Arctic Biology, University of Alaska, Fairbanks) developed the R code for many of these applications; these codes will be modified and incorporated into the database in late 2007.

Environmental data

Procedures for documenting environmental features at bird-survey points are described in SOP #6. We will collect data every five years at the spatial scale of the point (75-m radius) and subplot (various radii). Below, we discuss approaches for summarizing these data at both spatial scales.

75-m plot scale

We will subdivide summary data for environmental features within 75 m of survey points into "permanent" and "semi-permanent" features. We consider permanent features to be those that will not change over the course of the monitoring program: topographic position, aspect, and slope. We will measure these features only once and assign values to a permanent table in the database. We consider cover type to be a semi-permanent feature that is unlikely to change except over longer time periods.

Subplot scale

Most of the environmental data associated with each bird point will be collected at four subplots (see SOP #6, Figure 6.01.1); these data characterize vegetation and groundcover features. We will estimate and report all vegetation data for each point such that variation among subplots can provide estimates of precision. We will measure ground cover and foliage cover as percents and report means ± 1 SD for each category. Similarly, canopy cover will be converted to a percent and reported as mean ± 1 SD.

We will summarize data on dominant plant species in both the understory and overstory by calculating total-cover estimates and stem density, adding results from each subplot for each species and presenting data from the most- to least-dominant species based on cover. Photographs for each subplot will be incorporated into the database but will not be a component of the data analysis. Rather, these images will serve to relocate plots and in interpretation.

Automated report functions: Environmental data

Environmental data will be summarized via automated functions embedded within the database. These automated functions are now being developed. For permanent features, summary statistics will be listed as means ± SD for continuous factors and as percentages by category for categorical data.

Parameter Estimation

The goals of this monitoring program are to detect trends in density, occupancy, and relative abundance of birds. This section provides a general guideline for calculating parameter estimates and assessing trend over time, and includes discussion of computer software that is now used to estimate these parameters and test for trends. We have omitted step-by-step instructions for using software because rapid advances in these tools are expected to occur before density and occupancy parameters are calculated and trends assessed after the 3–5-year program review.

Density

We will estimate density at various spatial and temporal scales:

1. Annually for common species at some parks.
2. Annually for species within each vegetation community among all parks combined.
3. During longer time intervals (2–5 yrs) for rarer species that require a greater number of detections to generate estimates at scales one and two.

The Distance program is the software package of choice for density estimation based on distance sampling methods (Thomas et al. 2005). The theoretical foundation and practical application of the program are discussed by Buckland et al. (2001, 2004); these references are essential reading for anyone who plans to use Distance.

In the last three years, there have been dramatic improvements in the functionality and user interface of Distance. Recent versions can now interface with the statistical-analysis software R. There are also built-in GIS capabilities in the Distance program. Future versions will accommodate design-based estimates of abundance that are applicable to this project, power analysis, and a better GIS interface. Further, the Distance development website continues to host many modules for data analysis and presentation, many of which may useful for our purposes. Finally, the interface with R will produce an abundance of analytical modules for density estimation, graphical presentation, and trend detection. As a result, this SOP will be revised after the fourth field season to incorporate these new features into a comprehensive "cookbook" for parameter estimation and trend detection using the most up-to-date tools.

Occupancy

There are currently two software programs in use for occupancy estimation: Presence (MacKenzie et al. 2002) and MARK (White and Burnham 1999). At this time, we advocate use of Presence because MARK is more complicated to learn and there are likely to be significantly more advances in Presence in the next few years, including application of both maximum likelihood and Bayesian estimation methods.

Trend detection

There are many statistical software packages available for trend analysis. The open-source statistical package R is becoming increasingly popular for statistical computing and graphics. R includes an effective data-handling and storage facility; a suite of operators for calculations on arrays; a large, coherent, integrated collection of intermediate tools for data analysis; graphical facilities for data analysis; and display either on-screen or in hard copy. For our purposes, statisticians at the University of Alaska–Fairbanks, Alaska Center for Environmental Statistics, are developing a software package for R to analyze data for trend detection (called Trends and Abundance Monitoring). This package will be modified to analyze data for the SODN, and we will develop a complete SOP on exporting data into R, running the analyses, and presenting results.

Procedures for Detecting Trends

These will be developed in the future. Thomas et al. (2004) provides an excellent overview of trend detection in bird counts.

General Approaches to Variance Partitioning and Determining Program Effectiveness

Estimating abundance and occupancy at various spatial and temporal scales is not the ultimate goal of the landbird-monitoring program. Rather, our goal is detect trends in these parameters over time. The program design that we advocate appears to be a reasonable tradeoff between the amount of information gained and financial cost. However, we will not know if our objective of detecting meaningful changes in landbird monitoring parameters has been reached until a thorough review of the program takes places after 3 to 5 years. To facilitate that evaluation, we have created a general framework for variance partitioning that informs our ability to detect trends. We give an example of this approach in Supplement A. This work derives from the pioneering work of Scott Urquart, Thomas Kincaid, and others at the EMAP program (see Urquhart and Kincaid 1999; Kincaid et al. 2004).

We have designed the program to allow for the partitioning of variance that we address in Supplement A. We will visit the same sites each year and visit each site multiple times each season. We suggest that these data be used for variance partitioning according to the methods outlined in Kincaid et al. (2004), who used SAS to partition variance. We were able to do the same in the program JMP using the Variability Chart function for equal sample sizes (equal number of within-season visits).

Additional Applications for Bird Monitoring Data: Creating Bird-habitat Associations

Data collected from this monitoring program can provide invaluable information on a range of important topics in addition to parameter estimation and trend detection. Assuming that these data are collected continuously, they would represent one of the most intensive landbird monitoring efforts in the greater

Sonoran Desert region. These data could then be used to build habitat-associations models that would facilitate identification of important landscape variables, identify target species for conservation, and build predictive models (e.g., Macfaden and Capen 2002; Manley et al. 2004). Other areas of investigation may include determining changes in bird communities (abundance, distribution, composition) in response to changes in environmental characteristics (e.g., Krueper et al. 2003). Guidance for building bird–habitat relationships is beyond the scope of this protocol; we refer the reader to (Morrison et al. 1998) for myriad approaches to this topic (McGarigal et al. 2000; Scott et al. 2002).

Literature Cited

Buckland, S. T., D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borchers, and L. Thomas. 2001. Introduction to distance sampling: Estimating abundance of biological populations. Oxford, U.K.: Oxford University Press.

Buckland, S. T., D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borshers, and L. Thomas, eds. 2004. Advanced distance sampling. Oxford, U.K.: Oxford University Press.

Kincaid, T. M., D. P. Larsen, and N. S. Urquhart. 2004. The structure of variation and its influence on the estimation of status: Indicators of condition of lakes in the northeast, U.S.A. Environmental Monitoring and Assessment **98**:1–21.

Krueper, D., J. Bart, and T. D. Rich. 2003. Response of vegetation and breeding birds to the removal of cattle on the San Pedro River, Arizona (USA). Conservation Biology **17**:607–615.

Macfaden, S. W., and D. E. Capen. 2002. Avian habitat relationships at multiple scales in a New England forest. Forest Science **48**:243–253.

MacKenzie, D. I., J. D. Nichols, G. B. Lachman, S. Droege, J. A. Royle, and C. A. Langtimm. 2002. Estimating site occupancy rates when detection probabilities are less than one. Ecology **83**:2248–2255.

Manley, P. N., W. J. Zielinski, M. D. Schlesinger, and S. R. Mori. 2004. Evaluation of a multiple-species approach to monitoring species at the ecoregional scale. Ecological Applications **14**:296–310.

McGarigal, K., S. Cushman, and S. G. Stafford. 2000. Multivariate statistics for wildlife and ecology research. New York: Springer Inc.

Morrison, M. L., B. G. Marcot, and R. W. Mannan. 1998. Wildlife–habitat relationships: Concepts and applications. Madison: University of Wisconsin Press.

Scott, J. M., P. J. Hegland, M. L. Morrison, J. B. Haufler, M. G. Raphael, W. A. Wall, and F. B. Samson, eds. 2002. Predicting species occurrence: Issues of accuracy and scale. Washington, D.C.: Island Press.

Thomas, L., K. P. Burnham, and S. T. Buckland. 2004. Temporal inferences from distance sampling survey. Pages 71–105 *in* S. T. Buckland, D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borshers, and L. Thomas, eds. Advanced distance sampling. New York: Oxford University Press.

Thomas, L., J. L. Laake, S. Strindberg, F. F. C. Marques, S. T. Buckland, D. L. Borchers, D. R. Anderson, K. P. Burnham, S. L. Pollard J. H. Hedley, J. R. B. Bishop, and T. A. Marques. 2005. Distance 5.0. Release Beta 5. Research Unit for Wildlife Population Assessment, University of St. Andrews, UK. http:/www.ruspa.st-and.ac.uk/distance.

Urquhart, N. S., and T. M. Kincaid. 1999. Designs for detecting trend from repeated surveys of ecological resources. Journal of Agricultural, Biological and Environmental Statistics **4**:404–414.

White, G. C., and K. P. Burnham. 1999. Program MARK: Survival estimation from populations of marked animals. Bird Study **46** (Supplement):120–138.

Williams, B. K., J. D. Nichols, and M. J. Conroy. 2002. Analysis and management of animal populations. San Diego, Ca.: Academic Press.

SOP #9: Report Compilation

Version 1.02 (May 5, 2007)

Revision History Log

Previous Version #	Revision date	Author	Changes made	Section and paragraph	Reason for change	New Version #

Formal reports submitted to the SODN should be written and formatted in accordance with the Instructions for Authors and other guidelines for NPS Natural Resource Publications found at http://www.nature.nps.gov/publications/NRPM/index.cfm.

SOP #10: Post-Field-Season Procedures

Version 1.02 (May 5, 2007)

Revision History Log

Previous Version #	Revision date	Author	Changes made	Section and paragraph	Reason for change	New Version #

This SOP explains procedures that all observers for the landbird monitoring program for the SODN should be familiar with and follow after the field season is completed.

Procedures

1. Clean and repair all equipment before returning it to the project manager. Only the project manager or another appointed person will return equipment to the appropriate location in the SODN I&M office in Tucson. Prior to that, all returned equipment will be inspected for damage and any missing equipment will be noted for the next field season. All reference manuals should be re-shelved on their appropriate bookshelf. Other reference materials and extra data forms need to be filed in their appropriate filing cabinet. Clean the insides and outsides of all vehicles used in the field.

2. The project manager will be responsible for ensuring that each observer completes an exit questionnaire prior to their leaving the project. Information obtained from observers may inform protocol modifications and assist with refining the management of the program. If some of the questions pertain to sensitive information, observers can opt not to answer them and, instead, will be given a chance to discuss them personally with the project manager or other appropriate person in the SODN I&M office. Observers should be encouraged to answer the following in as much detail as possible:

   - Do you have any knowledge of unusual conditions over the course of the season (e.g., insect activity) that may have affected the bird communities?
   - Do you have any information about site-specific impacts that we should know about?
   - What are your feelings about the expectations placed on you, the amount of work, and the field conditions? Can you suggest ways to improve the experience for future observers?
   - Did you have any personal or professional difficulties with other observers or management personnel?
   - Do you have any suggestions for improvements to the design of the program or field effort?
   - Would you consider returning next year? Please explain.

SOP #11: Revising the Protocol

Version 1.02 (May 5, 2007)

Revision History Log

Previous Version #	Revision date	Author	Changes made	Section and paragraph	Reason for change	New Version #

This SOP explains how to make changes to the landbird monitoring protocol narrative and associated SOPs for SODN parks. Personnel who edit the protocol narrative or any of the SOPs need to be familiar with this SOP in order to identify and use the most current methodologies for revision. This SOP was adapted from Peitz et al. (2004).

Procedures

1. The protocol narrative and accompanying SOPs for landbird monitoring at SODN parks incorporate the most sound methodologies for collecting and analyzing bird and associated environmental data. However, all protocols, regardless of how sound, require editing as new and different information becomes available. Required edits should be made in a timely manner, with appropriate reviews undertaken.

2. All edits require review for clarity and technical soundness. Small changes or additions to existing methods will be reviewed by SODN I&M personnel and knowledgeable cooperators. If substantial changes in methods warrant consideration, then an outside review is required. Regional and national NPS staff with familiarity in avian research and data analysis should be used as reviewers. Experts in avian research and statistical methodologies outside of the NPS also will be utilized in the review process.

3. A revision history log accompanies the Protocol Narrative and each SOP. Changes made to the protocol narrative or an SOP should be noted in those documents only. Version numbers increase incrementally by hundredths (e.g., version 1.01, 1.02, 1.03) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0). In the revision history log, record the previous version number, date of revision, author of the revision, what changes were made, where changes were made (sections and paragraphs), the reason for making the changes, and the new version number.

4. Inform the data manager about changes to the protocol narrative or SOP so the new version number can be incorporated into the metadata of the project database. The data manager may have to edit the database to accompany changes in the protocol narrative and SOPs. Changes to the protocol narrative must also be noted at the top of the point-transect data form.

5. Post new versions of affected protocol narrative and/or SOPS on the Internet and forward copies to all individuals with previous versions.

Literature Cited

Peitz, D. G., S. G. Fancy, L. P. Thomas, G. A. Rowell, and M. D. Debacker. 2004. Bird monitoring protocol for Agate Fossil Beds National Monument, Nebraska and Tallgrass Prairie National Preserve, Kansas. Unpublished protocol to the Prairie Cluster Prototype Monitoring Program, National Park Service, U.S. Department of the Interior.

Section 3 Appendices

Appendix A. List of Bird Species Recorded in Sonoran Desert Network Parks.

Scientific name	Common name	Species code	CAGR[a]	CHIR[b]	CORO[c]	FOBO[d]	GICL[e]	MOCA[f]	ORPI[g]	SAGU[h]	TONT[i]	TUMA[j]	TUZI[k]
Pipilo aberti	Abert's towhee	ABTO			X			X	X	X	X	X	X
Melanerpes formicivorus	Acorn woodpecker	ACWO		X	X	X	X		X	X	X		X
Selasphorus sasin	Allen's hummingibrd	ALHU			X				X				
Recurvirostra americana	American avocet	AMAV							X				X
Botaurus lentiginosus	American bittern	AMBI							X				X
Fulica americana	American coot	AMCO						X	X				X
Corvus brachyrhynchos	American crow	AMCR						X	X				X
Carduelis tristis	American goldfinch	AMGO		X	X			X	X		X		X
Anthus rubescens	American pipit	AMPI	X			X		X	X			X	X
Setophaga ruticilla	American redstart	AMRE		X					X				
Turdus migratorius	American robin	AMRO		X	X	X	X	X	X	X	X	X	X
Anas americana	American wigeon	AMWI						X	X				X
Calypte anna	Anna's hummingbird	ANHU	X	X	X	X		X	X	X	X	X	X
Myiarchus cinerascens	Ash-throated flycatcher	ATFL	X	X	X	X	X	X	X	X	X	X	X
Spizella arborea	American tree sparrow	ATSP						X					
Dendroica coronata auduboni	Audubon's warbler	AUWA		X								X	
Pelecanus erythrorhynchos	American white pelican	AWPE							X		X		X
Picoides arizonae	Arizona woodpecker	AZWO		X	X					X			
Haliaeetus leucocephalus	Bald eagle	BAEA		X	X	X		X	X		X		X
Riparia riparia	Bank swallow	BANS						X	X			X	X
Hirundo rustica	Barn swallow	BARS		X	X	X	X		X		X	X	X
Calidris bairdii	Baird's sandpiper	BASA						X	X				
Ammodramus bairdii	Baird's sparrow	BASP				X							
Mniotilta varia	Black-and-white warbler	BAWW							X				
Empidonax fulvifrons pygmaeus	Buff-breasted flycatcher	BBFL		X									
Cynanthus latirostris	Broad-billed hummingbird	BBLH		X	X	X			X	X		X	
Pluvialis squatarola	Black-bellied plover	BBPL						X					
Dendrocygna autumnalis	Black-bellied whistling duck	BBWD										X	
Myiarchus tyrannulus	Brown-crested flycatcher	BCFL		X	X	X		X	X	X	X	X	X

Appendix A. List of bird species recorded in Sonoran Desert Network parks, cont.

Scientific name	Common name	Species code	CAGR[a]	CHIR[b]	CORO[c]	FOBO[d]	GICL[e]	MOCA[f]	ORPI[g]	SAGU[h]	TONT[i]	TUMA[j]	TUZI[k]
Archilochus alexandri	Black-chinned hummingbird	BCHU	X	X	X	X	X	X	X	X	X	X	X
Nycticorax nycticorax	Back-crowned night-heron	BCNH						X	X			X	X
Caprimulgus ridgwayi	Buff-collared nightjar	BCNI							X				
Spizella atrogularis	Black-chinned sparrow	BCSP	X	X	X	X		X	X	X	X		
Amazilia beryllina	Berylline hummingbird	BEHU		X									
Ceryle alcyon	Belted kingfisher	BEKI		X		X	X	X	X	X			X
Toxostoma bendirei	Bendire's thrasher	BETH		X	X	X			X	X			X
Vireo bellii	Bell's vireo	BEVI			X	X	X	X	X	X	X	X	X
Thryomanes bewickii	Bewick's wren	BEWR		X	X	X	X	X	X	X	X	X	X
Polioptila caerulea	Blue-gray gnatcatcher	BGGN	X	X	X	X	X	X	X	X	X	X	X
Molothrus ater	Brown-headed cowbird	BHCO	X	X	X	X	X	X	X	X	X	X	X
Pheucticus melanocephalus	Black-headed grosbeak	BHGR		X	X	X	X	X	X	X	X	X	X
Passerina caerulea	Blue grosbeak	BLGR		X	X	X	X	X	X	X		X	X
Sayornis nigricans	Black phoebe	BLPH		X	X	X	X	X	X	X	X	X	X
Dendroica striata	Blackpoll warbler	BLPW							X				
Laterallus jamaicensis	Black rail	BLRA							X				
Chlidonias niger	Black tern	BLTE							X				X
Lampornis clemenciae	Blue-throated hummingbird	BLUH		X	X			X					
Coragyps atratus	Black vulture	BLVU			X	X			X	X		X	
Tyto alba	Barn owl	BNOW	X	X	X	X		X	X	X	X	X	X
Himantopus mexicanus	Black-necked stilt	BNST	X						X				X
Larus philadelphia	Bonaparte's gull	BOGU							X				X
Aimophila botterri	Botteri's sparrow	BOSP		X									
Euphagus cyanocephalus	Brewer's blackbird	BRBL				X	X	X	X	X	X	X	X
Certhia americana	Brown creeper	BRCR		X	X	X		X	X	X	X		X
Molothrus aeneus	Bronzed cowbird	BROC	X	X	X	X			X	X	X	X	X
Pelecanus occidentalis	Brown pelican	BRPE							X				
Spizella breweri	Brewer's sparrow	BRSP	X	X	X	X	X	X	X	X	X	X	X
Toxostoma rufum	Brown thrasher	BRTH						X	X			X	
Baeolophus wollweberi	Bridled titmouse	BRTI		X	X	X	X	X	X	X	X	X	X

Appendix A. List of bird species recorded in Sonoran Desert Network parks, cont.

Scientific name	Common name	Species code	CAGR[a]	CHIR[b]	CORO[c]	FOBO[d]	GICL[e]	MOCA[f]	ORPI[g]	SAGU[h]	TONT[i]	TUMA[j]	TUZI[k]
Dendroica caerulescens	Black-throated blue warbler	BTBW						X	X				X
Polioptila melanura	Black-tailed gnatcatcher	BTGN	X			X			X	X	X	X	X
Selasphorus platycercus	Broad-tailed hummingbird	BTLH		X	X	X	X	X	X	X	X	X	X
Dendroica virens	Black-throated green warbler	BTNW			X				X				
Patagioenas fasciata	Band-tailed pigeon	BTPI		X	X	X	X		X	X	X	X	
Amphispiza bilineata	Black-throated sparrow	BTSP		X	X	X		X	X	X	X	X	X
Dendroica nigrescens	Black-throated gray warbler	BTYW	X	X	X	X	X	X	X	X	X	X	X
Bucephala albeola	Bufflehead	BUFF						X	X				X
Icterus bullockii	Bullock's oriole	BUOR	X	X	X	X	X	X	X	X	X	X	X
Athene cunicularia hypugaea	Burrowing owl	BUOW	X						X	X			
Psaltriparus minimus	Bushtit	BUSH		X	X	X	X	X	X	X	X	X	X
Anas discors	Blue-winged teal	BWTE						X	X				X
Campylorhynchus brunneicapillus	Cactus wren	CACW	X	X	X	X		X	X	X	X	X	X
Bubulcus ibis	Cattle egret	CAEG							X				X
Carpodacus cassinii	Cassin's finch	CAFI		X	X			X	X	X	X		X
Branta canadensis	Canada goose	CAGO				X		X	X		X		X
Larus californicus	California gull	CAGU							X				X
Stellula calliope	Calliope hummingbird	CAHU		X	X	X	X		X	X			X
Tyrannus vociferans	Cassin's kingbird	CAKI		X	X	X	X	X	X	X	X	X	X
Pipilo fuscus	Canyon towhee	CANT		X	X	X	X	X	X	X	X	X	X
Aythya valisineria	Canvasback	CANV						X	X				X
Catherpes mexicanus	Canyon wren	CANW		X	X	X	X	X	X	X	X		X
Aimophila cassinii	Cassin's sparrow	CASP		X	X	X			X	X		X	
Vireo cassinii	Cassin's vireo	CAVI			X						X	X	
Buteogallus anthracinus	Common black-hawk	CBHA		X	X	X	X	X	X	X			X
Toxostoma curvirostre	Curve-billed thrasher	CBTH	X	X	X	X	X		X	X	X	X	
Calcarius ornatus	Chestnut-collared longspur	CCLO			X								
Spizella pallida	Clay-colored sparrow	CCSP							X				
Bombycilla cedrorum	Cedar waxwing	CEDW		X	X	X		X	X	X		X	X
Glaucidium brasilianum cactorum	Cactus ferruginous pygmy-owl	CFPO							X	X	X		

Appendix A. List of bird species recorded in Sonoran Desert Network parks, cont.

Scientific name	Common name	Species code	CAGR[a]	CHIR[b]	CORO[c]	FOBO[d]	GICL[e]	MOCA[f]	ORPI[g]	SAGU[h]	TONT[i]	TUMA[j]	TUZI[k]
Corvus cryptoleucus	Chihuahuan raven	CHRA		X	X	X						X	
Spizella passerina	Chipping sparrow	CHSP	X	X	X	X	X	X	X	X	X	X	X
Anas cyanoptera	Cinnamon teal	CITE						X	X				X
Nucifraga columbiana	Clark's nutcracker	CLNU		X		X			X	X	X		
Petrochelidon pyrrhonota	Cliff swallow	CLSW	X	X		X	X	X	X	X	X	X	X
Empidonax occidentalis	Cordilleran flycatcher	COFL		X	X		X		X	X	X	X	X
Columbina passerina	Common ground-dove	COGD		X	X	X		X	X	X	X	X	
Bucephala clangula	Common goldeneye	COGO						X	X				X
Quiscalus quiscula	Common grackle	COGR							X				X
Accipiter cooperii	Cooper's hawk	COHA	X	X	X	X	X	X	X	X	X	X	X
Calypte costae	Costa's hummingbird	COHU	X		X	X		X	X	X	X	X	X
Gavia immer	Common loon	COLO							X				X
Mergus merganser	Common merganser	COME					X	X	X				X
Gallinula chloropus	Common moorhen	COMO						X	X				X
Chordeiles minor	Common nighthawk	CONI		X	X	X	X	X	X		X		X
Phalaenoptilus nuttallii	Common poorwill	COPW	X	X	X	X	X	X	X	X	X	X	X
Corvus corax	Common raven	CORA	X	X	X	X	X	X	X	X	X	X	X
Gallinago gallinago	Common snipe	COSN			X			X	X			X	X
Sterna hirundo	Common tern	COTE							X				
Geothlypis trichas	Common yellowthroat	COYE				X	X	X	X			X	X
Caracara cheriway	Crested caracara	CRCA							X				X
Toxostoma crissale	Crissal thrasher	CRTH		X	X	X		X	X	X	X	X	X
Phalacrocorax auritus	Double-crested cormorant	DCCO							X			X	X
Myiarchus tuberculifer	Dusky-capped flycatcher	DCFL		X	X	X	X		X	X		X	X
Junco hyemalis	Dark-eyed junco	DEJU		X	X	X	X	X	X	X	X	X	X
Spiza americana	Dickcissel	DICK							X				
Empidonax oberholseri	Dusky flycatcher	DUFL		X	X	X			X	X	X	X	X
Sialia sialis	Eastern bluebird	EABL		X	X					X			
Podiceps nigricollis	Eared grebe	EAGR							X				X
Sturnella magna lilianae	Eastern meadowlark	EAME		X	X	X			X	X			X

Appendix A. List of bird species recorded in Sonoran Desert Network parks, cont.

Scientific name	Common name	Species code	CAGR[a]	CHIR[b]	CORO[c]	FOBO[d]	GICL[e]	MOCA[f]	ORPI[g]	SAGU[h]	TONT[i]	TUMA[j]	TUZI[k]
Sayornis phoebe	Eastern phoebe	EAPH							X			X	
Euptilotis neoxenus	Eared quetzal (eared trogon)	EATR		X									
Steptopelia decaocto	Eurasian collared-dove	ECDO							X				X
Micrathene whitneyi	Elf owl	ELOW		X	X	X		X	X	X	X	X	X
Trogon elegans	Elegant trogon	ELTR		X	X					X		X	
Sturnus vulgaris	European starling	EUST	X			X		X	X	X	X	X	X
Anas penelope	Eurasian wigeon	EUWI						X					
Coccothraustes vespertinus	Evening grosbeak	EVGR		X		X		X	X	X	X		X
Buteo regalis	Ferruginous hawk	FEHA	X	X		X		X	X	X	X		X
Otus flammeolus	Flammulated owl	FLOW		X	X					X			
Passerella iliaca	Fox sparrow	FOSP		X	X	X			X	X			
Sterna forsteri	Forster's tern	FOTE							X				X
Larus pipixcan	Franklin's gull	FRGU							X				X
Anas strepera	Gadwall	GADW						X	X				X
Callipepla gambelii	Gambel's quail	GAQU	X	X	X	X	X	X	X	X	X	X	X
Ardea herodias	Great blue heron	GBHE	X			X	X	X	X		X	X	X
Regulus satrapa	Golden-crowned kinglet	GCKI							X				
Zonotrichia atricapilla	Golden-crowned sparrow	GCSP							X	X			
Junco hyemalis dorsalis	Gray-headed junco	GHJU		X	X	X							
Bubo virginianus	Great horned owl	GHOW	X	X	X	X	X	X	X	X	X	X	X
Colaptes chrysoides	Gilded flicker	GIFL	X		X				X	X	X	X	
Melanerpes uropygialis	Gila woodpecker	GIWO	X	X	X	X		X	X	X	X	X	X
Chloroceryle americana	Green kingfisher	GKIN										X	
Aquila chrysaetos	Golden eagle	GOEA		X	X	X	X	X	X	X	X		X
Dumetella carolinensis	Gray catbird	GRCA			X		X					X	
Ardea alba	Great egret	GREG	X						X			X	X
Empidonax wrightii	Gray flycatcher	GRFL	X	X	X	X	X	X	X	X	X	X	X
Asturina nitida	Gray hawk	GRHA								X		X	
Butorides virescens	Green heron	GRHE				X		X	X				X
Contopus pertinax	Greater pewee	GRPE		X	X	X				X			

Appendix A. List of bird species recorded in Sonoran Desert Network parks, cont.

Scientific name	Common name	Species code	CAGR[a]	CHIR[b]	CORO[c]	FOBO[d]	GICL[e]	MOCA[f]	ORPI[g]	SAGU[h]	TONT[i]	TUMA[j]	TUZI[k]
Geococcyx californianus	Greater roadrunner	GRRO	X	X	X	X		X	X	X	X	X	X
Ammondramus savannarum	Grasshopper sparrow	GRSP		X	X	X			X				
Vireo vicinior	Gray vireo	GRVI		X		X		X	X	X	X		X
Dendroica graciae	Grace's warbler	GRWA		X			X	X	X	X	X		
Tringa melanoleuca	Greater yellowlegs	GRYE							X				X
Quiscalus mexicanus	Great-tailed grackle	GTGR	X	X		X		X	X	X	X	X	X
Pipilo chlorurus	Green-tailed towhee	GTTO	X	X	X	X	X	X	X	X	X	X	X
Anser albifrons	Greater white-fronted goose	GWFG						X	X				X
Anas crecca	Green-winged teal	GWTE						X	X				X
Vermivora chrysoptera	Golden-winged warbler	GWWA						X	X				
Empidonax hammondii	Hammond's flycatcher	HAFL		X	X	X			X	X	X	X	X
Picoides villosus	Hairy woodpecker	HAWO		X	X		X		X	X		X	X
Larus heermanni	Heermann's gull	HEEG							X				
Larus argentatus	Herring gull	HERG							X				
Piranga flava	Hepatic tanager	HETA		X	X		X	X		X			
Catharus guttatus	Hermit thrush	HETH		X	X	X	X	X	X	X	X	X	X
Dendroica occidentalis	Hermit warbler	HEWA		X	X	X			X	X			X
Carpodacus mexicanus	House finch	HOFI	X	X	X	X	X	X	X	X	X	X	X
Eremophila alpestris	Horned lark	HOLA	X	X	X	X		X	X				
Lophodytes cucullatus	Hooded merganser	HOME						X	X				X
Icterus cucullatus	Hooded oriole	HOOR		X	X	X		X	X	X	X	X	X
Passer domesticus	House sparrow	HOSP	X		X	X		X	X	X	X	X	X
Wilsonia citrina	Hooded warbler	HOWA						X					
Troglodytes aedon	House wren	HOWR		X	X	X	X	X	X	X	X	X	X
Parabuteo unicinctus	Harris's hawk	HRSH	X		X			X	X	X	X		X
Vireo huttoni	Hutton's vireo	HUVI		X	X	X		X	X	X	X		
Passerina cyanea	Indigo bunting	INBU					X	X	X	X	X	X	X
Columbina inca	Inca dove	INDO	X		X				X	X		X	X
Baeolphus ridgwayi	Juniper titmouse	JUTI		X		X	X	X	X	X	X		X
Charadrius vociferus	Killdeer	KILL	X	X		X	X	X	X	X		X	X

Appendix A. List of bird species recorded in Sonoran Desert Network parks, cont.

Scientific name	Common name	Species code	CAGR[a]	CHIR[b]	CORO[c]	FOBO[d]	GICL[e]	MOCA[f]	ORPI[g]	SAGU[h]	TONT[i]	TUMA[j]	TUZI[k]
Carduelis lawrencei	Lawrence's goldfinch	LAGO							X	X	X		X
Calamospiza melanocorys	Lark bunting	LARB	X		X	X			X	X			X
Chondestes grammacus	Lark sparrow	LASP	X	X	X	X	X	X	X	X	X	X	X
Passerina amoena	Lazuli bunting	LAZB		X	X	X	X	X	X	X	X	X	X
Numenius americanus	Long-billed curlew	LBCU							X				X
Limnodromus scolopaceus	Long-billed dowitcher	LBDO							X				X
Egretta caerulea	Little blue heron	LBHE							X				X
Picoides scalaris	Ladder-backed woodpecker	LBWO	X	X	X	X		X	X	X	X	X	X
Toxostoma lecontei	Le Conte's thrasher	LCTH							X				X
Ixobrychus exilis	Least bittern	LEBI							X				X
Carduelis psaltria	Lesser goldfinch	LEGO	X	X	X	X	X	X	X	X	X	X	X
Tachybaptus dominicus	Least grebe	LEGR							X				
Chordeiles acutipennis	Lesser nighthawk	LENI	X			X		X	X	X	X	X	X
Asio otus	Long-eared owl	LEOW				X			X	X			X
Calidris minutilla	Least sandpiper	LESA							X				X
Aythya affinis	Lesser scaup	LESC						X	X				X
Sterna antillarum	Least tern	LETE							X				
Melanerpes lewis	Lewis's woodpecker	LEWO			X	X		X	X			X	X
Tringa flavipes	Lesser yellowlegs	LEYE				X			X				X
Melospiza lincolnii	Lincoln's sparrow	LISP		X	X	X	X	X	X	X	X	X	X
Lanius ludovicianus	Loggerhead shrike	LOSH	X	X	X	X		X	X	X	X		X
Seiurus motacilla	Louisiana waterthrush	LOWA										X	
Calothorax lucifer	Lucifer's hummingbird	LUHU		X	X	X							
Vermivora luciae	Lucy's warbler	LUWA	X	X	X	X		X	X	X	X	X	X
Limosa fedoa	Marbled godwit	MAGO							X				X
Eugenes fulgens	Magnificent hummingbird	MAHU		X	X	X				X			
Falco sparverius	American kestrel	MAKE	X	X	X	X	X	X	X	X	X	X	X
Anas platyrhynchos	Mallard	MALL	X				X	X	X	X	X	X	X
Dendroica magnolia	Magnolia warbler	MAWA							X				
Cistothorus palustris	Marsh wren	MAWR						X	X				X

Appendix A. List of bird species recorded in Sonoran Desert Network parks, cont.

Scientific name	Common name	Species code	CAGR[a]	CHIR[b]	CORO[c]	FOBO[d]	GICL[e]	MOCA[f]	ORPI[g]	SAGU[h]	TONT[i]	TUMA[j]	TUZI[k]
Poecile sclateri	Mexican chickadee	MECH		X									
Aphelocoma ultramarina	Mexican jay	MEJA		X	X	X		X	X	X			X
Falco columbarius	Merlin	MERL	X		X	X		X	X	X	X		X
Oporornis tolmiei	MacGillivray's warbler	MGWA	X	X	X	X	X	X	X	X	X	X	X
Sialia currucoides	Mountain bluebird	MOBL		X	X	X		X	X	X	X	X	X
Poecile gambeli	Mountain chickadee	MOCH		X			X	X		X	X		
Zenaida macroura	Mourning dove	MODO	X	X	X	X	X	X	X	X	X	X	X
Cyrtonyx montezumae	Montezuma quail	MONQ		X	X	X	X			X		X	
Vermivora ruficapilla	Nashville warbler	NAWA	X	X	X	X		X	X	X	X	X	X
Camptostoma imberbe	Northern beardless-tyrannulet	NBTY		X				X	X	X		X	
Cardinalis cardinalis	Northern cardinal	NOCA		X	X	X		X	X	X	X	X	X
Colaptes auratus	Northern flicker	NOFL	X	X	X	X	X	X	X	X	X	X	X
Accipiter gentilis	Northern goshawk	NOGO		X	X			X		X	X		
Circus cyaneus	Northern harrier	NOHA	X	X	X	X		X	X	X	X		X
Mimus polyglottos	Northern mockingbird	NOMO	X	X	X	X	X	X	X	X	X	X	X
Parula americana	Northern parula	NOPA										X	
Anas acuta	Northern pintail	NOPI						X	X				X
Glaucidium gnoma	Northern pygmy-owl	NOPO		X	X		X	X		X			
Seiurus noveboracensis	Northern waterthrush	NOWA				X		X	X			X	X
Stelgidopteryx serripennis	Northern rough-winged swallow	NRWS		X		X	X	X	X	X	X	X	X
Anas clypeata	Northern shoveler	NSHO						X	X				X
Aegolius acadicus	Northern saw-whet owl	NSWO		X					X				X
Myiarchus nuttingi	Nutting's flycatcher	NUFL							X				
Vermivora celata	Orange-crowned warbler	OCWA	X	X	X	X	X	X	X	X	X	X	X
Peucedramus taeniatus	Olive warbler	OLWA		X			X			X			
Junco hyemalis oreganus	Oregon junco	ORJU		X	X	X							
Contopus cooperi	Olive-sided flycatcher	OSFL		X		X		X	X	X	X	X	X
Pandion haliaetus	Osprey	OSPR		X		X		X	X	X	X		X
Seiurus aurocapilla	Ovenbird	OVEN			X				X			X	
Passerina ciris	Painted bunting	PABU		X		X			X			X	

Appendix A. List of bird species recorded in Sonoran Desert Network parks, cont.

Scientific name	Common name	Species code	CAGR[a]	CHIR[b]	CORO[c]	FOBO[d]	GICL[e]	MOCA[f]	ORPI[g]	SAGU[h]	TONT[i]	TUMA[j]	TUZI[k]
Myioborus pictus	Painted redstart	PARE		X	X		X		X	X	X		X
Podilymbus podiceps	Pied-billed grebe	PBGR						X	X				
Podilymbus podiceps podiceps	Pied-billed grebe	PBGR							X				X
Heliomaster constantii	Plain-capped starthroat	PCST			X								
Falco peregrinus	Peregrine falcon	PEFA	X	X	X	X	X	X	X	X	X	X	X
Phainopepla nitens	Phainopepla	PHAI	X	X	X	X		X	X	X	X	X	X
Gymnorhinus cyanocephalus	Pinyon jay	PIJA		X	X	X	X	X	X	X	X		X
Carduelis pinus	Pine siskin	PISI		X	X	X		X	X	X	X		X
Vireo plumbeus	Plumbeous vireo	PLVI		X	X	X	X	X	X	X		X	X
Falco mexicanus	Prairie falcon	PRFA	X	X	X	X			X	X	X		X
Empidonax difficilis	Pacific-slope flycatcher	PSFL							X	X	X	X	X
Junco hyemalis mearnsi	Pink-sided junco	PSJU		X	X	X							
Carpodacus purpureus	Purple finch	PUFI			X			X	X		X		X
Progne subis	Purple martin	PUMA		X			X	X	X	X	X		X
Sitta pygmaea	Pygmy nuthatch	PYNU		X			X	X		X			
Cardinalis sinuatus	Pyrrhuloxia	PYRR		X	X	X			X	X		X	
Pheucticus ludovicianus	Rose-breasted grosbeak	RBGR		X	X	X			X	X			
Larus delawarensis	Ring-billed gull	RBGU							X				X
Mergus serrator	Red-breasted merganser	RBME							X				
Sitta canadensis	Red-breasted nuthatch	RBNU		X					X	X			
Sphyrapicus ruber	Red-breasted sapsucker	RBSA			X				X				
Regulus calendula	Ruby-crowned kinglet	RCKI		X	X	X		X	X	X	X	X	X
Aimophila ruficeps	Rufous-crowned sparrow	RCSP		X	X	X		X	X	X	X	X	X
Loxia curvirostra	Red crossbill	RECR		X			X	X	X	X			X
Aythya americana	Redhead	REDH						X	X				X
Phalaropus fulicarius	Red phalarope	REPH							X				
Vireo olivaceus	Red-eyed vireo	REVI							X		X		
Cardellina rubrifrons	Red-faced warbler	RFWA		X	X		X		X	X	X		X
Melanerpes erythrocephalus	Red-headed woodpecker	RHWO						X					
Buteo lagopus	Rough-legged hawk	RLHA		X		X		X	X				X

Appendix A. List of bird species recorded in Sonoran Desert Network parks, cont.

Scientific name	Common name	Species code	CAGR[a]	CHIR[b]	CORO[c]	FOBO[d]	GICL[e]	MOCA[f]	ORPI[g]	SAGU[h]	TONT[i]	TUMA[j]	TUZI[k]
Aythya collaris	Ring-necked duck	RNDU						X	X				X
Phasianus colchicus	Ring-necked pheasant	RNEP						X					
Phalaropus lobatus	Red-necked phalarope	RNPH							X				X
Sphyrapicus nuchalis	Red-naped sapsucker	RNSA		X	X	X	X	X	X	X	X		X
Columba livia	Rock pigeon	RODO	X		X			X	X	X		X	X
Platalea ajaja	Roseate spoonbill	ROSP							X				
Salpinctes obsoletus	Rock wren	ROWR	X	X	X	X	X	X	X	X	X	X	X
Pachyramphus aglaiae	Rose-throated becard	RTBE										X	
Buteo jamaicensis	Red-tailed hawk	RTHA	X	X	X	X	X	X	X	X	X	X	X
Oxyura jamaicensis	Ruddy duck	RUDU						X	X				X
Selasphorus rufus	Rufous hummingbird	RUHU		X	X	X	X	X	X	X	X		X
Agelaius phoeniceus	Red-winged blackbird	RWBL	X					X	X	X	X	X	X
Aimophila carpalis	Rufous-winged sparrow	RWSP			X				X	X		X	
Grus canadensis	Sandhill crane	SACR	X	X		X			X				
Xema sabini	Sabine's gull	SAGU							X				X
Sayornis saya	Say's phoebe	SAPH	X	X	X	X	X	X	X	X	X	X	X
Amphispiza belli	Sage sparrow	SASP						X	X	X			X
Oreoscoptes montanus	Sage thrasher	SATH				X		X	X	X	X		X
Myiodynastes luteiventris	Sulphur-bellied flycatcher	SBFL		X	X					X		X	
Icterus parisorum	Scott's oriole	SCOR		X	X	X		X	X	X	X	X	X
Callipepla squamata	Scaled quail	SCQU		X	X	X				X			
Piranga olivacea	Scarlet tanager	SCTA							X		X		
Asio flammeus	Short-eared owl	SEOW						X					
Charadrius semipalmatus	Semipalmated plover	SEPL							X				
Egretta thula	Snowy egret	SNEG						X	X			X	X
Chen caerulescens	Snow goose	SNGO						X	X				X
Porzana carolina	Sora	SORA						X	X				X
Tringa solitaria	Solitary sandpiper	SOSA							X				X
Melospiza melodia	Song sparrow	SOSP			X	X		X	X	X	X	X	X
Strix occidentalis lucida	Mexican spotted owl	SPOW		X		X				X	X		

Appendix A. List of bird species recorded in Sonoran Desert Network parks, cont.

Scientific name	Common name	Species code	CAGR[a]	CHIR[b]	CORO[c]	FOBO[d]	GICL[e]	MOCA[f]	ORPI[g]	SAGU[h]	TONT[i]	TUMA[j]	TUZI[k]
Anthus spragueii	Sprague's pipit	SPPI							X				
Actitis macularia	Spotted sandpiper	SPSA				X	X	X	X	X		X	X
Pipilo maculatus	Spotted towhee	SPTO		X	X	X	X	X	X	X	X		X
Accipiter striatus	Sharp-shinned hawk	SSHA		X	X	X		X	X	X	X	X	X
Tyrannus forficatus	Scissor-tailed flycatcher	STFL							X				
Cyanocitta stelleri	Steller's jay	STJA		X	X	X	X	X	X	X	X		X
Icturus pustulatus	Streak-backed oriole	STRO			X								
Calidris himantopus	Stilt sandpiper	STSA							X				
Piranga rubra	Summer tanager	SUTA		X	X	X		X	X	X	X	X	X
Passerculus sandwichensis	Savannah sparrow	SVSP			X	X			X	X			X
Buteo swainsoni	Swainson's hawk	SWHA	X	X	X	X		X	X	X	X	X	X
Empidonax traillii traillii	Southwestern willow flycatcher	SWIFL										X	
Melospiza georgiana	Swamp sparrow	SWSP			X				X				
Catharus ustulatus	Swainson's thrush	SWTH			X	X			X			X	X
Tyrannus crassirostris	Thick-billed kingbird	TBKI							X				
Vermivora peregrina	Tennessee warbler	TEWA							X				
Myadestes townsendi	Townsend's solitaire	TOSO		X	X	X	X	X	X	X	X	X	X
Dendroica townsendi	Townsend's warbler	TOWA		X	X	X	X	X	X	X	X	X	X
Tyrannus melancholicus	Tropical kingbird	TRKI							X			X	
Tachycineta bicolor	Tree swallow	TRSW							X	X			X
Cygnus columbianus	Tundra swan	TUSW							X				X
Cathartes aura	Turkey vulture	TUVU	X	X	X	X	X	X	X	X	X		X
Passerina versicolor	Varied bunting	VABU							X	X		X	
Chaetura vauxi	Vaux's swift	VASW		X		X		X	X	X		X	X
Ixoreus naevius	Varied thrush	VATH			X				X				
Amazilia violiceps	Violet-crowned hummingbird	VCHU		X	X								
Pyrocephalus rubinus	Vermilion flycatcher	VEFL		X	X			X	X	X	X	X	X
Auriparus flaviceps	Verdin	VERD	X	X	X	X		X	X	X	X	X	X
Pooecetes gramineus	Vesper sparrow	VESP	X	X	X	X		X	X	X			X
Tachycineta thalassina	Violet-green swallow	VGSW		X	X	X	X	X	X	X	X	X	X

Appendix A. List of bird species recorded in Sonoran Desert Network parks, cont.

Scientific name	Common name	Species code	CAGR[a]	CHIR[b]	CORO[c]	FOBO[d]	GICL[e]	MOCA[f]	ORPI[g]	SAGU[h]	TONT[i]	TUMA[j]	TUZI[k]
Rallus limicola limicola	Virginia rail	VIRA						X	X				X
Vermivora virginiae	Virginia's warbler	VIWA	X	X	X	X	X	X	X	X	X	X	X
Vireo gilvus	Warbling vireo	WAVI		X	X	X	X	X	X	X	X	X	X
Sitta carolinensis	White-breasted nuthatch	WBNU		X	X	X	X	X	X	X	X	X	X
Zonotrichia leucophrys	White-crowned sparrow	WCSP	X	X	X	X	X	X	X	X	X	X	X
Sialia mexicana	Western bluebird	WEBL		X	X	X	X	X	X	X	X		X
Empidonax occidentalis or difficilis	Western flycatcher	WEFL				X		X					
Aechmophorus occidentalis	Western grebe	WEGR							X				X
Hylocharis leucotis	White-eared hummingbird	WEHU		X	X								
Tyrannus verticalis	Western kingbird	WEKI	X	X	X	X		X	X	X	X	X	X
Sturnella neglecta	Western meadowlark	WEME	X	X	X	X		X	X	X	X		X
Calidris mauri	Western sandpiper	WESA							X				X
Aphelocoma californica	Western scrub-jay	WESJ		X	X	X	X	X	X	X	X	X	X
Megascops kennicottii	Western screech-owl	WESO		X	X	X	X	X	X	X	X	X	X
Piranga ludoviciana	Western tanager	WETA	X	X	X	X	X	X	X	X	X	X	X
Helmitheros vermivorus	Worm-eating warbler	WEWA										X	
Contopus sordidulus	Western wood-pewee	WEWP	X	X	X	X	X	X	X	X	X	X	X
Plegadis chihi	White-faced Ibis	WFIB						X	X			X	X
Megascops trichopsis	Whiskered screech-owl	WHSO		X	X					X			
Empidonax traillii	Willow flycatcher	WIFL		X	X	X		X	X	X		X	X
Catoptrophorus semipalmatus	Willet	WILL						X	X				X
Phalaropus tricolor	Wilson's phalarope	WIPH						X	X				X
Sphyrapicus thyroideus	Williamson's sapsucker	WISA		X	X	X		X		X			
Meleagris gallopavo	Wild turkey	WITU		X	X		X			X	X		
Wilsonia pusilla	Wilson's warbler	WIWA	X	X	X	X	X	X	X	X	X	X	X
Troglodytes troglodytes	Winter wren	WIWR							X				X
Aix sponsa	Wood duck	WODU						X	X				X
Mycteria americana	Wood stork	WOST						X	X				
Caprimulgus vociferus	Whip-poor-will	WPWI		X	X	X				X			
Buteo albicaudatus	White-tailed hawk	WTHA							X				

Appendix A. List of bird species recorded in Sonoran Desert Network parks, cont.

Scientific name	Common name	Species code	CAGR[a]	CHIR[b]	CORO[c]	FOBO[d]	GICL[e]	MOCA[f]	ORPI[g]	SAGU[h]	TONT[i]	TUMA[j]	TUZI[k]
Elanus leucurus	White-tailed kite	WTKI			X				X				
Zonotrichia albicollis	White-throated sparrow	WTSP			X	X		X	X	X	X	X	X
Aeronautes saxatalis	White-throated swift	WTSW		X	X	X	X	X	X	X	X	X	X
Zenaida asiatica	White-winged dove	WWDO	X	X	X	X		X	X	X	X	X	X
Icteria virens	Yellow-breasted chat	YBCH			X	X	X	X	X	X	X	X	X
Coccyzus americanus occidentalis	Yellow-billed cuckoo	YBCU			X			X	X	X	X	X	X
Empidonax flaviventris	Yellow-bellied flycatcher	YBFL								X		X	
Sphyrapicus varius	Yellow-bellied sapsucker	YBSA			X	X			X	X	X		X
Rallus longirostris yumanensis	Yuma clapper rail	YCRA							X				X
Junco phaeonotus	Yellow-eyed junco	YEJU		X	X	X				X	X		
Xanthocephalus xanthocephalus	Yellow-headed blackbird	YHBL					X	X	X		X	X	X
Dendroica coronata	Yellow-rumped warbler	YRWA	X	X	X	X	X	X	X	X	X	X	X
Vireo flavifrons	Yellow-throated vireo	YTVI									X		
Dendroica petechia	Yellow warbler	YWAR	X	X	X	X	X	X	X	X	X	X	X
Buteo albonotatus	Zone-tailed hawk	ZTHA		X	X	X	X		X	X	X		X

See Table 1 of the protocol narrative for list of park acronyms.

[a] Powell et al. (2005c).

[b] Schmidt et al. (2005b).

[c] Powell et al. (2005d).

[d] Powell et al. (2005e).

[e] Powell et al. (2005a).

[f] Schmidt et al. (2006a).

[g] Schmidt et al. (2006b).

[h] Powell et al. (2006).

[i] Albrecht et al. (2005).

[j] Powell et al. (2005b).

[k] Schmidt et al. (2005a).

Revision History Log

Previous Version #	Revision date	Author	Changes made	Section and paragraph	Reason for change	New Version #

Appendix B. Field-Data Forms

Revision History Log

Previous Version #	Revision date	Author	Changes made	Section and paragraph	Reason for change	New Version #

This appendix includes field-data forms for recording (1) bird detections, (2) environmental features, (3) location data and broad-scale environmental data at each bird-count point, and (4) incidental observations. A portion of these datasheets should be copied onto Rite-in-the-Rain© paper. The landbird database will have data-entry screens that are similar to these data forms.

1. SODN Point-transect Landbird Surveys. Use these forms for conducting eight-minute point-transect counts. (Second form is to be printed on the back of the first).
2. Environmental Features at Survey Points: Subplots. Used for recording environmental features at each of four subplots associated with each bird-survey point.
3. Environmental Features at Survey Points: 75-m Plots. This form should be filled out the first time a point is established. The data form will provide clear directions to accessing sites from known locations and for recording environmental features within 75 m of bird-survey points.
4. Incidental Detections Data Form. This form is used for recording observations outside of the point-transect count period.
5. Establishing New Sites. This form is used when adding new sites or changing the location of an established site.

SODN Point-transect Landbird Surveys

Page ____ of _____

Copied: __________

Entered: _________

Proofed: _________

Verified: _________

Park code: __________ Transect/Group: ____________ Visit # ________ Protocol Version _______

Date (mm/dd/yyyy): _____ / _____ / __________ Observer (3-letter code): _________

Conditions: Temp. (°C) _____ /_____ Wind (0–6): _____ / _____ Humidity (%) _____ / _____

Cloud cover (%) _____ / _____ Precipitation (0–5) _____ / _____ Noise _____ / _____

Point	Start Time	Species	Minute	Distance	Detect type	Flock size	Sex	Age Class	Prev. Point	Comments

SODN Point-transect Landbird Surveys

Page _____ of _____

Park code: ___________ Transect/Group: _____________

Date (mm/dd/yyyy): _____ / _____ / ___________ Observer (3-letter code): __________

Point	Start Time	Species	Minute	Distance	Detect type	Flock size	Sex	Age Class	Prev. Point	Comments

Point Transect Data Form: Categories, Definitions, and Descriptions

Wind

Wind 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	Fresh breeze, small trees sway (30–39 km/h)
6	Strong breeze, large branches moving, wind whistles (40–50 km/h)

Precipitation

Precipitation code	Explanation
0	No precipitation
1	Mist or fog
2	Light drizzle
3	Light rain
4	Heavy rain; difficult to hear birds; discontinue count
5	Snow

Background noise

Noise code	Explanation
0	Quiet; normal background noises; 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

Detection type

Code	Description
V	Visual detection
A	Auditory detection
B or V/A	Both visual and auditory

Breeding codes

Code	Explanation
CN	Carrying nesting material (e.g., stick, grass, mud, cobwebs. This applies for all species except some species of wrens (cactus, Bewick's, house, marsh) and verdins.
NB	Nest building seen at actual nest site, excluding some species of wrens (see above), woodpeckers, and verdins.
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. Do not use for species that build multiple nests in a breeding season, such as cactus wrens and verdins.
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. Note: barely fledged blackbirds and swallows may fly considerable distances. Presence of young cowbirds confirms both cowbird and host.
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.

SODN Landbird Monitoring:
Environmental Features at Survey Points (Subplots)

Page ____ of _____

Copied: __________

Entered: _________

Proofed: _________

Verified: _________

Park code: ________ Date (mm/dd/yyyy): _____ / _____ / __________

Observer (3-letter code): _________ Transect/Group: _____________ Point ID: __________

SUBPLOT: ______ Photos Taken: Yes No

CANOPY COVER: (maximum = 96) N) _____ E) _____ S) _____ W) _____

HORIZONTAL VEGETATION COVERAGE (cover pole from 5 m): Obs. A ______ Obs. B ______

Dominant species in overstory
(>3-m height; 10-m radius plot)

Species	Cover estimate	# trees
Other		
Totals	**100%**	

Dominant species in understory
(<3-m height; 5-m radius plot)

Species	Cover estimate
Other	
Totals	**100%**

GROUND COVER (1.8 m plot)

Type	Cover class
Leaf litter	
Grass litter	
Bare soil	
Rock	
Woody debris	
Unvegetated	

FOLIAR COVER (1.8 m plot)

Type	Cover class	Type	Cover class
Perennial grass		Moss and fern	
Annual grass		Shrubs & vines	
Forbs		Total foliar cover	
Cactus			
Succulents			

Subplot notes: ____

____

____

Modified Daubenmire cover classes.

Cover class	Explanation
0	None present
1	0–1% coverage of measured variable
2	2–5% coverage of measured variable
3	6–25% coverage of measured variable
4	26–50% coverage of measured variable
5	51–75% coverage of measured variable
6	76–95% coverage of measured variable
7	96–100% coverage of measured variable

SODN Landbird Monitoring:
Environmental Features at Survey Points (75-m plots)

Page ____ of _____

Copied: __________

Entered: _________

Proofed: _________

Verified: _________

Park code: ________ Date (mm/dd/yyyy): _____ / _____ / __________

Observer (3-letter code): _________ Point ID: __________

Description of how to get to point or transect from known location: __________________________

____

____

UTM coordinates (NAD 83, Zone 12): UTMX: _________ UTMY: ______________________

POINT ATTRIBUTES: (75-m radius from center)

Slope (o): ________ Slope variability: high med low Aspect (o): _______

Aspect Variability: high med low

Topographic position:

Level Lower-slope Mid-slope Upper-slope Escarpment/face Ledge Crest Depression Draw

COVER TYPE

Vegetation type	Cover class	Vegetation type	Cover class
Sonoran Desert upland		Conifer forest	
Xeroriparian wash		Other	
Mesic riparian wash		Other	
Semidesert grassland			
Oak forest and woodland			

Other cover types	Cover class
Road	
Pasture (ag field)	
Standing water Stream	

Plot notes: ____

____

____

Modified Daubenmire cover classes.

Cover class	Explanation
0	None present
1	0–1% coverage of measured variable
2	2–5% coverage of measured variable
3	6–25% coverage of measured variable
4	26–50% coverage of measured variable
5	51–75% coverage of measured variable
6	76–95% coverage of measured variable
7	96–100% coverage of measured variable

Attach copy of 7.5 minute USGS quad map

SODN Incidental Detections Data Form

Date (mm/dd/yyyy): _____ / _____ / __________ Observer (3-letter code): _________

Taxon	Park	Date	Time	Species	No. of individuals	Sex	Age class	UTM	Comments (breeding behavior, etc.)
								/	
								/	
								/	
								/	
								/	
								/	
								/	
								/	
								/	
								/	
								/	
								/	
								/	

SODN Landbird Monitoring: Establishing New Sites

Download date: ___________

Uploaded to all units?: Y N

Park code: ________ Date (mm/dd/yyyy): _____ / _____ / __________

Observer (3-letter code): _________ Plot ID: __________

Description of how to get to point or transect from known location: ____

____

____

UTM coordinates (NAD 83, Zone 12):

Point: UTMX: ______________ UTMY: ________________

Point: UTMX: ______________ UTMY: ________________

Point: UTMX: ______________ UTMY: ________________

Point: UTMX: ______________ UTMY: ________________

Point: UTMX: ______________ UTMY: ________________

Point: UTMX: ______________ UTMY: ________________

Point: UTMX: ______________ UTMY: ________________

Point: UTMX: ______________ UTMY: ________________

Park code: ________ Date (mm/dd/yyyy): _____ / _____ / __________

Observer (3-letter code): _________ Plot ID: __________

Description of how to get to point or transect from known location: ____

____

____

UTM coordinates (NAD 83, Zone 12):

Point: UTMX: ______________ UTMY: ________________

Point: UTMX: ______________ UTMY: ________________

Point: UTMX: ______________ UTMY: ________________

Point: UTMX: ______________ UTMY: ________________

Point: UTMX: ______________ UTMY: ________________

Point: UTMX: ______________ UTMY: ________________

Point: UTMX: ______________ UTMY: ________________

Point: UTMX: ______________ UTMY: ________________

Point: UTMX: ______________ UTMY: ________________

Section 4
Supplements

Supplement A: Sample Size and Power for Trend in Landbird Density Estimation

Version 1.02 (May 5, 2007)

Revision History Log

Previous Version #	Revision date	Author	Changes made	Section and paragraph	Reason for change	New Version #

Introduction

Determining the effort required to estimate a population parameter, such as density, is essential when designing a monitoring program (Gibbs et al. 1998; Bart et al. 2004). Without this initial assessment to guide design and inform cost, effort expended on sampling may be inadequate to meet program objectives. The number of samples needed, and the frequency with which they are measured, are often the most important considerations when designing a monitoring program, because they greatly influence program cost. In the proposed program, our primary goal is to derive annual estimates of density for a subset of species, yet the number of samples required depends, in part, on the desired level of precision of these estimates (see Figure A.1 and Thomas et al. 2005). The coefficient of variation (CV) is an estimate of precision used to calculate log-based confidence intervals around density estimates, making it a useful tool for planning monitoring programs (Buckland et al. 2001); the larger the confidence interval, the lower our ability to detect trends (i.e., lower statistical power). Conversely, the smaller the confidence interval, the greater our ability to detect trends, yet more samples are needed to obtain

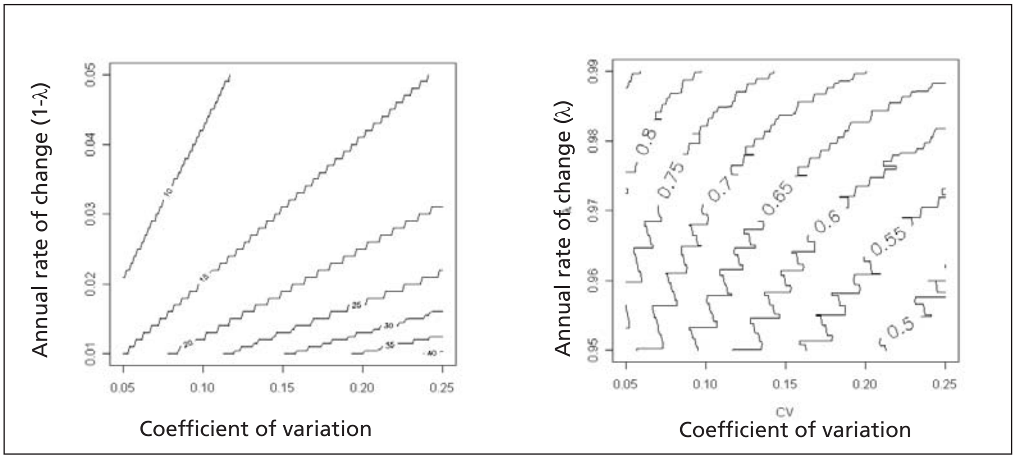


Figure A.1. (left) The number of years required to monitor so that power to detect a log-linear population trend is 0.9 (assuming two-tailed t-test and α = 0.1).

Annual rate of change (1-λ) is a typical range of values that we would expect for most bird populations. See text for description of coefficient of variation. (right) The relative size of the population after the number of years from (left). Note difference in y axis between two figures. From Thomas et al. (2004:103).

higher precision. For example, with a target CV of 15%, it would take approximately 19 years to detect a 2% annual change in density (power = 0.9 and $\alpha = 0.10$). In contrast, by increasing CV to 25% it would take six additional years to detect the same change.

Prospective power analysis can aid the efficiency of a monitoring program by providing an understanding of the tradeoffs between effort, cost, and the magnitude and probability of a trend that can be detected. During power analysis, these design elements can each be varied to determine a range of appropriate designs for meeting the desired objective (see Gerrodette 1987; Steidl et al. 1997; Gibbs et al. 1998). Statistical power is the probability of correctly rejecting a null hypothesis (i.e., no trend) that is false. Power analysis has four interrelated components: (1) power, (2) sample size, (3) α or the Type I error rate (probability of incorrectly concluding a trend has occurred when one has not), and (4) effect size or magnitude of the trend of interest (e.g., a 2% annual change). The expected sampling variance (σ^2) or coefficient of variation (σ/μ) is incorporated into power analyses and has an important effect on power; high variance leads to lower power or higher estimates of sample sizes needed to obtain precise estimates. In general, the ability to detect a trend is a function of the magnitude of the trend, variation around the trend line, and the amount of time or leverage over which the trend is assessed.

In this supplement, we assess the effects of variation around a trend line on power. More specifically, we assess whether initial density estimates at a specified level of precision are adequate for monitoring population trends by accounting for inter-annual (temporal) variation in estimates that, when high, can obscure trends that are actually occurring (Type II error) and result in lower power. Many planning efforts use a single estimate of variance—usually a combination of spatial and short-term, within-season temporal variance (process variation) and sampling error—to estimate power and calculate sample sizes. Without additional information, combining both process and sampling variation into one estimate of variance is a reasonable approach when designing a monitoring program if no other information is available. However, assessing each component of variance separately will augment efficiency, because each type of variance, and its magnitude, can have important consequences on trend detection (Urquhart et al. 1998; Kincaid et al. 2004; Sims et al. 2006).

To determine the efficacy of a range of potential designs with varying effort to monitor landbirds in Sonoran Desert Network (SODN) parks, we used pilot data collected at these parks to estimate density at various levels of precision for a subset of species. Using these data, we estimated the number of species in each of several vegetation communities for which density can be estimated across a range of encounter rates. We then used data from one park for which multiple years of data were available to determine the magnitude of each component of variance and its influence on statistical power and trend detection. Based on these analyses, we determined that a sufficient number of species can be monitored with the resources available, but sampling effort must be partitioned strategically to obtain sufficient samples to estimate some species, especially those with low encounter rates. This information will inform both our initial sampling effort and suggest ways to analyze data after the first 3–5 years after the program is implemented to determine if the program is meeting its stated objectives.

Methods

Study area

The Sonoran Desert Network includes 11 national parks in southern Arizona and New Mexico (see protocol narrative). The area is known for high diversity of plants and animals as a result of varied biogeographic affinities of species in the region, including those of the Sonoran, Chihuahuan, and Mojave deserts, Rocky Mountains, Sierra Madre Occidental, and Great Plains (McLaughlin 1986). Other important factors that influence diversity include a range of topographic, geologic, edaphic, and climatic factors, and variable land-use histories (Marshall et al. 2000). Taken together, these physical and biological factors make the network parks representative of the diverse landscape in which they are embedded.

Five dominant vegetation communities are found in SODN parks, separated by elevation (see Whittaker and Niering 1965). Sonoran Desert upland occurs at the lowest elevations and is dominated by mixed cactus, paloverde, creosote (*Larrea tridentata*), and bursage (*Ambrosia* spp.). Sonoran Desert upland transitions to semi-desert grasslands dominated by perennial grasses and, in most parks, by mesquite and other short trees and shrubs. Valley-bottom semi-desert grasslands make up small portions of only two parks (Chiricahua National Monument and Coronado National Memorial). Pine-oak forest and woodland, dominated by four species of oak (*Quercus* spp.), juniper, and pinyon pine occur above semi-desert grassland and are common in four parks. Mixed conifer forests dominated by fir (*Abies* spp.), ponderosa and Apache pine (*Pinus* spp.), and some Gambel oak (*Quercus gambelii*) occur in the highest-elevation areas. Broadleaf riparian woodlands, dominated by cottonwood and willow (*Populus* spp.), sycamore (*Platanus wrightii*), and dense understory, are located along perennial streams and rivers and are bordered by Sonoran Desert upland and pine-oak forest and woodland in many SODN parks.

Data analysis: Initial sample-size estimation and allocation of effort

We used data collected at nine SODN parks between 2001 and 2005 (see Powell et al. 2006). Data were collected using the point-transect survey method, which employs distance sampling from fixed survey points (Buckland et al. 2001), each spaced 250 m apart along transects. Survey effort from 2001–2005 did not include Organ Pipe Cactus National Monument or Montezuma Castle National Monument, both of which received thorough inventories prior to recent efforts and employed different survey methodologies. Because some parks were visited for two consecutive years, we randomly selected data from a single year within each park to eliminate the possibility that variation in our estimates resulted from among-year changes in abundance. The resulting dataset included 1,413 station visits at 50 point transects, totaling 19,790 bird detections of 190 species. We further reduced the dataset by considering only those species that were summer breeding residents within SODN parks ($n = 107$), leaving a total of 19,479 bird detections. Because the proportion of effort among parks and vegetation communities during this pilot study was similar to that which we propose, these data were adequate to evaluate the efficacy of allocating survey effort.

When estimating population parameters, precision and sampling efficiency are higher when considered within groupings that reflect their inherent organization in nature (Krebs 1999). Therefore, we stratified transects by vegetation communities as patterns of bird species occurrence varied among communities: (1) upland and (2) riparian transects in desert scrub/grassland and (3) upland and (4) riparian transects in woodland/forest.

The survey design for the landbird monitoring program (see protocol narrative) uses many of the same sampling elements that were used in the pilot effort, most notably the use of survey stations arranged in transects and multiple revisits to the same transects within each field season. From these pilot data we sought to determine the number of station visits (K; the number of stations multiplied by the number of visits) needed to estimate density. First, we calculated encounter rates as the total number of detections of a species divided by K. We excluded detections of birds that were flying over points and birds detected outside of the eight-minute count period. While not always appropriate for monitoring population trends because they are uncorrected for detectability (Williams et al. 2002), encounter rates are useful for assessing sample-size requirements for density estimation (Buckland et al. 2001). The relationship between encounter rates and the number of samples required to estimate density is provided by the following formula (Buckland et al. 2001):

$$K = \left(\frac{b}{\left\{ cv\left(\hat{\mathrm{D}}\right) \right\}^2} \right) \bullet \left(\frac{K_0}{n_0} \right)$$

Equation 1.1.

where $cv(\hat{\mathrm{D}})$ is the desired coefficient of variation or level of precision for the estimate of density, and K_0/n_0 is the inverse of the encounter rate determined from pilot data. Note that b is a variance-inflation parameter equal to the number of detections (n) multiplied by the CV of the density estimate [$cv(\hat{\mathrm{D}})$] that can be determined with pilot data. Although the value of b is often between 2 and 4 (Eberhardt 1978) and often assumed to be 3 for planning point-transect surveys (Buckland et al. 2001), we estimated b to provide more precise estimates of K

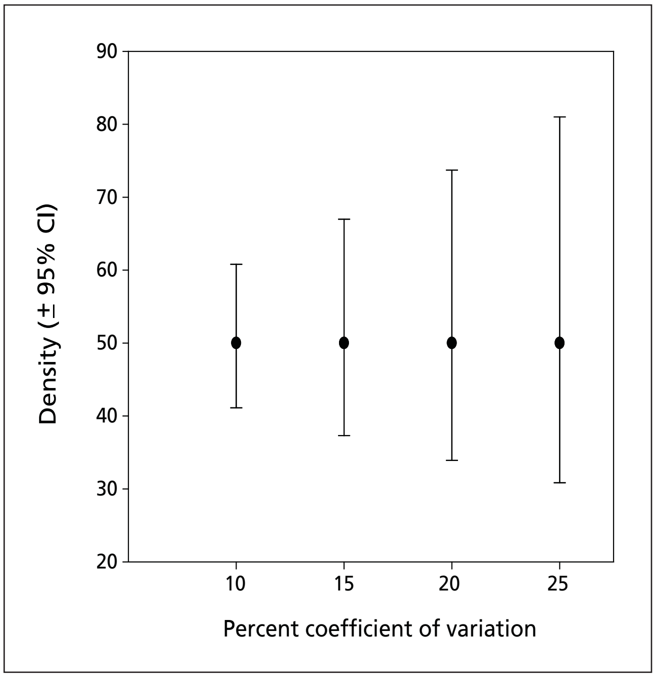


Figure A.2. Effect of coefficient of variation on precision of density estimates for a hypothetical species with density of 50 birds/km^2.

Note that the lower confidence limit is smaller than upper confidence limit; see Equation 1.2.

and to guide future planning efforts.

We used Distance Version 5 (Thomas et al. 2005) to calculate density and $cv(\hat{D})$ for a subset of species with varying encounter rates. We considered detections and effort only within those vegetation types in which each species was known to breed, and excluded data from vegetation types where species occurred as migrants. This resulted in four groups of species: (1) those found across all vegetation types combined, (2) those found at high elevations (woodland/forest and high-elevation riparian) or (3) low elevation desert/grassland, and (4) those restricted to low-elevation riparian areas. When using Distance, we fit both uniform and half-normal key functions with cosine, simple polynomial, and hermite polynomial series expansions to distance data of each species and selected models with the lowest AIC (Akaike information criterion; goodness of fit measure). We truncated 1–5% of observations farthest from count stations to improve model fit and placed detection data in intervals if histograms of detection distances indicated heaping.

To estimate the relationship between encounter rates and *K*, we selected 28 species with at least 30 detections across a range of variation in numbers of detections and patterns of occurrence among vegetation communities. Encounter rates varied from 0.032 to 0.960; effort varied from 328 to 1,413 point visits within each community. We plotted encounter rates of all 28 species versus *K* (from Equation 1.1) at three levels of precision (10, 15, and 20% CV) and selected the function that best fit these data as indicated by the lowest possible residual variation at each level of precision. Because we suspected that detectability could be an important covariate in the relationship between encounter rates and *K*, we assessed this relationship using both quadratic and linear regression. To estimate detectability, we determined the relationship between effective detection radius (e.g., distance at which detectability equals 0.5) for the 28 species for which density and detectability were estimated and mean detection distance. Because both variables were highly correlated ($r = 0.98$, $P < 0.0001$), we used mean detection distance for all 107 species as a covariate.

To determine the most efficient allocation of sample effort for our monitoring program, we used these equations to predict *K* for all 107 species. We considered two levels of proposed sampling effort: one with 2,324 station visits (full program) and another with half this effort (reduced program). As a starting point, we subdivided this effort to yield 1,833 station visits in desert/grasslands, 432 in low-elevation riparian areas, 920 in high-elevation riparian areas, and 488 station visits in woodland/forests. This allocation of effort was roughly proportional to the spatial coverage of vegetation types and similar to that from the pilot surveys; therefore, it required no adjustment in encounter rates due to among-vegetation differences for each species. We then predicted *K* using expected encounter rates and determined the number of species within each type for which density could be estimated with CV equal to 15%. We chose 15% because it presented a reasonable tradeoff between the overly restrictive (and therefore expensive) 10% and 20%, which may only be appropriate for detecting large changes in populations. As an example, an increase in CV from 15% to 20% results in a 20% increase in the width of confidence intervals around density estimates (Figure A.2). Using these calculations, we were able to estimate the number of species in each vegetation community and reallocate sampling effort according to these results. By reallocating effort among vegetation types, we were able to evaluate the efficacy of a number of potential program designs, each with a specified level of effort.

Variance partitioning

We used data from Organ Pipe Cactus National Monument (ORPI; NPS 1998) to determine if our initial estimates of sample size derived in the previous section were appropriate. Specifically, those estimates incorporate only spatial variance and one component of temporal (within-year) variance. Using data from ORPI, we were able to estimate two additional sources of temporal variance that may affect the precision of trend estimates.

In its most simple form, variance about the trend line (*β*) is expressed as:

$$\text{var}(\beta) = \frac{\sigma^2}{\sum (Y_i - \bar{Y})^2}$$

Equation 1.2.

This model can be expanded to incorporate components of variance from a multi-site, year, and visit model of variance partitioning. In an analysis of variance frameworks, there are four types of variance that can be estimated for landbirds (Lewis 1978; Urquhart et al. 1998; Kincaid et al. 2004). Population or spatial variance (σ^2_s) represents difference in abundance among sites as the result of site-specific factors such as vegetation and elevation. Year-to-year (coherent; Larson et al.) temporal variance (σ^2_y) is variation among years at all sites combined, and is a result of regional phenomena such as productivity and survivorship and broad-scale climatic conditions, such as a wet or dry year. Ephemeral, or site-x year variance, (σ^2_e) is independent, year-to-year variance, whereby abundance at each site tracks local resources independently of other sites and is a result of local factors such as rainfall, changes in land use, fire, or measures of habitat quality. If multiple measurements are not taken within each year at the same sites, this type of variance cannot be partitioned and it becomes part of σ^2_r. Residual (σ^2_r), the fourth type of variance, is made up of variance that is not explained by other components, including both process and sampling variance. Residual variance is an important source of variation in wildlife monitoring and includes within-season variance, observer bias, data handling, and miscellaneous errors.

These four types of variance can be used to expand Equation 1.2 to:

$$\text{var}(\beta) = \frac{\dfrac{\sigma_s^2}{s} + \sigma_y^2 + \dfrac{\sigma_e^2 + \dfrac{\sigma_r^2}{v}}{s}}{\sum (y_i - \bar{y})^2}$$

Equation 1.3.

where s = number of sites, y = number of years, and v = number of within-season visits.

At ORPI, nine transects were surveyed three times per year from mid- to late February to early May in 2000, 2002, and 2003. Each transect had eight points spaced approximately 500 m apart. Detections of each bird were noted in 50-m distance bands, and all data were collected by the same skilled observer. We used this dataset because it was the only one that had multiple within-season visits across >2 years. The bird community at ORPI is very similar to that of other parks in the network that have Sonoran Desert upland vegetation communities and were included in the previous analyses.

For this analysis, we used nine focal species: black-tailed gnatcatcher, black-throated sparrow, verdin, northern mockingbird, Gila woodpecker, curve-billed thrasher, house finch, cactus wren, and phainopepla. These species are all common resident breeders, chosen because they were present throughout the survey window each year. We used all detection data from within the first three distance bands (i.e., ≤150 m). We assumed that detectability among transects was not a significant source of error (which we tested using Analysis of Variance (ANOVA) and found no statistically significant differences; B. Powell, *unpublished data*). Also, we assumed that plot-specific detectability did change among years—a phenomenon that seems unlikely in such a short time period.

To partition variation into its constituent components, we first detrended the data by taking the mean encounter rate for each transect across years and subtracting annual estimates of encounter rates for each year. Detrend-

$$\sigma^2_{total} = \sigma^2_s + \sigma^2_y + \sigma^2_e + \sigma^2_r$$

$$\sigma^2_r = MS_r$$

$$\sigma^2_s = \frac{MS_s - MS_e}{Ny \times Nv}$$

$$\sigma^2_y = \frac{MS_y - MS_e}{Ns \times Nv}$$

$$\sigma^2_e = \frac{MS_e - MS_r}{Nv}$$

Equation 1.4.

ing ensures that differences among years are reflected in σ^2_y (Kincaid et al. 2004). Next, we summed the number of detections for each of three inter-annual visits to each transect and transformed these count data using log + 1 to better meet the assumptions of normality. We then calculated variance components with ANOVA using the Variability Chart function in the statistical program JMP. As a result, we calculated the variance components of Equation 1.3 (next page) as from Lewis (1978), where MS = mean squares from Equation 1.3. We partitioned the sum of squares (SS) from ANOVA to MS by SS/*df*.

Power analysis

We used each of the four types of variance outlined in the previous section to estimate power of trend detection for three species at ORPI that exemplified extreme differences in types of variance. These species represented a range of total variance in relation to their mean encounter rate (black-tailed gnatcatcher = 48%; black-throated sparrow = 63%; phainopepla = 130%). Using the open-source statistical power analysis package R (Version 2.2.1; script "power.fcn" included in this protocol), we varied effect size (1–3% annual change in density) and sample size. We maintained $\alpha = 0.10$ throughout to guard against Type II errors. Using these initial estimates of power, we then simulated sampling designs that approximated our effort. We simulated power by varying the percent contributions of each of three sources of variance (ephemeral, year, and residual) while holding the other two sources constant at 0%. We did not include site variance in this simulation exercise because it has little or no effect on trend detection when the sampling design includes revisits to the same sites over time (Kincaid et al. 2004), as was the case with our design (see protocol narrative).

Results

Initial sample-size estimation

Of the 107 species that occur as breeders within the SODN parks we considered, 31 were found across all vegetation communities, and 33, 25, 10, and 8 were restricted to high elevations, low elevations, low-elevation riparian areas, and both low-elevation riparian areas and high elevations, respectively (Table A.1; see end of this SOP). Mean encounter rates did not vary systematically among vegetation communities ($F_{4, 101} = 1.34$, $P = 0.26$, ANOVA) yet encounter rates tended to be higher at low elevations (mean ± SE = 0.27 ± 0.04) and in low-elevation riparian areas (0.25 ± 0.07) and lower at high elevations (0.14 ± 0.04). Encounter rates among all communities averaged 0.20 ± 0.02. Within the vegetation communities in which each occurred, encounter rates were high for Gambel's quail (0.97), Gila woodpecker (1.04), Bell's vireo (0.75), cactus wren (0.83), and Bewick's wren (0.74), moderate for summer tanager (0.39), brown-crested flycatcher (0.35), and song sparrow (0.28), and low for Abert's towhee (0.09), cordilleran flycatcher (0.09), and hermit thrush (0.09).

For the 28 species for which we estimated density and $cv(\hat{D})$, density (± CV) varied from 0.003 ± 0.283 to 0.355 ± 0.116 individuals/ha (Table A.2; see end of this SOP). As expected, there was a strong linear relationship between encounter rates and $cv(\hat{D})$ ($t_{26} = 4.57$, $P < 0.0001$), with each one-unit increase in encounter rate resulting in a 0.21 ± 0.05 (± SE) decrease in $cv(\hat{D})$. The scaling parameter *b* averaged 3.23 ± 0.15 (± SE), with 50% of values ranging from 2.60 to 4.00 (range = 2.04–4.84). The scaling parameter increased linearly with both encounter rate and density ($t_{26} \geq 2.69$, $P \leq 0.012$); each one-unit increase in encounter rate resulted in a 1.54 ± 0.57 increase in *b*, whereas each one-unit increase in density resulted in a 4.14 ± 1.47 increase in *b*.

The relationship between encounter rates and *K* (i.e., the number of point visits) was best described by a reciprocal model with the form $K = 1/a(n_0/K_0) + b$, where *a* and *b* are coefficients that are constant (Figure A.3). This relation-

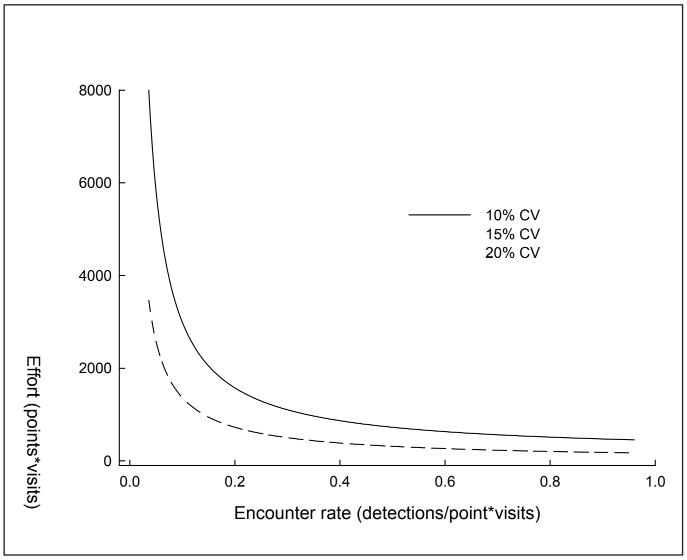


Figure A.3. Relationship between encounter rate and the number of point visits required to estimate density at three levels of precision using distance sampling.

Relationships were determined using detection data and effort from a sample of 28 bird species detected during pilot surveys during 1,413 point counts within nine Sonoran Desert Network parks between 2000 and 2005. Prediction equations for each curve follow a reciprocal relationship K = 1/a(n0/K0) + b where a and b are coefficients that are constant. Coefficient b equals 2.258 x 10-5, 5.306 x 10-5, or 9.093 x 10-5 and coefficient a equals 0.00269, 0.00662, or 0.0118, at CV 10, 15, and 20% respectively.

ship is simply the reciprocal of a standard least-squares regression equation, where *a* is the slope and *b* is the y-intercept, and is similar to a power function, $K = a(n_0/K_0)^b$, where *b* is a scaling component equal to the slope from linear regression in log-log space and a is the y-intercept in log space. To determine *K* required to estimate density at $cv(\hat{D})$ of 10, 15, and 20%, we evaluated the model coefficient *b* as 2.258×10^{-5}, 5.306×10^{-5}, or 9.093×10^{-5}, and the model coefficient *a* as 0.00269, 0.00662, or 0.0118, respectively, depending on the desired CV. Detectability, as indexed by mean detection distance, did not describe any variation in *K* ($P \geq 0.77$), and was therefore not included in the model.

Using our initial scenario of 2,324 station visits allocated, as indicated above, we were able to estimate density with CV of 15% for 45 of the 107 species (42%) using the full program and 25 species (23%) for the reduced program (Table A.1). These species, however, were not equally distributed among species groups. For the full program, density was estimable at CV 15% for more species that occurred across all vegetation types (65%) and those that occurred exclusively at low elevations (60%) than for species at high elevations (12%) or in low-elevation riparian areas (20%). The minimum number of observations required to estimate density at CV 15% across all species was 77 (encounter rate = 0.04 detections per eight-minute count).

The *K* required to estimate density with CV 10 and 20% varied widely from those at CV 15%. For the 31 species that occurred across all vegetation types, for example, 2.26 times more effort was required, on average, to estimate density with CV 10% than that for CV 15%, yet

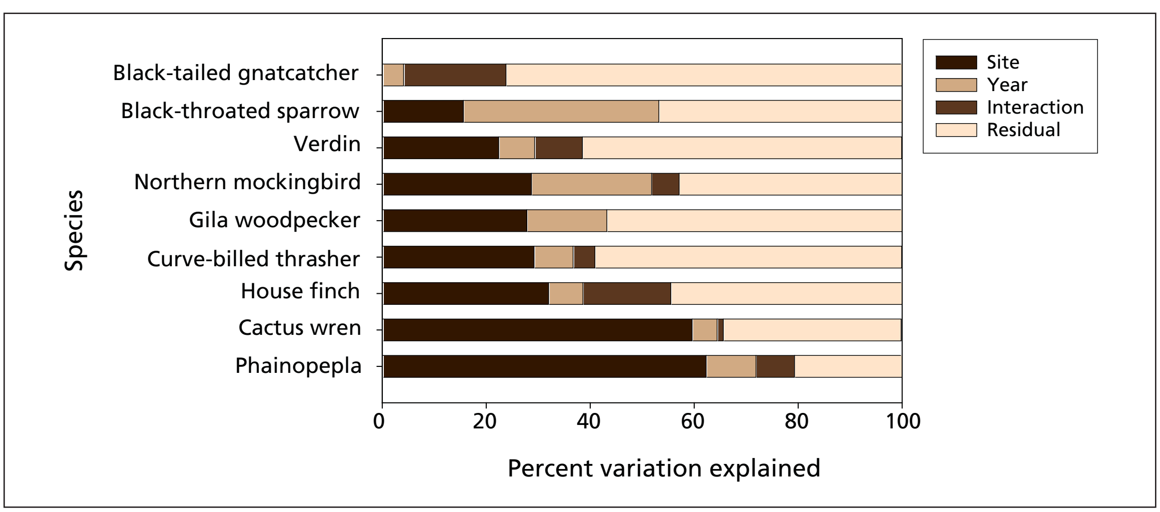


Figure A.4. Percent variance attributed to each of the four main sources of error from ANOVA models, Organ Pipe Cactus National Monument.

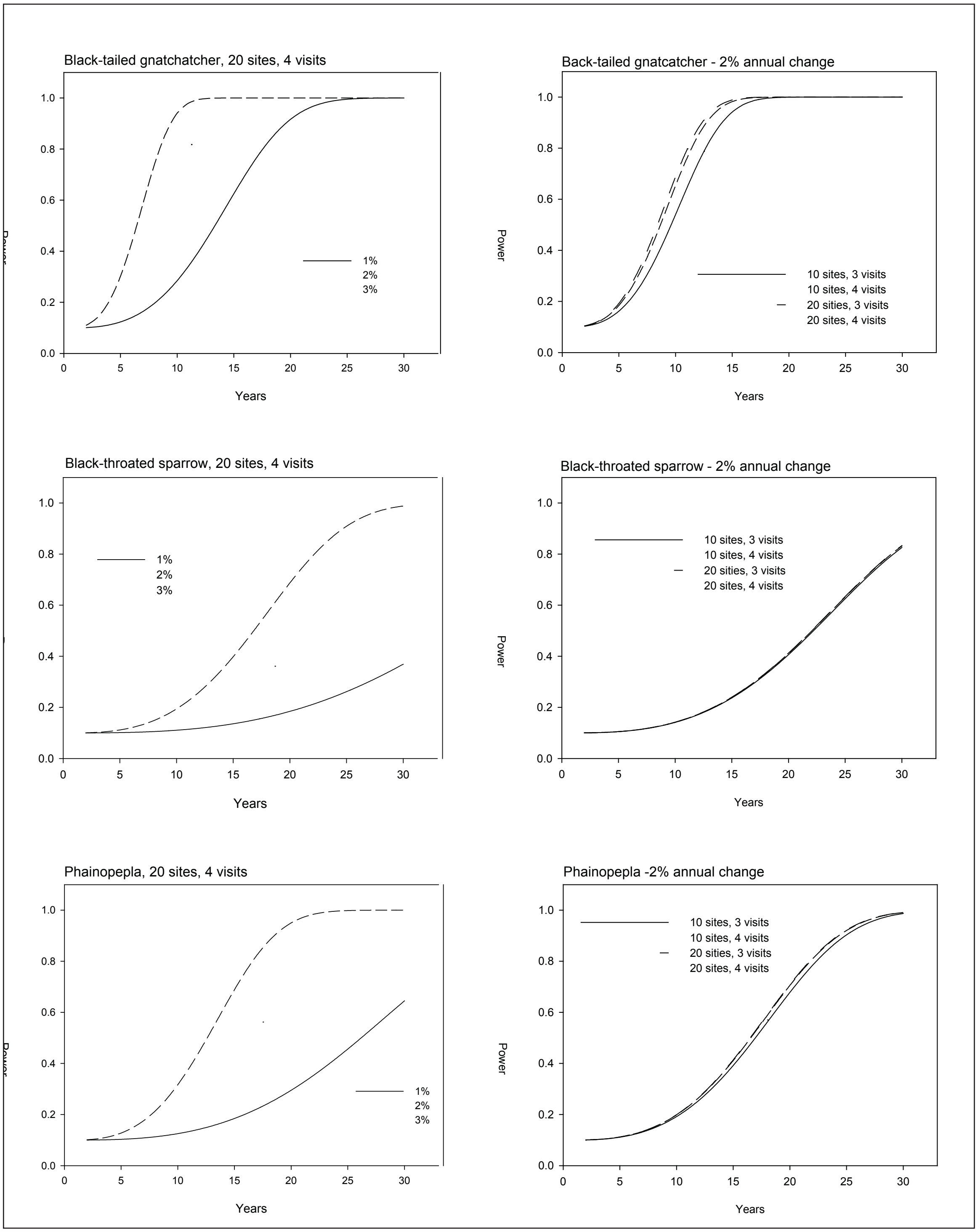


Figure A.5. *Left:* Statistical power curves for 1–3% annual change in abundance for three species from Figure A.4. *Right:* Effect of varying the number of visits and number of sites on our ability to detect trends.

only 43% less effort was required to estimate CV 20%.

Variance partitioning and power analysis

The percent of total variance attributable to each of the four sources of variance showed strikingly different patterns among species (Figure A.4). For all but two species, year and ephemeral variance accounted for less variance than both site and residual variance. The percent variance explained by site ranged from 0% for the black-tailed gnatcatcher to 62% for the phainopepla. Conversely, residual variance ranged from 76% for the black-tailed gnatcatcher to 20% for the phainopepla. Residual variance made up >40% of the total variance for seven of the nine species. Most notably, site variance for phainopepla made up 67% of the total variance for the species, and ephemeral and year variances made up only 14% of the total variance. By contrast, 40% of total variance for the black–throated sparrow was made up of ephemeral and year variances.

Different sources of variance and varying sampling strategies influenced power to detect temporal trends in abundance, as illustrated by three of the species we investigated (Figure A.5). Power to detect trends in abundance was greatest for the black-tailed gnatcatcher and approximately four times less (averaged among designs) for the black-throated sparrow (Figure A.5). Power was intermediate for the phainopepla, despite the fact that the total variance was >2 times that for the black-throated sparrow.

Power simulations for a hypothetical species with a mean encounter rate of 1.0 indicated that site variance had an overwhelming effect on power (Figure A.6). When we evaluated each of the three sources of variance separately, so that each equaled 10% of the mean encounter rate, we found that we could detect a 3% annual change (power = 0.8) after five years with residual variance alone, after eight years with ephemeral variance alone, and after 21 years with year variance alone. Even with only 1% of the encounter rate attributable to year variance, the ability to detect a 3% annual change in abundance could be realized after nine years.

Discussion

When designing any monitoring effort, determining the effort needed to estimate population parameters and detect changes in these parameters over time is essential. Monitoring programs may not be worth pursuing if the level of effort required exceeds available financial resources. We attempted to address these issues for the SODN landbird monitoring program by using pilot data recently collected within parks. First, we investigated the sample sizes necessary to obtain initial estimates of density across several levels of precision for species that occurred in four vegetation community types present in the parks. Next, we used a long-term dataset to partition variance components and investigate power to detect trends.

Program feasibility

Efforts to estimate the number of point visits needed to estimate density indicated that a reasonable number of species could be monitored with the effort facilitated by an annual program budget of $24,000, but few of these species were in high-elevation communities (Table A.1). Based on these findings and on recent clarification of the budget, we suggest reallocating survey effort among the different communities. Our overall suggestion, based on sampling efficiency, logistical constraints, and anticipated budget levels, is to reduce sampling at high elevations to once every 3–5 years, unless additional resources can be obtained. One reason for this suggestion is that in most SODN parks (Chiricahua NM, Coronado NM, Gila Cliff Dwellings NM, and Saguaro NP) high-elevation areas had much lower encounter rates than other communities, and therefore would require roughly twice as many point visits to obtain the same encounter rates as at low elevations. This lower encounter rate, coupled with the steep terrain and long travel time among points in most parks (see Supplement B), means that these surveys are inefficient when compared to those conducted in low-elevation areas.

Despite these challenges, high-elevation communities are particularly susceptible to change due to global climate change and increases in the number and severity of wildland fires. Climate change, in particular, will likely alter the structure of forest communities at highest elevations in the near term (Allen and Breshears 1998). If these changes are realized, we expect them to occur over longer time periods (15–50

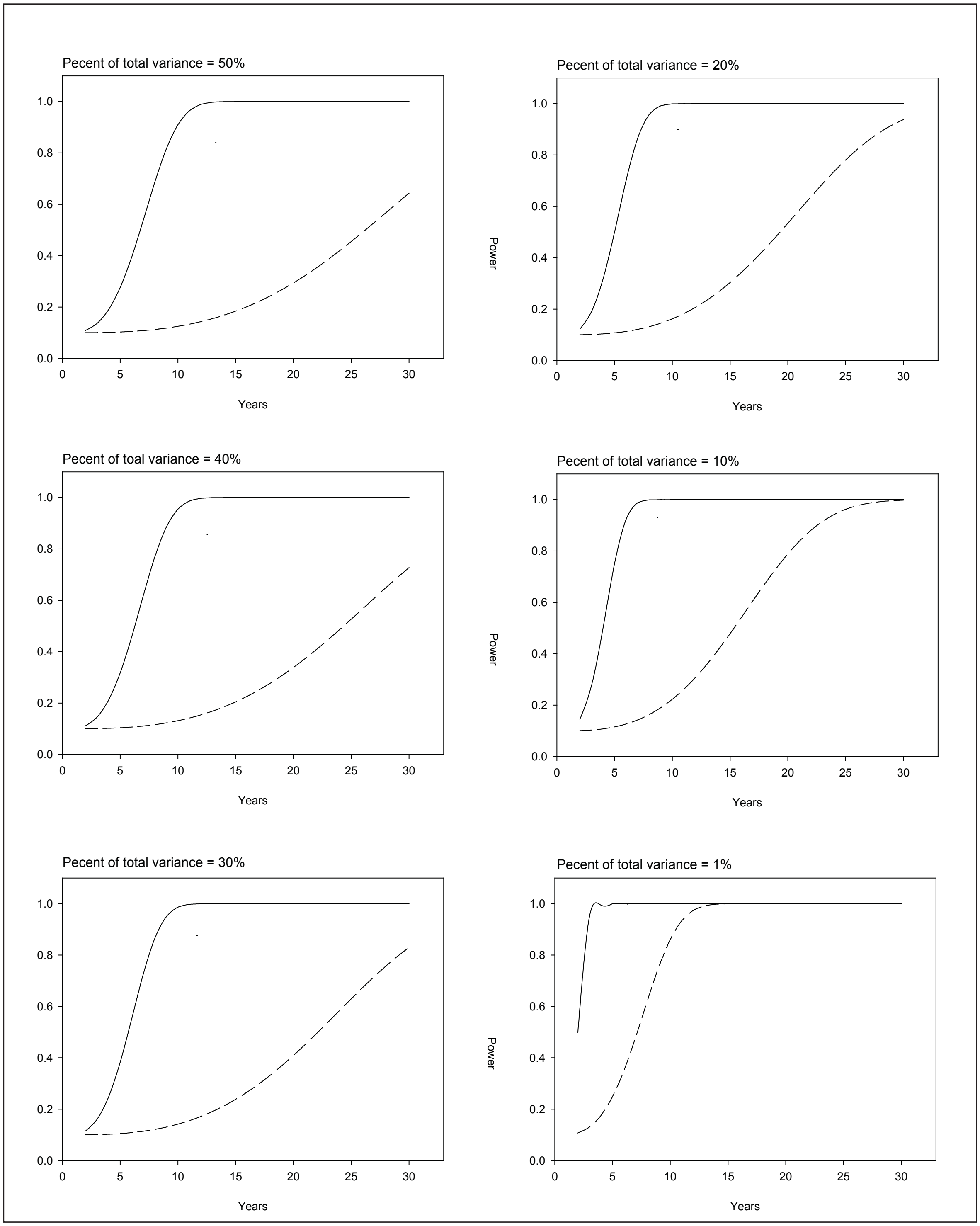


Figure A.6. Simulation of landbird monitoring data to show the relative influence of different types of variance components on statistical power (using code "Power.fcn").

Dashed line = year variance; dotted line = ephemeral variance; solid line = residual variance. Each simulation involves holding the three other variance components at 0% of total variance. Site variance was not included because the sampling design we chose involves revisits to the same sites and therefore site variance does not affect our ability to detect trends. For all figures: = 0.10; trend = 3% annual change; number of sites = 20, number of visits = 3.

years), with corresponding changes to bird species abundance and community composition. Therefore, allocating sufficient effort to obtain precise estimates of abundance every 3–5 years seems prudent to balance the high cost of sampling and the need to detect changes in bird parameters. Further, obtaining additional funds from other sources may facilitate more frequent sampling in these areas.

The annual budget for bird surveys will likely be fixed at $20–25K/year for the first few years, with additional funds needed during years when surveying occurs at high elevations. At low elevations, we will allocate effort that would have gone to high-elevation areas to increase number of sites and revisits in riparian areas (Table A.1). The focus on these areas seems justified because of their regional importance and because of conservation concern for many riparian-obligate species. Even after reallocating effort, it may only be possible to estimate density with a CV of 20% or greater for some species. Increasing precision of density estimates can also be accomplished by further stratifying riparian areas to maximize encounters of species of conservation value, particularly those that inhabit mesoriparian areas. We have attempted to accomplish this in the spatial sample design.

Other sampling design choices

We determined that we could estimate biologically meaningful changes in abundance of a sufficient number of species in select communities to warrant implementation of the monitoring protocol. Yet, based on other analyses (Figure A.5), it seems our initial estimates of sample size may be somewhat naïve, particularly for those species that exhibit significant year variance (Figure A.6). In light of this natural phenomenon, which no amount of extra sampling can remedy, our ability to detect trends may be compromised. We refer the reader to Larson et al. (2001) for a detailed discussion of the different types of variation and their consequences for trend detection. In short, the addition of more monitoring sites and/or visits can increase trend detection, but only to a point, because the numerator becomes dominated by time. Even more important from a program-design perspective is that if year variance is significant, then there is little that can be done except wait for time to pass.

Panel	Sample occasion (year)									
	1	2	3	4	5	6	7	8	9	10
1	x	x	x	x	x	x	x	x	x	x
2	x					x				
3		x					x			
4			x					x		
5				x					x	
6					x					x
7	x					x				
8		x					x			
9			x					x		
10				x					x	
11					x					x

Figure A.7. Typical panel design used in long-term monitoring programs.

Our analysis was based on data from a single park. Unfortunately, we do not have data to inform us of how many species in our monitoring region experience the different types of variance we investigated, and to what degree. In fact, to our knowledge, there are no published manuscripts that assess the effects of different sources of variance on trend detection for birds (but see Harding et al. 2005 for single-species example).

Because variance has such an important influence on trend detection and cost, we chose a sampling design that will inform this variance partitioning effort in future years. Specifically, we will err on the side of oversampling for the first few years to capture these sources of variance and enable a thorough review after 3–5 years. These analyses will help to refine our sampling design. More specifically, we will use these data to investigate use of panel designs (e.g., Urquhart et al. 1998; McDonald 2003) for some communities, such as uplands. There are numerous types of panel designs involving various combinations of either revisiting the same sites in a repeating pattern or visiting all new sites each year. The most common panel design, the augmented serial alternating design, for example, involves annual visitation to a small number of sites, and annual sampling of a larger number of sites on an annual repeating pattern of 2–10 years (Figure A.7). These designs were not selected because they involve complicated, even uncertain analyses, but are expected to be refined in the future.

In addition to the variance partitioning and power analyses explored in this effort, we also suggest a more thorough analysis of residual variance that can be controlled by modifying the protocol. For example, if the amount of variance attributed to observers is unacceptably high, then it may be appropriate to investigate ways to reduce this type of variance by hiring more-skilled observers. Within-season variance may also be an important source of variation (Link et al. 1994) that can be appropriately controlled by shifting the survey window. Miscellaneous errors include incorrect identification, data handling, and analytical errors, which can be controlled through quality-control and quality-assurance procedures.

Finally, it is worth noting that we excluded analysis of the three other parameters of interest that can be evaluated using the same sampling design and survey methods: occupancy, relative abundance, and species richness (see protocol narrative). Though we recommend analyses of these parameters, we focused our initial effort on density because it is the most desirable parameter. If it was determined that we could derive only a few density estimates, then we would have concentrated on other parameters or chosen not to pursue further development of the landbird-monitoring protocol.

Literature Cited

Allen, C. D., and D. D. Breshears. 1998. Drought-induced shift of a forest-woodland ecotone: Rapid landscape response to climate variation. Proceedings of the National Academy of Sciences of the United States of America **95**:14839–14842.

Bart, J., K. P. Burnham, E. H. Dunn, C. M. Francis, and C. J. Ralph. 2004. Goals and strategies for estimating trends in landbird abundance. Journal of Wildlife Management **68**:611–626.

Buckland, S. T., D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borchers, and L. Thomas. 2001. Introduction to distance sampling: Estimating abundance of biological populations. Oxford, U.K.: Oxford University Press.

Eberhardt, L. L. 1978. Appraising variability in population studies. Journal of Wildlife Management **42**:207–238.

Gerrodette, T. 1987. A power analysis for detecting trends. Ecology **68**:1364–1372.

Gibbs, J. P., S. Droege, and P. Eagle. 1998. Monitoring populations of plants and animals. BioScience **48**:935–940.

Harding, A. M. A., J. F. Piatt, G. V. Byrd, S. A. Hatch, N. B. Konyukhov, E. U. Golubova, and J. C. Williams. 2005. Variability in colony attendance of crevice-nesting horned puffins: Implications for population monitoring. Journal of Wildlife Management **69**:1279–1296.

Kincaid, T. M., D. P. Larsen, and N. S. Urquhart. 2004. The structure of variation and its influence on the estimation of status: Indicators of condition of lakes in the northeast, U.S.A. Environmental Monitoring and Assessment **98**:1–21.

Krebs, C. J. 1999. Ecological methodology. Second edition. Menlo Park, Ca.: Addison-Welsey Educational Publishers.

Larsen, D. P., T. M. Kincaid, S. E. Jacobs, and N. S. Urquhart. 2001. Designs for evaluating local and regional scale trends. Bioscience **51**:1069–1078.

Lewis, W. M. 1978. Comparison of temporal and spatial variation in the zooplankton of a lake by means of variance components. Ecology **59**:666–671.

Link, W. A., R. J. Barker, J. R. Sauer, and S. Droege. 1994. Within-site variability in surveys of wildlife populations. Ecology **75**:1097–1108.

Marshall, R. M., S. Anderson, M. Batcher, P. Comer, S. Cornelius, R. Cox, A. Gondor, D. Gori, J. Humke, R. Paredes Aguilar, I. E. Parra, and S. Schwartz. 2000. An ecological analysis of conservation priorities in the Sonoran Desert Ecoregion. Prepared by The Nature Conservancy Arizona Chapter, Sonoran Institute, and Instituto del Medio Ambiente y el Desarrollo Sustentable del Estado de Sonora, with support from Department of Defense Legacy Program.

McDonald, T. L. 2003. Review of environmental monitoring methods: Survey designs. Environmental Monitoring and Assessment **85**:277–292.

McLaughlin, S. P. 1986. A floristic analysis of the southwestern United States. Great

Basin Naturalist **46**:46–55.

National Park Service (NPS). 1998. Organ Pipe Cactus National Monument ecological monitoring program annual report 1994. Organ Pipe Cactus National Monument, Ajo, Arizona.

Powell, B. F., C. A. Schmidt, and W. L. Halvorson. 2006. Vascular plant and vertebrate inventory of Saguaro National Park, Rincon Mountain District. USGS OFR 2006-1075. USGS, Southwest Biological Science Center, Sonoran Desert Research Station, University of Arizona, Tucson, Arizona.

Sims, M., S. Wanless, M. P. Harris, P. I. Mitchell, and D. A. Elston. 2006. Evaluating the power of monitoring plot designs for detecting long-term trends in the numbers of common guillemots. Journal of Applied Ecology **43**:537–546.

Steidl, R. J., J. P. Hayes, and E. Schauber. 1997. Statistical power analysis in wildlife research. Journal of Wildlife Management **61**:270–279.

Thomas, L., K. P. Burnham, and S. T. Buckland. 2004. Temporal inferences from distance sampling survey. Pages 71–105 *in* S. T. Buckland, D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borshers, and L. Thomas, eds. Advanced distance sampling. New York: Oxford University Press.

Thomas, L., J. L. Laake, S. Strindberg, F. F. C. Marques, S. T. Buckland, D. L. Borchers, D. R. Anderson, K. P. Burnham, S. L. Pollard J. H. Hedley, J. R. B. Bishop, and T. A. Marques. 2005. Distance 5.0. Release Beta 5. Research Unit for Wildlife Population Assessment, University of St. Andrews, Scotland. http:/www.ruspa.st-and.ac.uk/distance.

Urquhart, N. S., S. G. Paulsen, and D. P. Larsen. 1998. Monitoring for policy-relevant regional trends over time. Ecological Applications **8**:246–257.

Whittaker, R. H., and W. A. Niering. 1965. Vegetation of the Santa Catalina Mountains, Arizona: A gradient analysis of the south slope. Ecology **46**:429–452.

Williams, B. K., J. D. Nichols, and M. J. Conroy. 2002. Analysis and management of animal populations. San Diego, Ca.: Academic Press.

Table A.1. Number of surveys (point visits) needed for initial estimates of density with 15% confidence intervals on density estimates, Sonoran Desert Network parks.

Community	Species	Point visits for initial proposed program: Full (48K/year)	Point visits for initial proposed program: Reduced (24K/year)	Encounter rate	Number of point visits needed	Species adequately monitored by effort: Full	Species adequately monitored by effort: Reduced
All communities	Bewick's wren	2,324	1,162	0.74	201	X	X
	White-winged dove	2,324	1,162	0.73	205	X	X
	Mourning dove	2,324	1,162	0.67	222	X	X
	Ash-throated flycatcher	2,324	1,162	0.61	245	X	X
	Spotted towhee	2,324	1,162	0.36	411	X	X
	Northern mockingbird	2,324	1,162	0.29	514	X	X
	House finch	2,324	1,162	0.28	523	X	X
	Canyon towhee	2,324	1,162	0.26	560	X	X
	Rufous-crowned sparrow	2,324	1,162	0.26	566	X	X
	Canyon wren	2,324	1,162	0.25	586	X	X
	Brown-headed cowbird	2,324	1,162	0.23	637	X	X
	Scott's oriole	2,324	1,162	0.22	671	X	X
	Cassin's kingbird	2,324	1,162	0.21	692	X	X
	Ladder-backed woodpecker	2,324	1,162	0.17	846	X	X
	Bridled titmouse	2,324	1,162	0.10	1,365	X	
	Bushtit	2,324	1,162	0.10	1,410	X	
	Rock wren	2,324	1,162	0.10	1,410	X	
	Lesser goldfinch	2,324	1,162	0.10	1,439	X	
	Blue grosbeak	2,324	1,162	0.06	2,086	X	
	Blue-gray gnatcatcher	2,324	1,162	0.06	2,171	X	
	Black-chinned sparrow	2,324	1,162	0.06	2,363		
	Black-chinned hummingbird	2,324	1,162	0.05	2,502		
	Common raven	2,324	1,162	0.03	3,598		
	Say's phoebe	2,324	1,162	0.03	3,723		
	Purple martin	2,324	1,162	0.02	4,709		
	Greater roadrunner	2,324	1,162	0.02	4,815		
	Anna's hummingbird	2,324	1,162	0.02	5,876		
	Cooper's hawk	2,324	1,162	0.02	6,042		
	Turkey vulture	2,324	1,162	0.02	6,405		
	Juniper titmouse	2,324	1,162	0.02	6,405		
	Red-tailed hawk	2,324	1,162	0.01	7,811		
High-elevation forest	Mexican jay	488	244	0.54	276	X	
	Black-headed grosbeak	488	244	0.50	299	X	
	Black-throated gray warbler	488	244	0.49	301	X	
	Hutton's vireo	488	244	0.30	489	X	
	Hepatic tanager	488	244	0.28	519		
	American robin	488	244	0.25	583		
	Plumbeous vireo	488	244	0.21	694		

Table A.1. Number of surveys (point visits) needed for initial estimates of density with 15% confidence intervals on density estimates, Sonoran Desert Network parks, cont.

Community	Species	Point visits for initial proposed program		Encounter rate	Number of point visits needed	Species adequately monitored by effort	
		Full (48K/ year)	Reduced (24K/ year)			Full	Reduced
High-elevation forest, cont.	Acorn woodpecker	488	244	0.18	792		
	Western tanager	488	244	0.16	874		
	Yellow-eyed junco	488	244	0.16	892		
	Steller's jay	488	244	0.16	912		
	Painted redstart	488	244	0.15	942		
	Grace's warbler	488	244	0.13	1,102		
	House wren	488	244	0.13	1,102		
	Arizona woodpecker	488	244	0.12	1,147		
	Virginia's warbler	488	244	0.10	1,442		
	Cordilleran flycatcher	488	244	0.09	1,467		
	Hermit thrush	488	244	0.09	1,519		
	Mountain chickadee	488	244	0.08	1,814		
	Brown creeper	488	244	0.06	2,083		
	Red-faced warbler	488	244	0.06	2,191		
	Warbling vireo	488	244	0.06	2,249		
	Yellow-rumped warbler	488	244	0.06	2,376		
	Broad-tailed hummingbird	488	244	0.05	2,596		
	Band-tailed pigeon	488	244	0.05	2,678		
	Hairy woodpecker	488	244	0.04	2,860		
	Greater pewee	488	244	0.04	3,068		
	Pygmy nuthatch	488	244	0.04	3,068		
	Sulphur-bellied flycatcher	488	244	0.03	3,751		
	Red-breasted nuthatch	488	244	0.03	4,117		
	Solitary vireo type	488	244	0.03	4,117		
	Western bluebird	488	244	0.03	4,117		
	Olive warbler	488	244	0.03	4,329		
High-elevation riparian	Dusky-capped flycatcher	920	460	0.30	491	X	
	Western wood-pewee	920	460	0.20	716	X	
	Yellow-breasted chat	920	460	0.20	716	X	
	Northern flicker	920	460	0.19	765	X	
	White-breasted nuthatch	920	460	0.14	1,038		
	Red-winged blackbird	920	460	0.09	1,471		
	Black phoebe	920	460	0.02	5,557		
	Common ground-dove	920	460	0.02	6,060		

Table A.1. Number of surveys (point visits) needed for initial estimates of density with 15% confidence intervals on density estimates, Sonoran Desert Network parks, cont.

Community	Species	Point visits for initial proposed program		Encounter rate	Number of point visits needed	Species adequately monitored by effort	
		Full (48K/ year)	Reduced (24K/ year)			Full	Reduced
Low-elevation desert/grassland	Gila woodpecker	1,833	917	1.04	148	X	X
	Gambel's quail	1,833	917	0.97	206	X	X
	Cactus wren	1,833	917	0.83	323	X	X
	Black-throated sparrow	1,833	917	0.55	806	X	X
Low-elevation desert/grassland, cont.	Verdin	1,833	917	0.55	262	X	X
	Lucy's warbler	1,833	917	0.43	166	X	X
	Northern cardinal	1,833	917	0.39	191	X	X
	Curve-billed thrasher	1,833	917	0.36	554	X	X
	Brown-crested flycatcher	1,833	917	0.35	307	X	X
	Phainopepla	1,833	917	0.18	426	X	X
	Black-tailed gnatcatcher	1,833	917	0.17	1,571	X	
	Pyrrhuloxia	1,833	917	0.13	7,488		
	Gilded flicker	1,833	917	0.10	8,816		
	Abert's towhee	1,833	917	0.09	675	X	X
	Rufous-winged sparrow	1,833	917	0.08	1,286	X	
	Western scrub-jay	1,833	917	0.08	2,667		
	Bullock's oriole	1,833	917	0.07	1,166	X	
	Great-tailed grackle	1,833	917	0.06	1,866	X	
	House sparrow	1,833	917	0.06	1,866	X	
	Crissal thrasher	1,833	917	0.05	2,195		
	Western kingbird	1,833	917	0.04	1,798	X	
	Varied bunting	1,833	917	0.03	2,017		
	Costa's hummingbird	1,833	917	0.02	5,157		
	Great horned owl	1,833	917	0.02	7,488		
	Montezuma quail	1,833	917	0.01	18,847		
Low-elevation riparian	Bell's vireo	432	216	0.75	199	X	X
	Summer tanager	432	216	0.39	378	X	
	Song sparrow	432	216	0.28	520		
	Yellow warbler	432	216	0.24	601		
	Vermilion flycatcher	432	216	0.22	666		
	Common yellowthroat	432	216	0.19	781		
	Broad-billed hummingbird	432	216	0.12	1,139		
	Gray hawk	432	216	0.11	1,320		
	Northern beardless-tyrannulet	432	216	0.09	1,622		
	Hooded oriole	432	216	0.08	1,735		

Encounter rate is from pilot survey efforts in each community and represents the average number of detections point visit. See text for formulas for calculating number of surveys needed. Allocation of sampling effort for "Initial proposed program" will change based on the findings of this exercise. See protocol narrative for additional information.

Table A.2. Sample-size requirements for estimating density of select birds species using distance sampling at three levels of precision.

Community/Species	Park unit										Obs (n)	Points x visits (K)	Encounter rate per point (n/K)	Density (no/ha)	CV (D)	Scaling Parameter b (n*CV2)	Estimate of K at %CV		
	CAGR	CHIR	CORO	FOBO	GICL	SAGU–RMD	SAGU–TMD	TONT	TUMA	TUZI							10%	15%	20%
Low-elevation riparian areas																			
Grey hawk				x		x		x	x	x	34	328	0.104	0.003	0.283	2.72	2627	1168	657
Common yellowthroat				x		x		x	x	x	59	328	0.180	0.063	0.220	2.86	1588	706	397
Yellow warbler				x		x		x	x	x	78	328	0.238	0.146	0.231	4.16	1750	778	438
Song sparrow				x		x		x	x	x	93	328	0.284	0.081	0.180	3.01	1063	472	266
Summer tanager				x		x		x	x	x	129	328	0.393	0.154	0.145	2.69	685	304	171
Bell's vireo				x		x		x	x	x	243	328	0.741	0.355	0.116	3.27	441	196	110
High-elevation																			
Red-faced warbler		x	x		x	x					32	558	0.057	0.019	0.389	4.84	8444	3753	2111
Hermit thrush		x	x		x	x					48	558	0.086	0.004	0.221	2.34	2725	1211	681
Painted redstart		x	x		x	x					85	558	0.152	0.018	0.155	2.04	1341	596	335
Hepatic tanager		x	x		x	x					150	558	0.269	0.066	0.141	2.98	1109	493	277
Black-headed grosbeak		x	x		x	x					266	558	0.477	0.071	0.112	3.31	694	308	173
Low-elevation uplands																			
Curve-billed thrasher	x		x	x		x	x	x	x	x	45	854	0.053	0.023	0.232	2.42	4597	2043	1149
Abert's towhee	x		x	x		x	x	x	x	x	78	854	0.091	0.086	0.242	4.57	5001	2223	1250
Gilded flicker	x		x	x		x	x	x	x	x	87	854	0.102	0.007	0.175	2.66	2615	1162	654
Pyrrhuloxia	x		x	x		x	x	x	x	x	108	854	0.126	0.016	0.155	2.59	2052	912	513
Black-tailed gnatcatcher	x		x	x		x	x	x	x	x	144	854	0.169	0.100	0.149	3.20	1896	843	474
Ladder-backed woodpecker	x		x	x		x	x	x	x	x	205	854	0.240	0.032	0.110	2.48	1033	459	258
Lucy's warbler	x		x	x		x	x	x	x	x	362	854	0.424	0.221	0.109	4.30	1015	451	254
Verdin	x		x	x		x	x	x	x	x	457	854	0.535	0.244	0.089	3.62	676	301	169
Gambel's quail	x		x	x		x	x	x	x	x	820	854	0.960	0.063	0.071	4.13	431	191	108
All communities and parks																			
Say's phoebe	x	x	x	x	x	x	x	x	x	x	45	1413	0.032	0.007	0.240	2.59	8139	3617	2035
Blue grosbeak	x	x	x	x	x	x	x	x	x	x	89	1413	0.063	0.018	0.165	2.42	3847	1710	962
Bridled titmouse	x	x	x	x	x	x	x	x	x	x	138	1413	0.098	0.064	0.156	3.36	3439	1528	860

Table A.2. Sample-size requirements for estimating density of select birds species using distance sampling at three levels of precision, cont..

Community/Species	Park unit										Obs (n)	Points x visits (K)	Encounter rate per point (n/K)	Density (no/ha)	CV (D)	Scaling Parameter b (n*CV2)	Estimate of K at %CV		
	CAGR	CHIR	CORO	FOBO	GICL	SAGU–RMD	SAGU–TMD	TONT	TUMA	TUZI							10%	15%	20%
All communities and parks, cont.																			
Ladder-backed woodpecker	x	x	x	x	x	x	x	x	x	x	232	1413	0.164	0.024	0.116	3.12	1901	845	475
Scott's oriole	x	x	x	x	x	x	x	x	x	x	292	1413	0.207	0.018	0.095	2.64	1275	567	319
Spotted towhee	x	x	x	x	x	x	x	x	x	x	504	1413	0.357	0.087	0.080	3.23	904	402	226
Ash-throated flycatcher	x	x	x	x	x	x	x	x	x	x	833	1413	0.590	0.078	0.072	4.32	732	326	183
Bewick's wren	x	x	x	x	x	x	x	x	x	x	1025	1413	0.725	0.308	0.068	4.74	653	290	163

Data are from point counts within 10 Sonoran Desert Network park units between 2000 and 2005. Density estimates and CV were computed in program DISTANCE. See protocol narrative for park-unit acronyms.

Supplement B: Determining Length of Count Period, Survey Timing, and Travel Times for Application to the SODN Landbird Monitoring Protocol

Version 1.02 (May 5, 2007)

Revision History Log

Previous Version #	Revision date	Author	Changes made	Section and paragraph	Reason for change	New Version #

Introduction

We will employ the point-transect method (Buckland et al. 2001; see SOP #5) to monitor population parameters in SODN parks. Prior to the initiation of monitoring, a number of questions and refinements to the study design and survey protocol need to be addressed to maximize information gained from surveys. Because field surveys comprise the bulk of the program's cost, refining the design and protocol can augment efficiency by reducing field costs and allowing for greater precision in parameter estimation. Topics we seek to address are the length of the count period, daily timing of survey periods, and calculating travel time between points. At the beginning of each section, we introduce the question of interest, then describe methods used to address those questions. We then present results and discuss application to the landbird monitoring protocol.

For each section, we use data that were collected at nine SODN parks between 2001 and 2005 during vertebrate and vascular plant inventories (Albrecht et al. 2005; Powell et al. 2005a, 2005b, 2005c, 2005d, 2005e, 2006; Schmidt et al. 2005a, 2005b). The point-transect method was used in these inventory efforts to survey diurnal birds during the peak breeding period for most landbirds in SODN parks (mid-April to early July). Data were collected at 282 survey points spaced 250 m apart and placed along 58 transects (n = 2–12 points/transect; Table B.1). Surveys at each point consisted of counting all birds detected aurally or visually during an eight-minute active count period and noting the minute when each individual was detected. Observers also recorded bird species detected both before and after surveys and while moving between points (passive period), facilitating detections of secretive species that would not have otherwise been recorded. Observers attempted to begin surveys approximately 20 minutes before local sunrise and conclude surveys within three hours after sunrise. After arriving at a station, observers waited between 30 and 60 seconds before beginning counts so that birds disturbed as observers walked to points could resume their normal activities. For the following analyses, we used only observations of birds identified to species, and did not include birds that were observed flying over points.

Section 1: Length of the Count Period

Introduction

Determining the length of time to survey at each point has important implications for survey design. Counts of shorter duration (3–5 minutes) enable observers to visit more points in a single morning, but likely decrease opportunities for observers to detect some birds due to low song frequency or infrequent movement. Longer surveys enable observers to detect more individuals, but are less efficient and can increase the potential for double counting because they

Table B.1. Summary of bird inventory effort in Sonoran Desert Network parks, 2001–2005.

Park unit	Transect name	Number of survey points	Number of visits by year				
			2001	2002	2003	2004	2005
Casa Grande Ruins NM	Casa Grande	12	4	4			
Chiricahua NM	Bonita	8			5	6	
	Bonita Canyon	7					5
	Bonita/Whitetail Canyons	7					5
	Faraway	8					5
	Little Picket	7					5
	North Canyon	8					5
	Rhyolite	8			5	6	
	Rhyolite/Sarah Demming Canyons	9					4
	Sugarloaf/Massai	8					5
Coronado NM	North	6					2
	Riparian	8			5	5	
	South	6					3
	Wash	8			4	4	
Fort Bowie NHS	Butterfield	8				6	
	East	10					4
	Siphon Canyon	8			5	6	
	West	10					4
Gila Cliff Dwellings NM	Cliff Dweller Canyon	7					2
	Riparian	6	5	6			
	Uplands	6	4	5			
	West Fork	8					2
Saguaro NP-Rincon MD	101, 106, 107, 111,112,113, 115, 120, 121, 125, 128, 130, 138, 139, 155, 189, 191	4a	4a				
	Auto Loop	4					3
	Douglas Springs	8		2			
	Happy Valley Saddle	6	4	2			
	Lower Rincon Creek	8	4	7			5
	Box Canyon	7	4	5			
	Rincon Peak	4	4	2			
	Upper Loma Verde Creek	2	4	3			
	Upper Rincon Creek	4	4	5			
Saguaro NP-Tucson MD	204, 212, 213, 238, 239	4a	4a				
Tonto NM	Riparian	6	4	5	5		
Tumacácori NHP	East	7					4
	Mission	8	4	7			
	West	7					4
Tuzigoot NM	East	7			6	5	
	West	7			6	5	

All transects were randomly located, had four survey points, and were surveyed four times. See text for citations.

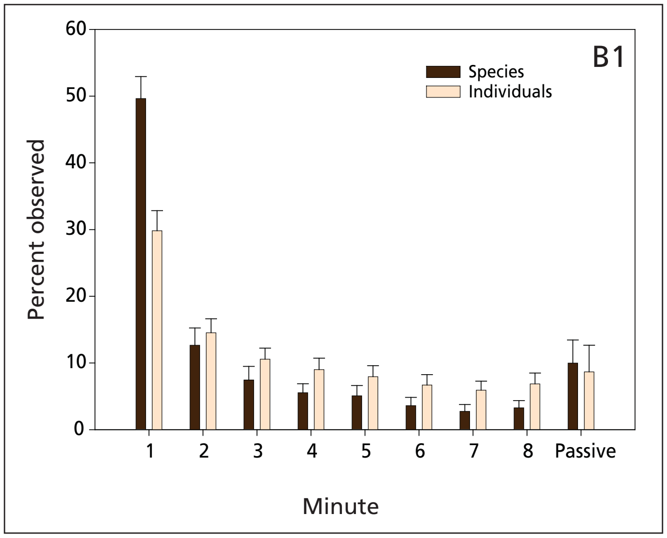


Figure B.1. Mean percent (+ SD) of species and individuals observed in each of the eight active-period minutes and during the passive period, Sonoran Desert Network parks, 2001–2005.

Passive-period observations were those recorded before or after active periods.

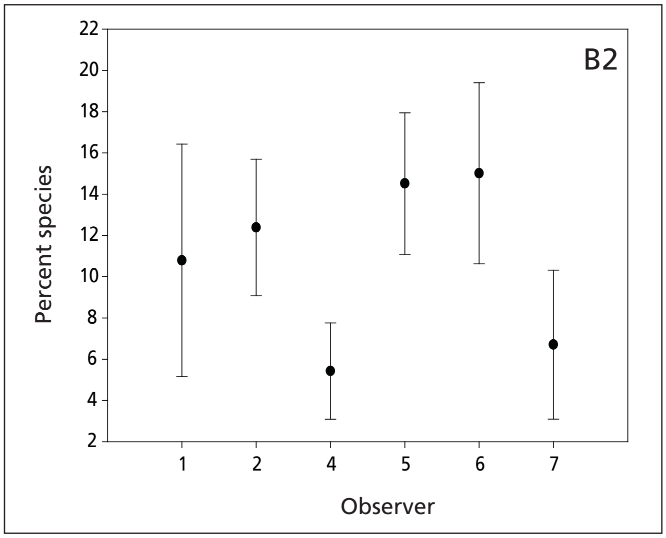


Figure B.2. Percent of passive-period observations by observers with >1,500 observations each, Sonoran Desert Network parks, 2001–2005.

Differences among observers are likely attributable to differences in skill or ability to follow protocol.

give birds more time to move around plots; these movements are difficult to track. To balance the trade-offs of survey efficiency and accuracy, we sought to identify the optimal count time.

Methods

To determine the optimal count time, we summarized data from all 58 transects (Table B.1) and estimated the number of species and individuals recorded during the active periods of each count and during the passive period before and after each count. We organized data for each of the 2,300 counts by listing the first minute in which each species was detected, regardless of how many times the species was detected in subsequent minutes. For example, if mourning doves were recorded at a point in minutes 3, 5, and 8, we only used the observation from minute 3. We summarized data for each transect and averaged data among transects and parks. We analyzed data similarly to determine the total number of individuals recorded in each minute. We summed the number of observations for each active period minute and for the passive period, but we did not exclude multiple observations of the same species.

Because the length of the active period (eight minutes) used during bird surveys in SODN parks was determined from expert opinion, we wanted to evaluate the potential benefits of reducing or extending the count period. We therefore used simple linear regression using the percentage of species observed in minutes 3 to 7 and excluded all detections during the passive period. We used minutes 3 to 7 to determine the slope of the regression line because the number of new species added per minute decreased linearly. We excluded minute 8 from the regression model because of the tendency for observers to "pack" observations made after minute 8 into that minute (Figure B.1). We also excluded minutes 1 and 2 from the analysis because the large number of observations during those minutes overwhelmingly influenced the slope of the regression line.

Results

Almost 50% of species recorded during eight-minute surveys were detected in the first minute (Figure B.1). As expected, the number of new species detected in each subsequent minute decreased progressively, except for minute 8. This is an almost certainly an artifact of measurement error, whereby observers recorded birds detected after the eighth minute as occurring during that minute. The tendency to pack observations into the eighth minute did not differ among the seven primary observers ($F_{6,392}$ = 0.85, P = 0.53, ANOVA). Patterns in the number of individuals recorded in each minute mirrored the results for species, except that there was a much lower percentage of individuals recorded in minute 1 (Figure B.1). This is expected, because it was common to observe multiple individuals of the same species throughout the survey period, and for this analysis, we included only the first observation of a species.

The mean percent change in the number of species observed from minutes 3 to 7 decreased by 1.4 % (± 0.1 SE) per minute (t_{318} = 19.0, P = <0.001, test of slope from regression). Extrapolating this to minutes 8–10, given that 5.4% of species were detected during minute 7, only 4.0% (± 0.1 SE) of new species would be observed in minute 8, 2.7% (± 0.1 SE); in minute 9, and 1.3% (± 0.1 SE) in minute 10. Based on the mean number of species detected per active-period count (24.5 ± 0.4 [SE]), we would expect only a single new species to be observed in minute 8 (we extrapolate to minute 8 because of "packing" in that minute), and only a single new species on every third visit in minute 10.

Observers recorded an additional 9.4% (± 0.5 SE) more species along transects by including detections during the passive period. Much of the variation in the percent of passive-period observations results from differences among observers ($F_{6,32}$ = 6.17, P = <0.001, ANOVA; Figure B.2). Among all observers, 10 species had >25% of their observations during the passive period. These species often could be characterized as follows: (1) uncommon but conspicuous and with large home ranges (raptors), (2) passage migrants that were difficult to detect aurally (e.g., warbling vireo, Wilson's warbler, and Brewer's and chipping sparrows), and/or (3) species that breed in the parks but which vocalize less frequently (e.g., greater roadrunner and black phoebe). By contrast, three very conspicuous species were rarely observed only during passive periods (<1.0% of observations; red-winged blackbird, Gila woodpecker, and Cassin's kingbird).

Application to survey protocol

The eight-minute survey period used during point-transect counts seemed to represent an appropriate trade-off between efficiency and accuracy. Although counts of longer duration would add additional species, the mean number of species would have been <5%, thereby making a longer count period inefficient. By keeping the count to eight minutes, observers can survey additional points each morning (see Section 3, below).

Because there is a greater chance of counting the same individual more than once during longer counts and this double counting can result in significant biases in parameter estimates (Smith et al. 1998), we advocate counts of eight-minute duration (Scott and Ramsey 1981). One solution to double counting could be to record only new species observed at the end of the count period (e.g., minutes 9 and 10), yet it seems more productive to record new species during the passive period. Therefore, it is warranted to include passive period observations into the landbird monitoring protocol. Because of difference among observers in the number of species recorded during passive period, the importance of collecting these data should be stressed during the five-day training period at the beginning of the season (see SOP #2).

Section 2: Daily Timing of Surveys

Introduction

Estimating population and community parameters requires that individuals that are present but undetected be considered in estimation. Because singing frequency declines as the morning progresses, detectability and survey efficiency also decline, which can bias parameter estimates. Therefore, we seek to estimate change in the number of species and individuals detected as the survey morning progresses and identify a cut-off point after which surveys are no longer efficient.

Methods

We converted survey start times to minutes after sunrise by subtracting start times from local sunrise times for Tucson for the date of each survey. Start times ranged from 23 minutes before to 289 minutes after local sunrise, but we truncated observations after 240 minutes because sample size was low after that time (Table B.2). For some analyses and for presentation, we classified each count as occurring within one of nine 30-minute time periods that start-

Table B.2. Summary of survey effort in each half-hour survey period, Sonoran Desert Network parks, 2001–2005.

Time period	Minutes from sunrise	Number of counts in time period
1	-30 to sunrise	186
2	1–30	471
3	31–60	508
4	61–90	514
5	91–120	396
6	121–150	330
7	151–180	124
8	181–210	47
9	211–241	27

ed 30 minutes before sunrise. The number of counts in each 30-minute period varied, with most surveys taking place between sunrise and 150 minutes after sunrise (Table B.2). After 150 minutes, the number of surveys was small.

As response variables, we summarized the number of individuals and species detected at each point. We tested for changes in both responses as a function of count start time, while adjusting for the influence of four covariates, using multiple linear regression. Because count start time was the variable of interest, we sought to determine its influence after accounting for the influences of year, Julian date, park, and observer. Finally, we used the same procedure to test for the influence of start time on the number of individuals of common species.

Results

The number of individuals detected across time decreased by 0.022 ± 0.002 per minute across the survey period ($t_{1,2600}$ =-11.19, P = <0.001). We found similar patterns for species richness (regression coefficient = -0.013 ± 0.0013 [SE]; $t_{1,2600}$ =-9.5, P = <0.001). Similarly, we found statistical differences among half-hour time periods (t-test graphically displayed as 95% CI; Figure B.3). The influence of survey timing varied considerably among parks, after accounting for other variables (Table B.3). Surveys from two of the seven parks did not show a significant decline in the number of observations after sunrise, indicating that surveys in those parks might have been extended longer without missing many individuals. However, the general pattern of decline shown in Figure B.3 holds for this analysis. On average, we found a mean decline among the seven parks of 0.84 ± 0.324 (SE) individuals per ½ hour after sunrise.

The prevailing pattern of fewer individuals de-

Table B.3. Regression coefficients and test for regression slopes for the number of individuals on each survey (all species) as a function of the time (minute) before and after sunrise, from multiple linear regression, Sonoran Desert Network parks, 2001–2005.

Park unit	Estimate		t	P
	Mean	SE		
CHIR	-0.022	0.004	-6.53	>0.001
CORO	-0.019	0.005	-3.91	>0.001
FOBO	-0.015	0.005	-2.80	0.006
GICL	-0.002	0.007	0.24	0.814
SAGU–RMD	-0.019	0.004	-5.19	>0.001
TUMA	-0.018	0.008	-2.36	0.019
TUZI	-0.003	0.005	-0.72	0.472

T-tests indicate the slope of the estimate is significantly different from zero. Only parks with >100 surveys are included in this analysis. See text for other explanatory variables included in the models.

Table B.4. Regression coefficients and test for regression slopes for the number of individuals of the most-common species (n ≥ 500 observations each) as a function of the time from sunrise, from multiple linear regression, Sonoran Desert Network parks, 2001–2005.

Species	Estimate		t	P
	Mean	SE		
Ash-throated flycatcher	-0.0003	0.0004	-0.78	0.433
Bewick's wren	-0.0013	0.0004	-3.27	0.001
Cactus wren	-0.0015	0.0005	-2.68	0.008
Gambel's quail	-0.0022	0.0021	-1.02	0.305
Gila woodpecker	-0.0010	0.0006	-1.61	0.108
House finch	0.0007	0.0009	-0.82	0.413
Mourning dove	-0.0018	0.0005	-3.38	0.001
Northern cardinal	-0.0012	0.0005	-2.18	0.029
Verdin	0.0002	0.0004	0.60	0.546
White-winged dove	-0.0013	0.0005	-2.22	0.027

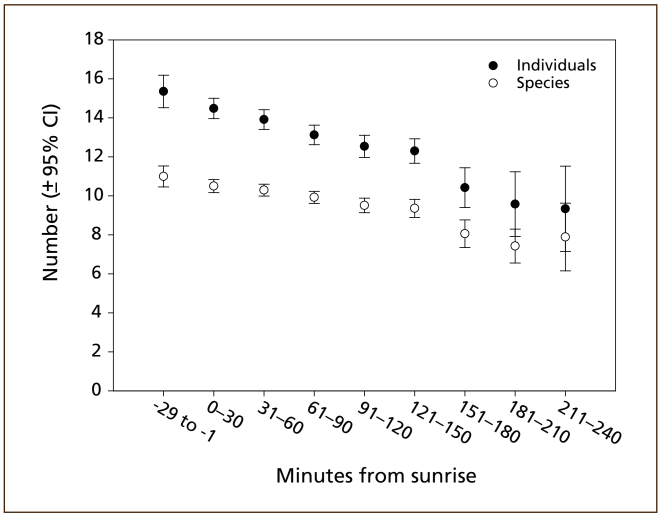


Figure B.3. Mean number of individuals and species observed as a function of time from sunrise, all parks and species, Sonoran Desert Network parks, 2001–2005.

Larger confidence intervals from the last two time periods are a result of small sample size (see Table B.1).

tected with increasing time from sunrise for all species was similar to that for the most-common species recorded at all parks (Table B.4). For six of the 10 species we assessed, the number of individuals detected declined as a function of time after sunrise ($P < 0.05$). For two species, verdin and house finch, the number of individuals observed seemed to increase as the morning progressed, though the results were not statistically significant (Figure B.4). Among all species, we found an average decline of 0.06 $\pm$ 0.04 individuals per minute after sunrise, equivalent to a decrease of 4% per hour.

Application to survey protocol

Detectability is one of the most important considerations when designing monitoring programs for wildlife. Failure to detect a species when it is present (false absence) can lead to biased estimates of population parameters. In general, the number of birds observed declined as the morning progressed (Tables B.2, B.3; Figure B.3). However, most of our surveys occurred within three hours of sunrise, and the decrease in number of individuals did not seem to be biologically significant. Therefore, surveys within three hours of sunrise did not seem to affect overall observation rates for most species such that surveys within four hours of sunrise might be appropriate. However, the number of species observed as a function of season, time of day, locations, and observer explained very little variation in the number of individuals for the most-common species (Table 2.3; mean R^2 = 0.13; range = 0.05–0.33), suggesting that other factors, such as vegetation features, contributed more strongly to the number of individuals observed. Sufficient data may be available at the time of the five-year review to more accurately model detection rates as a function of time of day and other factors for a wider range of species. Data from projects that survey in mornings and extend those surveys further into the breeding season may also be valuable to guide survey timing. Sources of data for these analyses may be available from the Southern Colorado Plateau Network, which plans to survey 15–20 points per morning.

To more accurately assess the influence of time of day on detection rates, we will collect data that allow for better optimization of survey timing and establish cut-off times after which surveys are ineffective for some species (e.g., Calladine et al. 1999). In particular, for each bird detected, we will indicate how individuals were detected (i.e., song, call, visual, or combination) so as to understand how counts later in the morning influence detection of singing males, which is the index used for density estimation. Singing frequency in relation to breeding phenology has been well studied for some species (Wilson and Bart 1985; Gutzwiller et al. 1997; Amrhein et al. 2004) and is often related to timing of breeding; most singing occurs early in the nesting cycle and declines thereafter. By collecting the right type of information, such as survey minute, type of detection, and daily timing of surveys, future reviewers will be able to model detectability for each species as a function of these variables (e.g., Farnsworth et al. 2002) and augment accuracy of parameter and trend estimates.

Finally, survey methods that compensate for lower observation rates as the morning survey period progresses will be employed. In particular, observers will alternate the order in which points are surveyed along transects during each visit. Because points will be surveyed at least four times each season, this should control for biases from survey timing. Finally, it may be possible to fit survey timing as a covariate when analyzing data.

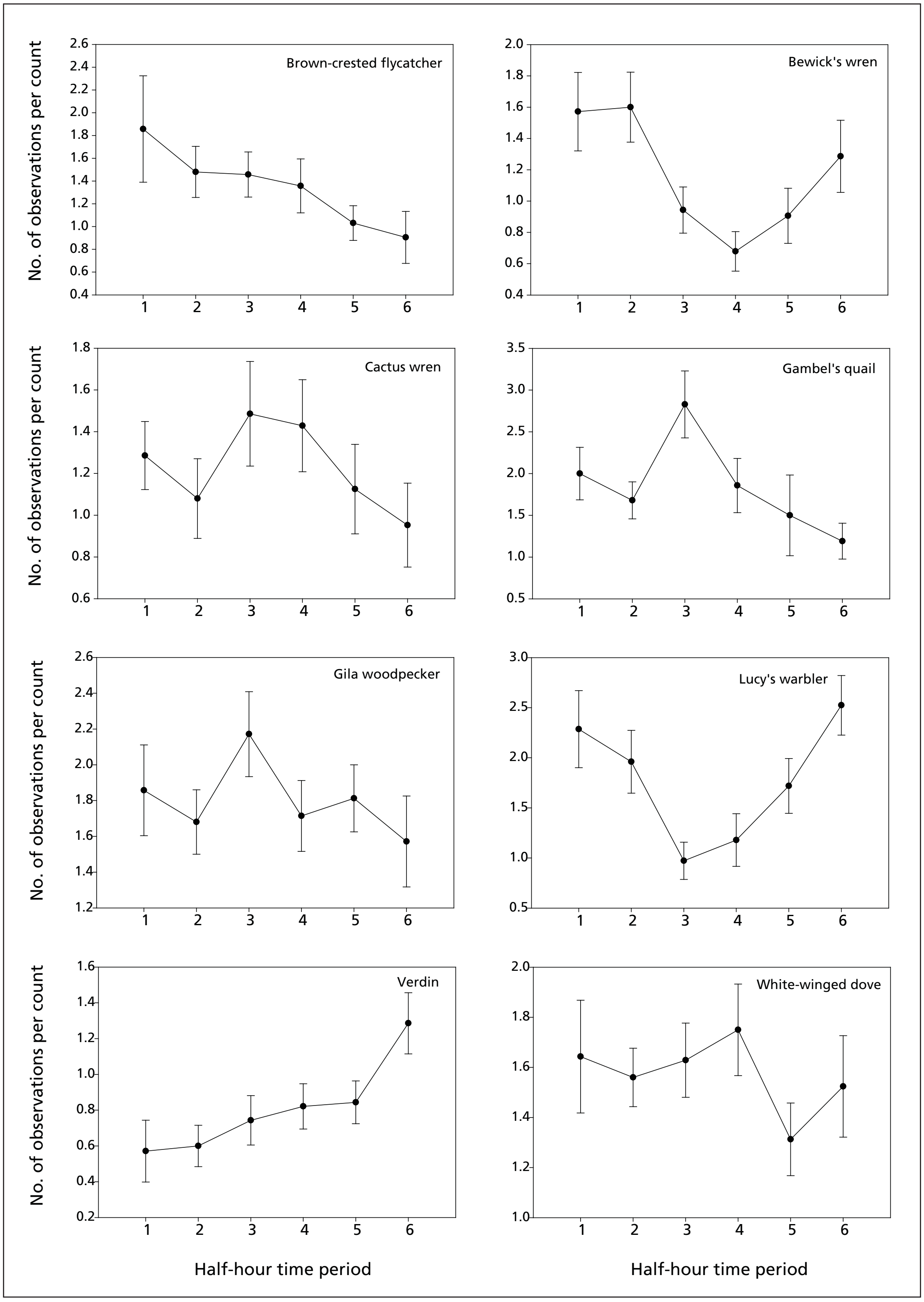


Figure B.4. Number of detections (mean + SE) by half-hour time periods for the most common species along Rincon Creek, Saguaro NP, 2001–2005.

See Table B.2 for definition of time periods. Statistically significant declines in the number of observations were noted only for the brown-crested flycatcher (P = 0.05, test of slope from linear regression), whereas the verdin showed the opposite pattern. Time period 6 = three hours after the start of surveys.

Section 3: Estimating Travel Time Between Survey Points

Introduction

Results from Section 2 indicate that 3½ hours after sunrise is a conservative cut-off point for morning surveys, and that longer surveys may be warranted in some areas and times of year. An extension of these results would be to assess the number of survey points that can be visited each morning, which is a function of both the count-period length and travel time between survey points. For surveys along trails or roads, walking is not hindered by vegetation or topography, and travel time between survey points is minimal. However, at sites far from trails, or where distances between points are greater than 250 m, travel time should be considered in planning the program. In this section, we model travel time under a variety of survey conditions, assuming eight-minute surveys, and use this information to guide sampling design.

Methods

We used a subset of data described in previous sections and used only data from those transects where survey points were located 250 m apart for standardization. To estimate travel time between points, we classified transects into four types according to increasing difficulty of travel: riparian areas, trails, off-trails desert, and off-trails forest. We summarized data from seven transects along riparian areas (n = 78 visits) and five transects along trails (n = 44). We also summarized data from transects that were placed randomly throughout Saguaro National Park (SAGU). These transects were placed irrespective of their location in relation to trails or riparian areas (see Powell et al. 2006 for descriptions of random transects). Because of differences in vegetation communities at random transects, we classified them based on the dominant vegetation community as being either desert (n = 57; Sonoran Desert uplands and semi-desert grasslands/oak savannah) or forest (n = 24; manzanita/oak forest and woodland). Almost all transects were in uneven terrain or on steep slopes, so we did not classify transects based on these characteristics.

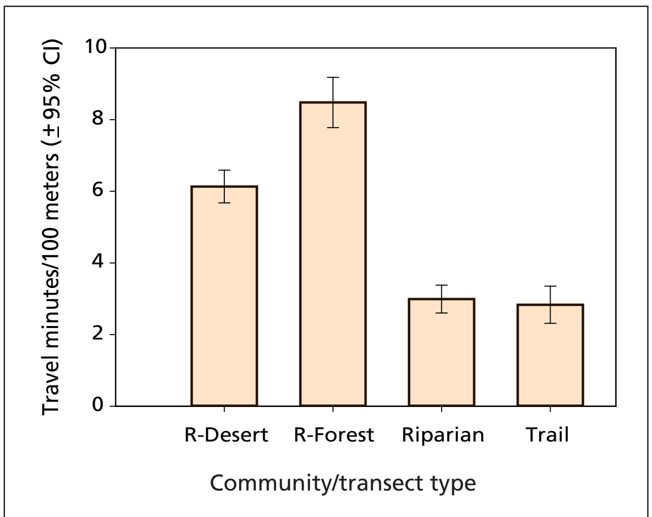


Figure B.5. Travel time (mean + 95% CI) per 100 m between bird survey points by community type or transect type, Sonoran Desert Network parks, 2001–2005.

"R" indicates transect was off-trail in either Sonoran Desert upland or semi-desert grasslands (desert) or in chaparral/oak woodland and forest (forest), Saguaro NP, 2001. "Riparian" transects were in Fort Bowie NHS, Tumacácori NHP, Coronado NM, Chiricahua NM, and Saguaro NP. "Trail" transects were in Casa Grande Ruins NM, Tuzigoot NM, Fort Bowie NHS, and Saguaro NP.

For each visit to a transect, we calculated total survey time by subtracting the start time at the first survey point from the end time at the last survey point. We then divided total survey time by the number of survey points to calculate mean survey time per point. This time included both active survey time (eight minutes), rest time before and after counts (two minutes on average), and travel time. To calculate travel time, we subtracted 10 minutes from the mean survey time. Finally, we estimated travel time per meter by dividing the mean travel time for each of the four transect types by 250 (distance between survey points).

We used these estimates to model the maximum number of points (N_{max}) that could be surveyed in a single morning within 3½ hrs of sunrise. The number of points is maximized when the following formula is closest to zero for the closest integer:

$$N_{max} = T - (A \times B)$$

where T is the maximum time after which surveys will no longer be conducted (210 minutes for this exercise); A is the upper 95% confidence interval (CI) for travel time between points for the transect type of interest; and B is the distance between survey points. We used the upper 95% CI because it provided a more conservative estimate; CI values averaged 11.7% greater than the mean (range = 7.4% to

18.3%). To assist in planning, we plotted the number of points that could be surveyed under a range of sampling conditions by transect type and distance between points.

Results

Travel time varied among the four types of transects ($F_{3,199}$ = 91.3, P = <0.001, ANOVA), with travel time being greater in the manzanita/oak woodland and forest type in the Rincon Mountain District of SAGU (Figure B.5) than in other types. Travel times between random points in desert communities were also greater than travel time in riparian areas, and greater than along trails (P < 0.001). Similarity between travel times for riparian areas and trails was due to the ease in walking along dry washes.

The number of points that can be surveyed within 3½ hours of sunrise ranged from 5 to 12, depending on distance between points and the transect type (Figure B.6). The maximum number of points can be surveyed along trails or riparian areas (9–12 points per morning), and the fewest in forested areas off of trails (5–7 points per morning). Extending the morning cut-off period to four hours after sunrise adds approximately one additional point for off-trail or along washes.

Application to survey protocol

Travel time between points will significantly impact the number of points that can be surveyed in a morning (Figure B.6). We will use these data during the planning process when selecting study locations. During the planning process, we will round up the number of points that can be surveyed, because (1) some transects can be started approximately 15 minutes before sunrise and (2) our calculations of travel time were conservative (we used the upper 95% confidence interval); actual travel time may not be as long.

A critical assumption of these estimates is that field workers can begin surveys at or near sunrise every morning. In 2001, at Saguaro National Park, field observers were able to camp near the beginning of each random transect on the evening prior to surveys. Since that time, the park has decided to forbid camping off of trails or outside of designated campsites. Because of safety concerns, Organ Pipe Cactus National

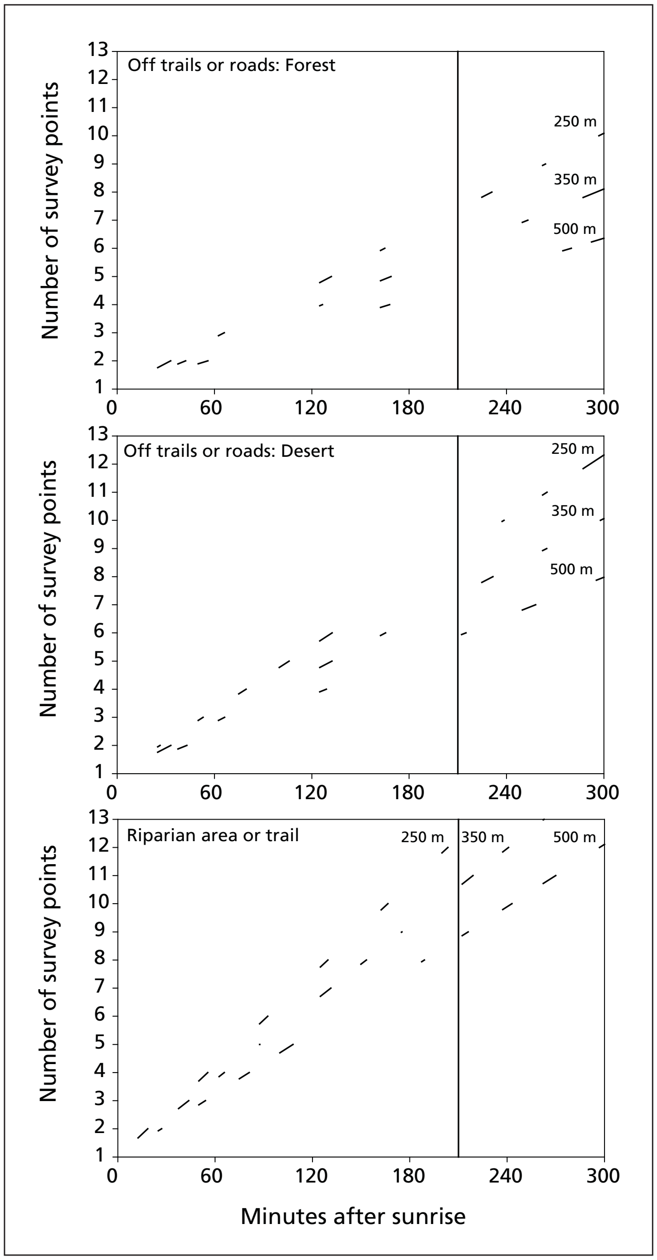


Figure B.6. Estimated number of points that can be surveyed within 3½ hours after sunrise (solid line) for three community types/types of transects by varying distance between points.

Data from Sonoran Desert Network parks, 2001–2005.

Monument (ORPI) also has significant camping restrictions that may influence our ability to access monitoring sites. As a result, transect start points at SAGU and ORPI can not be further than a 30-minute walk from an existing trail and, ideally, would not be more than a one-hour walk from the closest trailhead. By parking at the closest trailhead and using trails or open washes, field workers can walk along trails in the darkness, then exit the trail and walk off-trail as it gets light. Like other aspects of this protocol, the question of the survey timing and efficiency (including Section 2) should be investigated during the five-year review.

Literature Cited

Albrecht, E. W., W. L. Halvorson, P. P. Guertin, B. F. Powell, and C. A. Schmidt. 2005. A biological inventory and hydrological assessment of the Cave Springs riparian area, Tonto National Monument, Arizona. Unpublished report. USGS Southwest Biological Science Center, Sonoran Desert Research Station, University of Arizona, Tucson, Arizona.

Amrhein, V., H. P. Kunc, and M. Naguib. 2004. Seasonal patterns of singing activity vary with time of day in the nightingale (*Luscinia megarhynchos*). Auk **121**:110–117.

Buckland, S. T., D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borchers, and L. Thomas. 2001. Introduction to distance sampling: Estimating abundance of biological populations. Oxford, U.K.: Oxford University Press.

Calladine, J., F. Buner, and N. J. Aebischer. 1999. Temporal variations in the singing activity and the detection of turtle doves (*Streptopelia turtur*): Implications for surveys. Bird Study **46**:74–80.

Farnsworth, G. L., K. H. Pollock, J. D. Nichols, T. R. Simons, J. E. Hines, and J. R. Sauer. 2002. A removal model for estimating detection probabilities from point-count surveys. Auk **119**:414–425.

Gutzwiller, K. J., E. A. Kroese, S. H. Anderson, and C. A. Wilkins. 1997. Does human intrusion alter the seasonal timing of avian song during breeding periods? Auk **114**:55–65.

Powell, B. F., E. W. Albrecht, W. L. Halvorson, C. A. Schmidt, K. Docherty, and P. Anning. 2005a. Vascular plant and vertebrate inventory of Gila Cliff Dwellings National Monument. USGS Open File Report 2005-1187. USGS, Southwest Biological Science Center, Sonoran Desert Research Station, University of Arizona, Tucson, Arizona.

Powell, B. F., E. W. Albrecht, W. L. Halvorson, C. A. Schmidt, P. Anning, and K. Docherty. 2005b. Vascular plant and vertebrate inventory of Tumacácori National Historical Park. USGS Open File Report 2005-1142. USGS, Southwest Biological Science Center, Sonoran Desert Research Station, University of Arizona, Tucson, Arizona.

Powell, B. F., E. W. Albrecht, C. A. Schmidt, W. L. Halvorson, P. Anning, and K. Docherty. 2005c. Vascular plant and vertebrate inventory of Casa Grande Ruins National Monument. USGS Open File Report 2005-1185. USGS, Southwest Biological Science Center, Sonoran Desert Research Station, University of Arizona, Tucson, Arizona.

Powell, B. F., C. A. Schmidt, and W. L. Halvorson. 2005d. Vascular plant and vertebrate inventory of Coronado National Memorial. Unpublished report. USGS Southwest Biological Science Center, Sonoran Desert Research Station, University of Arizona, Tucson, Arizona.

Powell, B. F., C. A. Schmidt, W. L. Halvorson, and P. Anning. 2005e. Vascular plant and vertebrate inventory of Fort Bowie National Historic Site. USGS Open File Report 2005-1167. USGS Southwest Biological Science Center, Sonoran Desert Research Station, University of Arizona, Tucson, Arizona.

Powell, B. F., C. A. Schmidt, and W. L. Halvorson. 2006. Vascular plant and vertebrate inventory of Saguaro National Park, Rincon Mountain District. USGS Open File Report 2005-1075. USGS, Southwest Biological Science Center, Sonoran Desert Research Station, University of Arizona, Tucson, Arizona.

Schmidt, C. A., B. F. Powell, and W. L. Halvorson. 2005a. Vascular plant and vertebrate inventory of Tuzigoot National Monument. USGS Open File Report 2005-1347. USGS Southwest Biological Science Center, Sonoran Desert Research Station, University of Arizona, Tucson, Arizona.

Schmidt, C. A., B. F. Powell, W. L. Halvorson, and P. Anning. 2005b. Vascular plant and vertebrate inventory of Chiricahua National Monument. Unpublished Report. USGS Southwest Biological Science Center, Sonoran Desert Research Station, University of Arizona, Tucson, Arizona.

Scott, J. M., and F. L. Ramsey. 1981. Length of count period as a possible source of bias in estimating bird densities. Studies in Avian Biology **6**:409–413.

Smith, W. P., D. J. Twedt, P. B. Hamel, R. P. Ford, D. A. Wiedenfeld, and R. J. Cooper. 1998. Increasing point-count duration increases standard error. Journal of Field Ornithology **69**:450–456.

Wilson, D. M., and J. Bart. 1985. Reliability of singing bird surveys: Effects of song phenology during the breeding season. Condor **87**:69–73.

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS D-XXX, August 2007

National Park Service
U.S. Department of the Interior

Natural Resource Program Center
1201 Oak Ridge Drive, Suite 150
Fort Collins, Colorado 80525

www.nature.nps.gov

EXPERIENCE YOUR AMERICA™