



Monitoring the Birds of Badlands National Park

2011 Report

Natural Resource Technical Report NPS/NGPN/NRTR—2014/836



ON THE COVER

Female and Male Red-winged Blackbirds and Upland Sandpiper
Photographs by: Jeff Birek

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Executive Summary

The Northern Great Plains Inventory and Monitoring Network (NGPN) of the National Park Service (NPS) and Rocky Mountain Bird Observatory (RMBO) conducted landbird surveys in the North Unit of Badlands National Park in 2011 as part of NPS's Vital Signs monitoring program. The primary goal of the 2011 bird surveys at Badlands National Park was to design and implement a program of landbird monitoring at the park, and to use the lessons learned from the 2011 surveys to develop a bird monitoring protocol for all parks in the NGPN. Specifically, objectives were to:

1. Develop a landbird monitoring sampling protocol for a large NGPN park that allows monitoring of density for common species and of occupancy dynamics for uncommon species,
2. Conduct traditional Breeding Bird Surveys in Badlands National Park at the standard stops,
3. Conduct landbird surveys using a point-count protocol during the breeding season, and
4. Make recommendations, based on the 2011 results, for creating a Network-wide landbird monitoring sampling design and field protocol.

RMBO developed a spatially balanced sampling design and field survey protocol based on those implemented in 12 states as part of a program titled "Integrated Monitoring in Bird Conservation Regions" (IMBCR). The IMBCR design produces estimates of avian species occurrence and population sizes from local to Bird Conservation Region (BCR) scales, facilitating conservation at local and national levels.

In the North Unit of Badlands National Park, twenty-five 1 km^2 cells were selected in each of two substrata (alluvial soils and non-alluvial soils) using generalized random-tessellation stratification (GRTS), a spatially-balanced sampling algorithm. Point count technicians surveyed landbirds at each of 16 points spaced 250 m apart in a 4 x 4 grid within each selected cell. Each count, conducted within 5 hours of sunrise, lasted 6 minutes during which technicians recorded all birds heard and seen. RMBO completed 581 point counts between 22 May and 8 July, 2011. Field technicians observed 81 bird species including 20 priority species. Technicians also conducted the Cedar Pass Breeding Bird Survey and detected 12 species, including three species of concern, on the 13 stops that occur within the Badlands National Park boundary.

The point count data then were used to estimate density and population size for each species with sufficient sample size. The first step was to estimate the detection probability using distance analysis. The detection probability was used to adjust the count of birds to account for birds that were present but undetected. We fit a detection function to the distribution of recorded distances and then used Akaike's Information Criterion and model selection theory to select the most parsimonious detection function for each species. RMBO estimated densities and population sizes of 58 species in at least one stratum, including 13 priority species. Grasshopper Sparrow (130 birds/km^2), Western Meadowlark (77 birds/km^2), and Cliff Swallow (67 birds/km^2) had the highest estimated densities in the North Unit. This result is not surprising as most of the North Unit is covered in grassland and cliff habitat. Black-billed Magpie (0.5 birds/km^2) had the lowest estimated density of the six other priority species with robust density estimates ($\text{CV} < 50\%$). Comparing priority species' estimated densities in Badlands National Park to those in all of BCR 17, Northern Rough-winged Swallow density was seven times higher, Say's Phoebe density was

3.7 times higher, and Grasshopper Sparrow and Western Meadowlark densities were twice as high. Lark Bunting and Upland Sandpiper densities were approximately the same while Black-billed Magpie density in Badlands was half the density detected in the entire BCR. The latter result may be because this species is at the extreme east edge of its range in Badlands National Park and its preferred habitat is more abundant in the central and western parts of the BCR.

In addition to density and population size estimates, we estimated Occupancy (Psi) of each species with sufficient sample size, which quantifies the proportion of grid cells occupied by a species, taking into account detection probability. RMBO estimated Psi for 65 species in at least one stratum, including 14 priority species. Western Meadowlark, Mourning Dove, and Grasshopper Sparrow were estimated to occupy more than 90% of grids, both in the North Unit of the park as a whole and in each soil stratum. Upland Sandpiper (35%) and Dickcissel (25%) had the lowest estimated occupancy rates among the four other priority species with CV < 50%. Comparing priority species estimated occupancy rates in Badlands National Park to those in all of BCR 17 in 2011, Say's Phoebe and Dickcissel occupancy rates in Badlands were more than 2.5 times higher while Grasshopper Sparrow estimated occupancy was 1.5 times higher. Lark Bunting, Upland Sandpiper, and Western Meadowlark estimated occupancy rates in Badlands National Park were similar to those of the entire BCR. To view interactive maps showing 2011 Badlands National Park survey and detection locations, species counts, and density, population and occupancy results please visit RMBO's Avian Data Center at <http://adc.rmbo.org>.

The 2011 pilot project in Badlands National Park shows that the GRTS-based sampling design and field protocol developed by the IMBCR meets the goals and objectives of the NGPN bird monitoring program. Thus, we recommend that this sampling design and monitoring protocol be extended to all of the parks in the network. The advantages are as follows:

- The GRTS sampling design and point count monitoring protocol allows for more precise population and occupancy estimates to be generated using detection probability.
- The GRTS approach has the flexibility to generate valid population estimates at scales relevant to land management agencies, as well as support conservation efforts at both local and regional scales.
- Incorporating data collected at small scales to estimate parameters at larger scales allows this design to address the need for large-scale monitoring and research, which has been emphasized in bird conservation initiatives. The region-wide population estimates generated from these data can better assist managers in understanding trends in landbird populations (US North American Bird Conservation Initiative 2009).
- By analyzing data across both the North Unit of Badlands National Park and the BCR 17 sampling frames we can estimate common detection probabilities for species that would have otherwise had an insufficient number of detections for analyses.
- All sample units in the sampling frame are ordered, such that any set of consecutively numbered units is a spatially well-balanced sample. In the case of fluctuating budgets, monitoring partners can adjust the sampling effort among years within each stratum while still preserving a random, spatially-balanced sampling design.

- Occupancy estimation increases the number of bird species that can be effectively monitored and provides managers with information about populations of rare and uncommon species (MacKenzie et al. 2005).
- The IMBCR design allows sampling of all habitats, allowing managers to relate changes in bird populations to landscape changes over time.
- Data generated by this design give a scientific basis for park bird lists and general breeding status of each species.

This spatially-balanced sampling design serves as a model for other long-term monitoring efforts because of its ability to address the conservation and management needs of a wide range of stakeholders, landowners and government entities at both local and regional scales. The IMBCR design represents one method for achieving effective collaboration in North American bird monitoring and could be applied to other National Parks, Inventory and Monitoring Networks, BCRs and regions across the continent.

Acknowledgments

Many individuals helped make the 2011 field season a success. Stratification and allocation of survey efforts were determined in collaboration with partner agencies and organizations, each of which provided funding or in-kind assistance in 2011. We thank G. White, professor emeritus of Colorado State University, for writing the initial SAS code and implementing the multi-scale occupancy model in program MARK and P. Lukacs of the University of Montana who wrote code in program R for generating density estimates from detection probabilities. We thank J. Laake for implementing the multi-scale occupancy model in the RMark package which aided in automation of the analyses. L. Catron and C. Pugsley of Custer State Park and staff at the Creekside Lodge provided excellent training facilities for the northern monitoring effort. We also thank the field technicians who collected the avian and vegetation point count data. We would like to thank the NPS staff, E. Childers, S. Wakamiya, and M. Wilson, for their support and review of this report.

Introduction

Monitoring is an essential component of wildlife management and conservation science (Witmer 2005, Marsh and Trenham 2008). Common goals of population monitoring are to estimate the population status of target species and to detect changes in populations over time (Thompson et al. 1998, Sauer and Knutson 2008). Effective monitoring programs can identify species with declining populations (Dreitz et al. 2006); provide an understanding of how management actions affect populations (Alexander et al. 2008, Lyons et al. 2008); evaluate population responses to landscape alteration and climate change (Baron et al. 2008, Lindenmayer and Likens 2009); as well as provide basic information on species distributions.

Recognizing the importance of monitoring, the National Park Service (NPS) developed a long-term ‘Vital Signs’ ecological monitoring program. The overall goal of the ‘Vital Signs’ program is to develop scientifically sound information on the current status and long-term trends in composition, structure, and function of park ecosystems, and to determine how well current management practices are sustaining those ecosystems (Gitzen et al. 2010). NPS’s Northern Great Plains Inventory and Monitoring Network (NGPN), of which Badlands National Park is a part, has chosen to monitor landbirds as a vital sign of biological integrity (Gitzen et al. 2010). Large-scale declines of avian populations and the loss, fragmentation and degradation of native habitats highlight the need for extensive and rigorous landbird monitoring programs (Rich et al. 2004, U.S. North American Bird Conservation Initiative 2007). Thus, landbirds are of high interest to park managers within the NGPN. About 1/3 of the 100 landbird species on the Partners in Flight (PIF) Watch list (Rich et al. 2004) and more than half of the PIF North American Land Conservation Plan Stewardship Species List occur in NGPN parks (Gitzen et al. 2010). The objectives for monitoring landbirds in NGPN parks are to:

1. Determine changes in breeding-season density of common species, relative abundance and occupancy of less common species, species richness, and other community characteristics in all parks,
2. Determine correlations between avian population/community changes and changes in land cover, vegetation structural stages, landscape composition, and climate, and
3. Determine similarity of these park-level trends vs. regional trends estimates from Breeding Bird Surveys and other monitoring efforts.

In order for monitoring results to be useful to guide conservation efforts, sound program designs and analytic methods are necessary to produce unbiased population estimates (Sauer and Knutson 2008). At the most fundamental level, reliable knowledge about the status of avian populations requires accounting for spatial variation and incomplete detection of the target species (Pollock et al. 2002, Rosenstock et al. 2002, Thompson 2002). Addressing spatial variation entails probabilistic sampling designs that allow population estimates to be extended over the entire area of interest (Thompson et al. 1998). Adjusting for incomplete detection involves the use of appropriate sampling and analytic methods to address the fact that few, if any, species are so conspicuous that they are detected with certainty during surveys even when present (Pollock et al. 2002, Thompson 2002). Accounting for these two sources of variation ensures observed trends reflect true population changes rather than artifacts of the sampling and observation processes (Pollock et al. 2002, Thompson 2002). Therefore, the NGPN sampling

design for monitoring landbirds specifies the use of probabilistic sampling design and sampling protocols that estimate density, occupancy, or community metrics that account for incomplete detectability of individuals and species during each survey (Gitzen et al. 2010).

The NGPN Vital Signs program attempts to implement Network monitoring as part of local, regional, and national partnerships (Gitzen et al. 2010). Two large-scale bird monitoring programs exist in the northern and central Great Plains. In 2008, Rocky Mountain Bird Observatory (RMBO) and its partners initiated a broad-scale program for bird monitoring titled “Integrated Monitoring in Bird Conservation Regions” (IMBCR) (Blakesley and Hanni 2009). This protocol uses Bird Conservation Regions (BCRs) as sampling frames (Figure 1), stratified by land ownership inside each BCR (US North American Bird Conservation Initiative Monitoring Subcommittee 2007). BCRs provide a spatially consistent framework for bird conservation in North America. Each BCR represents a distinct ecological region with similar bird communities, vegetation types and resource management interests (U.S. North American Bird Conservation Initiative Committee 2000). Population monitoring within the IMBCR program can be implemented within a flexible hierarchical framework of nested units, where information on status of bird populations can be partitioned into smaller units, such as an individual National Park for small-scale conservation planning, or aggregated up to support large-scale conservation efforts for a species’ geographic range. By focusing on scales relevant to management and conservation, information obtained from monitoring in BCRs can be integrated into research and management at a multitude of scales applicable to land managers (Ruth et al. 2003).

The 13 national parks of the NGPN occur within BCRs 11, 17, 18, and 19; Badlands National Park is within BCR 17 (Badlands and Prairies BCR). Incorporating the NGPN landbird monitoring into the IMBCR program will allow the NGPN to compare local bird population information with those in the larger region. As a pilot project, the NGPN, in partnership with RMBO, designed a monitoring program for Badlands National Park in 2011, utilizing the IMBCR design and protocols. Important properties of the design are:

- All areas are available for sampling including all vegetation types.
- Strata are based on fixed attributes; this will allow us to relate changes in bird populations to changes on the landscape through time.
- Aggregation of strata-wide estimates to combined estimates is built into the design.
- Local population trends can be directly compared to regional trends.

The second large-scale bird monitoring program in the region is the North American Breeding Bird Survey (BBS) (Bystrak 1981, Patuxent Wildlife Research Center 2012). Since its inception in 1966, the main emphasis has been to provide information on the distribution and trends of all bird species regularly encountered along roadsides. Analysis and interpretation of BBS data are tricky because the survey incorporates information from an enormous geographic area and varies greatly in quality of information over the area. To evaluate population changes over time, BBS indices from individual routes are combined to obtain regional and continental estimates of trends. The BBS creates indices of relative abundance, not actual density estimates or occupancy rates, which can be produced in the IMBCR design. In addition, although BBS analyses model differences among observers, they do not take into account detection probability when calculating relative density and trend indices.

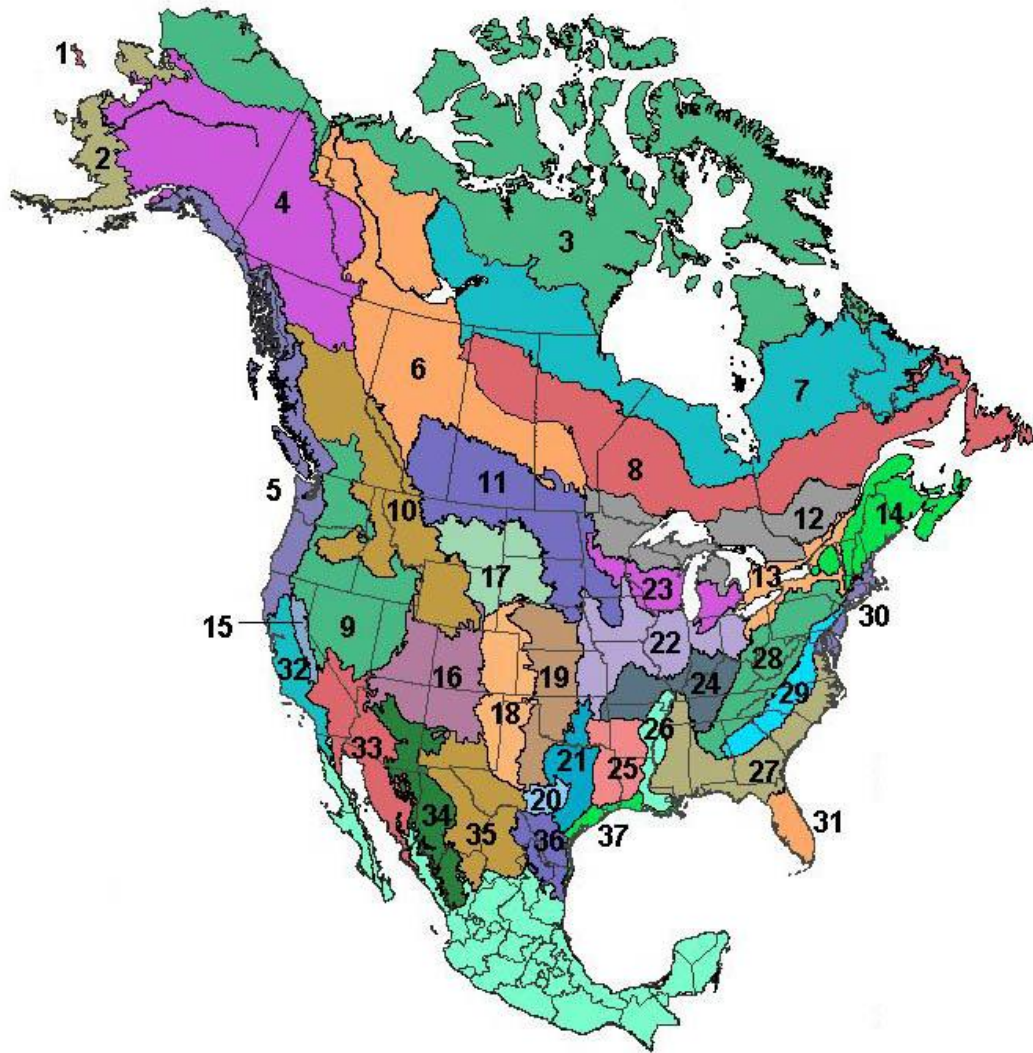


Figure 1. Bird Conservation Regions in North America, excluding Hawaii and Mexico (Source: <http://www.nabci-us.org/map.html>).

Objectives

The primary goal of the 2011 bird surveys at Badlands National Park was to design and implement a program of landbird monitoring at the park, and use the lessons learned from the 2011 surveys to develop a bird monitoring protocol for all parks in the NGPN. Specifically, objectives were to:

1. Develop a landbird monitoring sampling protocol for a large NGPN park that allows monitoring of density for common species and of occupancy dynamics for uncommon species,
2. Conduct traditional Breeding Bird Surveys in Badlands National Park at the standard stops,
3. Conduct landbird surveys using point-count protocol during the breeding season, and
4. Make recommendations, based on 2011 results, for creating a Network-wide landbird monitoring sampling design and field protocol.

Study Area

The RMBO and the NPS identified the North Unit of Badlands National Park as the sampling frame, the area where surveys occurred to monitor bird populations (Figure 2). We established two strata within the sampling frame based on two soil types found within the park: alluvial soils/shrubland (BA-BCR17-SH) and non-alluvial soils/grassland (BA-BCR17-GG). These two strata were combined for analysis into an area of inference that encompassed the entire sampling frame.

Portions of two BBS routes occur within the North Unit of Badlands National Park – 47 of 50 points on the Badlands Route and 13 of 50 points on the Cedar Pass Route.

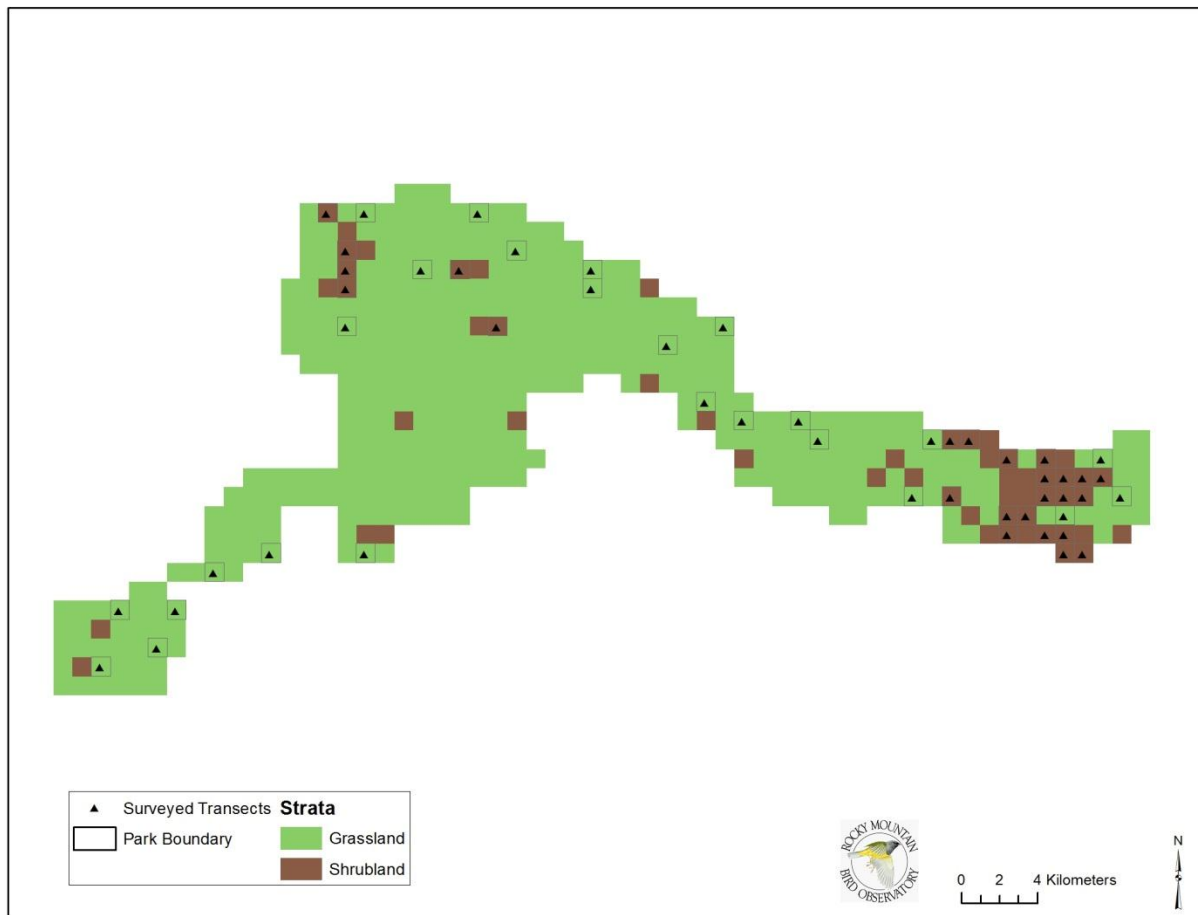


Figure 2. North Unit of Badlands National Park with strata and samples.

Methods

Study Design

Point Count Samples

We created a uniform grid of 1-km² cells over the entire North Unit of Badlands National Park. Within each soil stratum in the park, we used generalized random-tessellation stratification (GRTS), a spatially-balanced sampling algorithm, to select sample cell units (Stevens and Olsen 2004). Point count technicians surveyed for landbirds at each of 16 points spaced 250 m apart in a 4 x 4 grid within each selected sample unit (Figure 3). All spatial data were compiled using ARCGIS 9.2 (Environmental Systems Research Institute 2006).

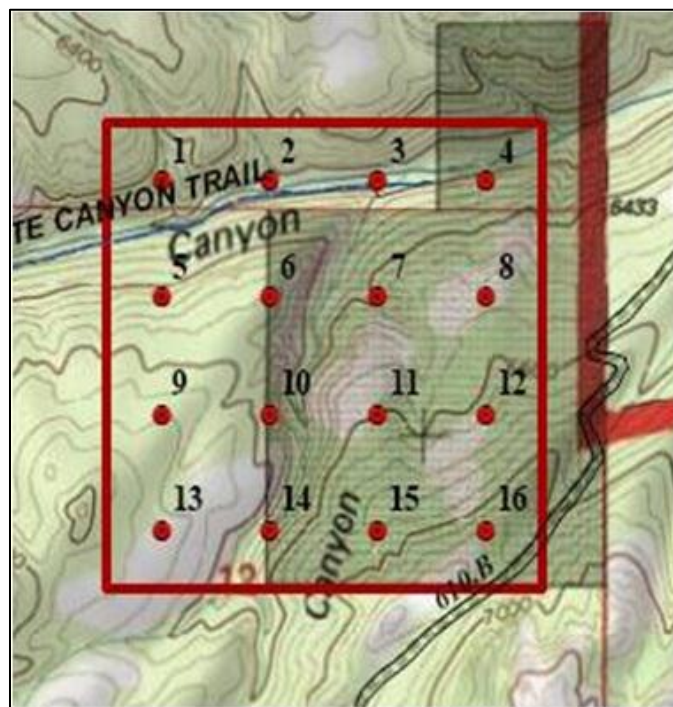


Figure 3. Example 1 km² grid cell using the GRTS design.

Breeding Bird Surveys

In the 1960's, Breeding Bird Survey (BBS) routes throughout the continent were selected according to a stratified random design (Geissler and Noon 1981). Both the route start point and direction were selected at random on the basis of one-degree blocks of latitude and longitude. The BBS does not have predefined primary sampling units. A route consists of point counts conducted at 50 stops along roads, each stop 0.5 miles apart. Each route is surveyed every year in June at fixed points using a standardized survey protocol.

Field Methods

Point Count Samples

RMBO observers with bird-identification skills conducted field work in 2011. Prior to conducting surveys, technicians completed an intensive 5-day training program to ensure full understanding of field protocols and to practice bird and plant identification and distance estimation in a variety of habitats.

Field technicians conducted point counts (Buckland et al. 2001) following the protocol established by RMBO (Hanni et. al. 2011). Observers conducted sampling in the morning, beginning 30 minutes before sunrise and concluding no later than 11 AM. The survey duration at each point was 6 minutes. For every bird detected during the 6-minute period, observers recorded species, sex, horizontal distance from the observer, minute each bird was detected and type of detection (i.e., call, song, visual). Observers measured distances to each bird using laser rangefinders. When it was not possible to measure the distance to a bird, observers estimated the distance by measuring to some nearby object. Observers recorded birds flying over but not using the immediate surrounding landscape. These “flyover” detections were not included in the estimates of density, population size or occupancy. Observers also recorded the presence of species which are rare or difficult to detect (i.e., woodpeckers, owls, raptors) while they traveled between points within a grid cell. The opportunistic detections of these rare species were used for distribution mapping purposes only.

Technicians considered all non-independent detections of birds (i.e., flocks or pairs of conspecific birds together in close proximity) as part of a ‘cluster’ rather than as independent observations. Observers recorded the number of birds detected within each cluster.

Observers recorded time, ambient temperature, cloud cover, precipitation and wind speed at the beginning and end of the morning sampling period. Technicians navigated to each point using hand-held GPS units. Before beginning each 6-minute count, surveyors recorded vegetation data (within a 50-meter radius) and distance from a road (if within 100 m). Technicians recorded vegetation data including the dominant habitat type, structural stage and the relative abundance, percent cover and mean height of trees and shrubs by species, as well as grass height and ground cover types. They recorded vegetation data quietly to allow birds, potentially disturbed by their approach, time to return to their normal habits prior to beginning each count.

For more detailed information about survey methods and vegetation data collection protocols, refer to RMBO’s Field Protocol for Spatially Balanced Sampling of Landbird Populations on the RMBO Avian Data Center website at <http://adc.rmbo.org>.

Breeding Bird Surveys

The BBS, conducted once a year during June, began 30 minutes before sunrise. A 3-minute point count was conducted at each stop, during which the observer counted all birds, except dependent young, heard or seen within 0.25 miles of the stop. Observers also recorded the number of vehicles passing by and the presence of excessive noise during the 3-minute count. Sky conditions, wind speed, and temperatures were recorded at the beginning and end of the 5-hour survey.

For a more detailed description of the BBS methods see Robbins and Van Velzen (1967).

Data Analysis

Density Analysis

The first step in analyzing the point count data was to estimate the detection probability using distance analysis. The detection probability is used to adjust the count of birds to account for birds that were present but undetected. Distance sampling theory was applied to account for the decreasing probability of detecting an object of interest (e.g., a bird) with increasing distance from the observer to the object (Buckland et al. 2001). Application of distance theory requires that three critical assumptions be met: 1) all birds at or near the sampling location (distance = 0) are detected; 2) distances of birds are measured accurately; and 3) birds do not move in response to the observer's presence (Buckland et al. 2001, Thomas et al. 2010). Detection probability is estimated based on the number of birds detected during consecutive sampling intervals using removal modeling. Removal modeling is based on mark-recapture theory and can also incorporate distance data (Farnsworth et al. 2002). In this study, sampling intervals consisted of consecutive 2-minute segments of a complete 6-minute sampling period.

We analyzed distance data by fitting a detection function to the distribution of recorded distances. The distribution of distances can be a function of characteristics of the object (e.g., for birds, size and color, movement, volume of song or call and frequency of call), the surrounding environment (e.g., density of vegetation) and observer ability. Because detectability varies among species, we analyzed the data separately for each species.

We used the analysis software Distance 6.0 (Thomas et al. 2010) to estimate detection probabilities. We estimated densities of species for which we obtained a sufficient number of independent detections ($n \geq 80$). We excluded birds flying over but not using the immediate surrounding landscape and birds detected between points from the analyses. For each species' distribution of distances, we fit a half normal key function with cosine series expansion and hazard rate key function with cosine series expansion (Buckland et al. 2001). We used Akaike's Information Criterion (AIC) corrected for small sample size (AICc) and model selection theory to select the most parsimonious detection function for each species (Burnham and Anderson 2002). For the BCR-level estimates presented in this report, we combined data across years (2008 – 2011) and strata to estimate global detection functions and compared these models with

models that estimated detection probability as a function of year. We modeled year as a covariate using the Multiple Covariate Distance Sampling engine in program Distance. In addition, when sample sizes allowed ($n \geq 80$ per year) we modeled year as a categorical variable, to allow more flexibility in modeling detection probability.

We used the SPSURVEY package (Kincaid 2008) in Program R (R Development Core Team 2011) to estimate density, population size and its variance for each species. We computed estimates for each stratum as well as aggregation of the two soil strata for Badlands National Park estimates, and all strata within BCR 17 for the BCR-level estimates. Estimates from multiple strata represent a weighted mean indexed by stratum area. We did not estimate density for a species with less than five detections in a given stratum or combination of strata.

Occupancy Analysis

In addition to density and population size estimates, we estimated occupancy of each species, which quantifies the proportion of sample units (i.e., grid cells) occupied by an organism (MacKenzie et al. 2002). The application of occupancy models requires multiple surveys of the sample unit in space or time to estimate a detection probability (MacKenzie et al. 2006). The detection probability adjusts the proportion of sites occupied to account for species that were present but undetected (MacKenzie et al. 2002). The assumptions of the occupancy model are 1) the probabilities of detection and occupancy are constant across the sample units, 2) each point is closed to changes in occupancy over the sampling season, 3) the detection of species at each point are independent and 4) species are never incorrectly identified (MacKenzie et al. 2006).

We used a multi-scale occupancy model (Nichols et al. 2008, Pavlacky et al. 2012) to estimate 1) the probability of detecting a species given presence (p), 2) the proportion of points occupied by a species given presence within sampled grid cells (Theta) and 3) the proportion of grid cells occupied by a species (Psi). We used program MARK (White and Burnham 1999) and package RMark (R Development Core Team 2011) to fit the multi-scale occupancy models and estimate the model parameters.

We used a removal design (MacKenzie et al. 2006) to estimate a detection probability for each species by partitioning the 6-minute count into three sequential 2-minute sampling intervals. We binned minutes one and two, minutes three and four, and minutes five and six to meet the assumption of a monotonic decline in the detection rates through time. After the species was detected at a point, we set all subsequent sampling intervals at that point to missing data (MacKenzie et al. 2006). We truncated the data, using only detections within 125 m of the sample points. Truncating the data allowed us to use bird detections over a consistent plot size and ensured that the points were independent (points were spread 250 m apart), which in turn allowed us to estimate Theta (the proportion of points occupied within each grid cell) (Pavlacky et al. 2012). The 16 grid points served as spatial replicates for estimating the proportion of points occupied within the sampled grid cells. Finally, we estimated the proportion of grid cells occupied for any species that was detected within 125 m of a point on a minimum of five grid cells throughout all surveys using the GRTS. Occupancy estimates for species occurring on fewer than five grid cells across RMBO's 2011 survey effort are not reported here because of unreliable model convergence.

For BCR-wide estimates, we combined stratum-level estimates of Ψ using a weighted mean indexed by stratum area. We estimated the sampling variance and standard error for the combined estimates of Ψ using the delta method (Powell 2007) in program R (R Development Core Team 2011).

Breeding Bird Survey Analysis

BBS data from individual routes are used to calculate species population trends at state, provincial, BCR, and range-wide levels. Long-term regional population trends are estimated with hierarchical log-linear models, using Markov chain Monte Carlo methods (Link and Sauer 2002, Sauer and Link 2011). The hierarchical analyses incorporate ‘nuisance’ effects, such as year, stratum and observer effects, as random effects. Annual abundance indices and trends for each region are estimated from the year effects and other model outputs; regional summaries are functions of the underlying regional abundance and population change parameters. This method can utilize data that are unbalanced by changes in years surveyed and that have variable quality because of observer differences and number of routes per region. BBS analyses do not take into account detection probability during calculations.

The BBS also produces species distribution maps which indicate the number of birds seen on BBS routes grouped into categories of relative abundance. The maps predict the average number of birds that could be seen in about 2.5 hours of bird watching along roadsides by very good birders. They are based on mean counts on BBS routes over the previous 5-year interval.

Because of the BBS’s study design and limits imposed by that design, it is not possible to obtain species population trend or size estimates for a single BBS route or partial route. Thus, for this report, we can only provide a list of species and number of individuals detected on BBS stops within Badlands National Park in 2011 compared to the historical average.

Results

Point Count Samples

Field technicians conducted 581 point counts within the 25 surveyed grid cells in each of two strata (50 total grids) between 22 May and 8 July 2011 (Figure 2). They detected 8,525 individuals of 81 bird species, including 20 priority species (Table 1).

Table 1: Number of birds detected on point count samples in Badlands National Park by species and strata in 2011. Priority species are in bold; non-breeding species are highlighted. All bird species names are from the American Ornithologists' Union Checklist (2007).

Common Name	Non-alluvial Soils Counts	Alluvial Soils Counts	Total Counts
American Bittern	1		1
American Crow	108	62	170
American Goldfinch	3	17	20
American Kestrel	3	13	16
American Robin		8	8
American White Pelican	7		7
Bank Swallow	2	15	17
Barn Swallow	7	6	13
Black-billed Magpie	12	43	55
Black-capped Chickadee		2	2
Blue Grosbeak	6	2	8
Blue Jay		2	2
Blue-winged Teal	1	5	6
Bobolink	13		13
Brewer's Blackbird	11	30	41
Brown Thrasher	18	9	27
Brown-headed Cowbird	149	177	326
Bullock's Oriole		3	3
Burrowing Owl	9	2	11
Canada Goose	9	7	16
Cedar Waxwing		5	5
Chipping Sparrow		5	5
Clay-colored Sparrow	4		4
Cliff Swallow	145	239	384
Common Grackle	6	46	52
Common Nighthawk	25	18	43
Common Yellowthroat	3	1	4
Cooper's Hawk		1	1
Dickcissel	38	1	39
Eastern Bluebird	2	1	3

Common Name	Non-alluvial Soils Counts	Alluvial Soils Counts	Total Counts
Eastern Kingbird	10	28	38
Eurasian Collared-Dove		1	1
European Starling	15	74	89
Field Sparrow	12	15	27
Golden Eagle	1		1
Grasshopper Sparrow	387	379	766
Great Blue Heron		1	1
Great Horned Owl		2	2
Horned Lark	202	100	302
House Wren	1	14	15
Killdeer	17	36	53
Lark Bunting	145	331	476
Lark Sparrow	154	199	353
Lazuli Bunting		2	2
Loggerhead Shrike	1	1	2
Mallard	13	7	20
Mountain Bluebird	11	16	27
Mourning Dove	279	372	651
Northern Flicker		2	2
Northern Harrier	1		1
Northern Rough-winged Swallow	18	24	42
Orchard Oriole	8	33	41
Prairie Falcon	1	2	3
Red-headed Woodpecker		2	2
Red-tailed Hawk	3	11	14
Red-winged Blackbird	326	234	560
Ring-necked Pheasant	3	13	16
Rock Pigeon	26	30	56
Rock Wren	65	91	156
Say's Phoebe	35	40	75
Sharp-tailed Grouse	32	23	55
Sora		2	2
Spotted Towhee	23	31	54
Sprague's Pipit		2	2
Swainson's Hawk	1		1
Tree Swallow	1		1
Turkey Vulture	23	22	45
Unknown Bird	269	210	479
Upland Sandpiper	92	42	134
Vesper Sparrow	1	1	2
Violet-green Swallow		6	6

Common Name	Non-alluvial Soils Counts	Alluvial Soils Counts	Total Counts
Warbling Vireo		3	3
Western Grebe		1	1
Western Kingbird	20	79	99
Western Meadowlark	1079	1399	2478
White-throated Swift	10	5	15
Wild Turkey	2	10	12
Wilson's Snipe	1		1
Yellow Warbler	14	4	18
Yellow-breasted Chat	2	1	3
Yellow-headed Blackbird	18		18
Total	3904	4621	8525

We estimated densities and population sizes for 58 species in at least one stratum (Table 2), including 13 priority species (Appendix A), as well as in the entire North Unit. Our analyses resulted in precise density estimates ($CV < 50\%$) for 27 species in at least one stratum, including eight priority species. For the entire North Unit of the park, Grasshopper Sparrow (130 birds/km^2), Western Meadowlark (77 birds/km^2), and Cliff Swallow (67 birds/km^2) had the highest estimated densities. Black-billed Magpie (0.5 birds/km^2) had lowest estimated density of the six other priority species with $CV < 50\%$. Comparing priority species estimated densities in Badlands National Park to those in all of BCR 17, Northern Rough-winged Swallow density was seven times higher, Say's Phoebe density was 3.7 times higher, and Grasshopper Sparrow and Western Meadowlark densities were twice as high. Lark Bunting and Upland Sandpiper densities were approximately the same while Black-billed Magpie density in Badlands was half the density detected in the entire BCR.

We estimated the proportion of 1 km^2 grid cells occupied (Psi) for 65 species in at least one stratum (Table 3), including 14 priority species (Appendix A), as well as in the entire North Unit. The data yielded robust occupancy estimates ($CV < 50\%$) for 27 species in at least one stratum, including six priority species. Western Meadowlark, Mourning Dove, and Grasshopper Sparrow were estimated to occupy more than 90% of grids, both in the North Unit of the park as a whole and in each soil stratum. Upland Sandpiper (35%) and Dickcissel (25%) had the lowest estimated occupancy rates among the six priority species with $CV < 50\%$. Comparing priority species estimated occupancy rates in Badlands National Park to those in all of BCR 17 in 2011, Say's Phoebe and Dickcissel occupancy rates in Badlands were more than 2.5 times higher while Grasshopper Sparrow estimated occupancy was 1.5 times higher. Lark Bunting, Upland Sandpiper, and Western Meadowlark estimated occupancy rates in Badlands National Park were similar to those of the entire BCR.

Table 2: Bird Densities estimated from surveys conducted in 2011 in the North Unit of Badlands National Park, two substrata within the North Unit and BCR 17. Estimated densities per km² (D), population size (N), percent coefficient of variation of estimates (% CV), and sample sizes (n) of breeding birds used in analyses. Dashes indicate the sample size was insufficient for estimating density. Species of Special Concern are in bold.

	Badlands National Park				Non-alluvial Soils				Alluvial Soils				BCR 17				
Common Name	D	N	%C V	n	D	N	%C V	n	D	N	%C V	n	D	N	%C V	n	
American Crow	1.20	540	18	103	1.27	503	19	63	0.68	37	22	40	0.28	103833	25	106	
American Goldfinch	0.27	121	108	2	--	--	--	0	2.19	121	109	2	7.72	2839771	19	97	
American Kestrel	0.12	55	62	4	0.09	37	88	1	0.32	18	57	3	0.17	61423	48	14	
American Robin	0.05	24	84	3	--	--	--	0	0.43	24	85	3	5.35	1967575	31	290	
Barn Swallow	5.11	2301	52	7	5.56	2198	54	5	1.87	103	92	2	3.42	1256486	40	28	
Black-billed Magpie	0.52	234	44	39	0.47	185	56	12	0.88	49	24	27	1.09	400632	33	62	
Black-capped Chickadee	0.07	30	91	2	--	--	--	0	0.55	30	91	2	5.52	2029004	31	128	
Blue Grosbeak	0.90	405	49	7	0.99	390	51	6	0.28	15	88	1	--	--	--	0	
Blue-winged Teal	0.12	54	98	1	--	--	--	0	0.98	54	98	1	1.64	601677	57	25	
Bobolink	0.86	388	58	6	0.98	388	58	6	--	--	--	0	8.69	3196689	37	162	
Brewer's Blackbird	2.34	1053	69	14	2.10	828	86	5	4.10	226	54	9	10.9	5	4028539	34	132
Brown Thrasher	1.03	465	41	22	1.10	436	43	14	0.53	29	43	8	0.13	48804	43	10	
Brown-headed Cowbird	22.16	9971	14	175	22.22	8777	16	78	119	4	16	97	28.7	1055443	8	14	
Bullock's Oriole	0.09	42	83	3	--	--	--	0	0.76	42	84	3	0.14	49810	41	11	
Canada Goose	0.00	2	100	3	--	--	--	0	0.04	2	92	3	0.16	58110	34	52	
Chipping Sparrow	0.17	77	66	4	--	--	--	0	1.39	77	67	4	9.52	3499423	26	217	
Clay-colored Sparrow	0.15	69	88	1	0.17	69	89	1	--	--	--	0	0.60	221086	51	54	
Cliff Swallow	67.25	3026	2	35	122	68.12	2690	7	38	5	39	63	14.9	4	5495542	60	36
Common Grackle	1.63	735	51	16	0.62	246	83	1	8.89	489	64	15	5.02	1847473	28	26	
Common Nighthawk	3.24	1460	39	24	3.56	1406	41	18	0.99	55	42	6	0.32	115737	40	31	
Common Yellowthroat	0.29	131	82	3	0.31	124	87	2	0.13	7	90	1	1.02	373704	45	29	
Dickcissel	5.22	2348	41	37	5.92	2340	42	36	0.14	8	84	1	3.59	1318828	65	22	
Eastern Kingbird	1.72	776	38	27	1.54	607	48	8	3.06	168	27	19	1.70	624961	31	77	
European Starling	1.52	682	64	7	1.59	627	69	4	1.00	55	86	3	1.44	528129	35	32	
Field Sparrow	0.63	285	51	22	0.65	255	57	11	0.54	30	56	11	0.98	360259	42	134	
Grasshopper Sparrow	129.4	5826	8	8	11	708	132.9	5250	36	5	2	10	343	66.4	2443706	5	2
	8	8	11	708	3	6	12	5	5	2	10	343	5	2	12	8	

Common Name	Badlands National Park				Non-alluvial Soils				Alluvial Soils				BCR 17			
	D	N	%C V	n	D	N	%C V	n	D	N	%C V	n	D	N	%C V	n
Horned Lark	30.55	1374 6	18	215	33.20	1311 6	19	3	11.47	631	22	62	20.3 5	7485439	21	624
House Wren	0.39	174	45	11	0.20	80	83	1	1.70	94	42	10	7.71	2836813	36	232
Killdeer	2.54	1142	27	39	2.39	945	31	14	3.58	197	29	25	2.24	823711	23	90
Lark Bunting	18.60	8371 1077	23	315	16.99	6711	28	9	30.17	165 9	23	206	19.1 5	7041931	24	108 8
Lark Sparrow	23.94	1	19	231	23.52	9291	22	99	26.90	147 9	21	132	9.01	3313685	24	219
Lazuli Bunting	0.04	20	62	2	--	--	--	0	0.37	20	61	2	0.39	141864	52	26
Loggerhead Shrike	0.14	65	88	1	0.16	65	88	1	--	--	--	0	0.25	90716	55	11
Mallard	1.90	856	50	14	2.09	824	52	11	0.58	32	62	3	2.48	911955	33	58
Mountain Bluebird	1.86	835	76	11	1.92	759	84	7	1.38	76	69	4	2.74	1008161	54	56
Mourning Dove	18.21	8195	8	478	17.81	7033	9	8	21.12	116 1	9	280	5.46	2008531	14	325
Northern Harrier	0.05	21	85	1	0.05	21	85	1	--	--	--	0	0.10	34805	40	13
Northern Rough-winged Swallow	5.14	2311	35	18	5.11	2017	40	8	5.35	294	32	10	0.72	264890	46	5
Red-tailed Hawk	0.01	4	58	2	--	--	--	0	0.07	4	61	2	0.14	52753	32	19
Red-winged Blackbird	42.16	1897 3	18	325	44.95	1775 4	19	4	22.15	121 8	19	121	14.9 7	5505629	26	393
Ring-necked Pheasant	0.06	26	46	15	0.05	18	64	3	0.15	8	41	12	0.66	243816	25	186
Rock Pigeon	0.42	191	47	8	0.36	141	62	2	0.90	49	41	6	--	--	--	0
Rock Wren	3.74	1684	24	118	3.60	1424	28	46	4.73	260	26	72	1.61	592928	24	99
Say's Phoebe	2.65	1191	21	64	2.68	1060	24	31	2.40	132	21	33	0.72	263398	31	41
Spotted Towhee	4.00	1802	28	36	4.08	1613	30	18	3.42	188	62	18	6.90	2539125	19	263
Sprague's Pipit	0.01	6	60	2	--	--	--	0	0.11	6	62	2	0.11	41091	62	7
Turkey Vulture	1.28	574	50	5	1.35	533	53	3	0.75	41	84	2	0.27	98029	51	14
Upland Sandpiper	3.76	1692	34	52	4.11	1623	36	38	1.27	70	33	14	4.22	1553453	49	165
Vesper Sparrow	0.14	63	76	2	0.14	56	85	1	0.12	7	88	1	12.4 6	4582084	16	512
Violet-green Swallow	0.15	68	60	2	--	--	--	0	1.24	68	60	2	0.55	202845	47	10
Western Kingbird	2.63	1183	20	54	2.13	840	26	12	6.24	343	31	42	1.78	655191	35	59
Western Meadowlark	77.15	3471 6	204 4	7	77.00	3041 5	92 5	8	78.21	430 2	111 4	9	41.5 5	1528166 9	372 7	6
White-throated Swift	1.06	477	60	8	1.13	446	64	5	0.57	31	63	3	0.02	7147	91	2

Common Name	Badlands National Park				Non-alluvial Soils				Alluvial Soils				BCR 17			
	D	N	%C V	n	D	N	%C V	n	D	N	%C V	n	D	N	%C V	n
Wild Turkey	0.01	6	96	2	--	--	--	0	0.12	6	90	2	0.15	54074	37	18
Wilson's Snipe	0.17	75	85	1	0.19	75	85	1	--	--	--	0	0.74	270914	88	9
Yellow Warbler	3.30	1487	34	13	3.64	1436	35	10	0.91	50	59	3	3.40	1251134	42	68
Yellow-breasted Chat	0.14	61	76	2	0.14	54	85	1	0.12	6	84	1	0.31	112325	56	30
Yellow-headed Blackbird	1.60	722	57	11	1.83	722	57	11	--	--	--	0	0.53	192976	69	13

Table 3: Bird Occupancy Rates estimated from 2011 surveys in the North Unit of Badlands National Park, two substrata within the North Unit, and BCR 17. Estimated proportion of sample units occupied (Psi), standard error of Psi (SE), percent coefficient of variation of Psi (% CV) and number of grid cells with one or more detections (Ntran) of breeding bird species in Badlands National Park, Non-alluvial soils stratum, Alluvial soils stratum and BCR 17 (not including Badlands National Park). Dashes indicate the data were insufficient for estimating site occupancy. A Psi estimate equal to 1 indicates the species was detected on all transects surveyed and no SE or %CV is presented. Species of Special Concern are in bold.

Common Name	Badlands National Park				Non-alluvial Soils				Alluvial Soils				BCR 17			
	Psi	SE	%CV	Ntran	Psi	SE	%CV	Ntran	Psi	SE	%CV	Ntran	Psi	SE	%CV	Ntran
American Crow	0.513	0.155	30	14	0.516	0.173	33	7	0.488	0.163	33	7	0.074	0.013	17	17
American Goldfinch	0.010	0.007	68	2	--	--	--	0	0.086	0.058	68	2	0.288	0.060	21	37
American Kestrel	0.176	0.136	77	4	0.148	0.150	101	1	0.378	0.225	59	3	0.195	0.128	66	8
American Robin	0.005	0.005	98	1	--	--	--	0	0.040	0.040	98	1	0.271	0.063	23	55
Bank Swallow	0.053	0.042	79	3	0.048	0.047	98	1	0.091	0.062	68	2	0.160	0.071	44	6
Barn Swallow	0.313	0.137	44	7	0.326	0.155	48	4	0.221	0.123	55	3	0.203	0.062	30	29
Black-billed Magpie	0.147	0.080	54	7	0.128	0.089	69	2	0.285	0.119	42	5	0.157	0.067	43	14
Black-capped Chickadee	0.005	0.005	98	1	--	--	--	0	0.043	0.042	98	1	0.196	0.055	28	36
Brown-headed Cowbird	0.750	0.080	11	41	0.726	0.091	12	18	0.920	0.054	6	23	0.893	0.037	4	134
Blue Grosbeak	0.136	0.072	53	4	0.149	0.081	55	3	0.046	0.046	98	1	--	--	--	0
Bobolink	0.071	0.048	68	2	0.081	0.055	68	2	--	--	--	0	0.240	0.049	20	23
Brewer's Blackbird	0.070	0.040	57	7	0.044	0.043	98	1	0.254	0.091	36	6	0.352	0.074	21	44
Brown Thrasher	0.403	0.142	35	10	0.424	0.162	38	6	0.249	0.118	48	4	0.048	0.031	64	5
Bullock's Oriole	0.007	0.007	100	1	--	--	--	0	0.059	0.059	100	1	0.085	0.062	73	8
Burrowing Owl	0.135	0.098	72	2	0.154	0.112	72	2	--	--	--	0	0.039	0.004	10	3
Blue-winged Teal	0.059	0.052	89	2	0.059	0.059	99	1	0.054	0.053	99	1	0.163	0.087	53	10
Canada Goose	0.105	0.090	86	3	0.097	0.100	103	1	0.167	0.123	74	2	0.110	0.056	50	9
Clay-colored Sparrow	0.041	0.040	98	1	0.047	0.046	98	1	--	--	--	0	0.047	0.021	45	15
Cedar Waxwing	0.008	0.008	99	1	--	--	--	0	0.068	0.067	99	1	0.086	0.045	52	9

Common Name	Badlands National Park				Non-alluvial Soils				Alluvial Soils				BCR 17			
	Psi	SE	%CV	Ntran	Psi	SE	%CV	Ntran	Psi	SE	%CV	Ntran	Psi	SE	%CV	Ntran
Chipping Sparrow	0.010	0.007	68	2	--	--	--	0	0.081	0.055	68	2	0.209	0.052	25	52
Cliff Swallow	0.577	0.096	17	29	0.563	0.108	19	13	0.672	0.100	15	16	0.174	0.044	25	17
Common Grackle	0.089	0.048	54	8	0.053	0.052	98	1	0.345	0.112	33	7	0.375	0.095	25	21
Common Nighthawk	0.587	0.173	30	11	0.650	0.197	30	9	0.128	0.089	69	2	0.072	0.032	44	15
Common Yellowthroat	0.044	0.043	98	1	0.050	0.050	98	1	--	--	--	0	0.065	0.027	42	10
Dickcissel	0.256	0.081	32	8	0.286	0.092	32	7	0.041	0.040	98	1	0.101	0.045	45	5
Eastern Bluebird	0.065	0.066	101	1	0.074	0.075	101	1	--	--	--	0	0.030	0.015	49	3
Eastern Kingbird	0.302	0.100	33	14	0.279	0.112	40	5	0.469	0.126	27	9	0.380	0.093	24	43
European Starling	0.123	0.072	59	5	0.117	0.081	69	2	0.163	0.090	55	3	0.236	0.093	40	17
Field Sparrow	0.121	0.060	50	5	0.126	0.068	54	3	0.082	0.056	68	2	0.149	0.052	35	21
Grasshopper Sparrow	0.926	0.048	5	47	0.921	0.054	6	23	0.960	0.039	4	24	0.603	0.060	10	97
Horned Lark	0.699	0.080	11	31	0.723	0.090	12	18	0.524	0.101	19	13	0.525	0.067	13	81
House Wren	0.051	0.036	71	4	0.041	0.040	98	1	0.121	0.066	54	3	0.248	0.058	24	37
Killdeer	0.404	0.116	29	19	0.362	0.130	36	6	0.704	0.138	20	13	0.420	0.089	21	44
Lark Bunting	0.481	0.089	18	24	0.481	0.100	21	12	0.480	0.100	21	12	0.380	0.066	17	63
Lark Sparrow	0.676	0.087	13	36	0.658	0.099	15	16	0.803	0.080	10	20	0.382	0.042	11	52
Lazuli Bunting	0.011	0.008	68	2	--	--	--	0	0.093	0.063	68	2	0.037	0.013	36	12
Loggerhead Shrike	0.073	0.072	99	1	0.083	0.082	99	1	--	--	--	0	0.081	0.039	48	10
Mallard	0.183	0.090	49	6	0.185	0.101	55	3	0.167	0.091	55	3	0.384	0.113	30	37
Mountain Bluebird	0.054	0.038	71	4	0.043	0.042	98	1	0.127	0.069	54	3	0.158	0.051	32	26
Mourning Dove	0.989	0.036	4	49	0.988	0.041	4	24	1.000	--	--	25	0.591	0.067	11	82
Orchard Oriole	0.197	0.087	44	13	0.132	0.093	70	2	0.665	0.183	28	11	0.066	0.063	96	1
Ring-necked Pheasant	0.013	0.009	69	2	--	--	--	0	0.105	0.072	69	2	0.204	0.083	41	14
Rock Pigeon	0.135	0.072	53	7	0.117	0.080	69	2	0.267	0.109	41	5	0.001	0.001	71	1
Rock Wren	0.447	0.093	21	24	0.428	0.105	24	10	0.586	0.104	18	14	0.299	0.052	18	30
Red-tailed Hawk	0.014	0.014	103	1	--	--	--	0	0.112	0.115	103	1	0.022	0.011	48	6
Red-winged Blackbird	0.705	0.085	12	35	0.701	0.096	14	17	0.728	0.091	12	18	0.363	0.056	15	62
Say's Phoebe	0.607	0.133	22	22	0.601	0.149	25	10	0.650	0.139	21	12	0.221	0.069	31	17
Sora	0.006	0.006	98	1	--	--	--	0	0.047	0.046	98	1	0.022	0.021	93	2
Sprague's Pipit	0.010	0.007	68	2	--	--	--	0	0.083	0.057	68	2	0.001	0.001	87	1
Spotted Towhee	0.168	0.066	40	9	0.163	0.075	46	4	0.202	0.081	40	5	0.318	0.060	19	51
Sharp-tailed Grouse	0.134	0.080	60	5	0.129	0.090	69	2	0.173	0.096	56	3	0.087	0.061	71	9

Common Name	Badlands National Park				Non-alluvial Soils				Alluvial Soils				BCR 17			
	Psi	SE	%CV	Ntran	Psi	SE	%CV	Ntran	Psi	SE	%CV	Ntran	Psi	SE	%CV	Ntran
Tree Swallow	0.057	0.056	100	1	0.064	0.064	100	1	--	--	--	0	0.014	0.006	47	8
Turkey Vulture	0.289	0.157	54	4	0.317	0.179	56	3	0.091	0.090	99	1	0.053	0.033	63	12
Upland Sandpiper	0.347	0.096	28	12	0.371	0.108	29	8	0.175	0.080	46	4	0.295	0.079	27	40
Vesper Sparrow	0.041	0.035	87	2	0.041	0.040	98	1	0.040	0.039	98	1	0.472	0.063	13	67
Violet-green Swallow	0.026	0.016	59	3	--	--	--	0	0.216	0.128	59	3	0.064	0.026	41	10
Warbling Vireo	0.010	0.007	68	2	--	--	--	0	0.086	0.058	68	2	0.034	0.018	52	12
Western Kingbird	0.412	0.101	25	20	0.392	0.114	29	8	0.553	0.115	21	12	0.313	0.085	27	32
Western Meadowlark	1.000	--	--	50	1.000	--	--	25	1.000	--	--	25	0.942	0.019	2	139
Wilson's Snipe	0.049	0.048	98	1	0.056	0.055	98	1	--	--	--	0	0.026	0.023	90	2
Wild Turkey	0.008	0.008	102	1	--	--	--	0	0.064	0.065	102	1	0.049	0.030	61	6
White-throated Swift	0.176	0.096	55	5	0.185	0.108	59	3	0.112	0.079	71	2	0.009	0.006	60	3
Yellow-breasted Chat	0.048	0.042	88	2	0.048	0.047	98	1	0.045	0.045	98	1	0.042	0.024	58	8
Yellow-headed Blackbird	0.123	0.086	70	2	0.141	0.098	70	2	--	--	--	0	0.112	0.078	70	5
Yellow Warbler	0.132	0.064	48	6	0.133	0.072	54	3	0.128	0.069	54	3	0.154	0.048	31	27

To view interactive maps showing survey and detection locations, species counts and density, population and occupancy results using the GRTS study design, visit RMBO's Avian Data Center (<http://rmbo.org/v3/avian/Home.aspx>). For instructions and tips on the use of this site refer to Appendix B.

Breeding Bird Surveys

One breeding bird survey route, the Cedar Pass Route, was conducted in Badlands National Park in 2011. During stops 1 – 13, the part of the route within the park, we counted 75 individual birds of 12 species, including three species of special concern (Table 4). Since 1997, counts in stops 1 – 13 on this route had an average of 133 individual birds of 12 species detected each year. The Badlands Breeding Bird Survey Route was not completed in 2011. Data from 2010 for the Badlands Route are presented alongside the all-year average for comparison (Table 4).

Table 4: Cedar Pass Breeding (stops 1-13) and Badlands Bird Survey Route summaries. Species in bold are Species of Special Concern (Appendix A); non-breeding species are highlighted.

Common Name	Cedar Pass Route		Badlands Route	
	# of individuals 2011	Average # of Individuals 1997-2010	# of individuals 2010	Average # of Individuals 1997-2009
American Avocet	0	0	0	0.08
American Coot	0	0	0	1.17
American Crow	0	1.27	1	25.00
American Goldfinch	0	0.00	0	4.17
American Kestrel	0	0.09	1	0.67
American Robin	1	0.36	0	0.75
American White Pelican	0	0.00	0	1.33
Bank Swallow	0	0.00	0	0.33
Barn Swallow	0	2.55	14	9.50
Bell's Vireo	0	0	1	0.50
Black-billed Cuckoo	0	0	0	0.17
Black-billed Magpie	0	3.36	0	0.33
Black-headed Grosbeak	0	0	0	0.50
Blue Grosbeak	0	0.27	0	1.50
Blue-winged Teal	0	0	2	0.75
Bobolink	0	0	0	0.83
Brewer's Blackbird	0	0	0	0.33
Brown Thrasher	0	0.27	0	1.17
Brown-headed Cowbird	1	1.54	7	13.25
Burrowing Owl	0	0	1	1.00
Canada Goose	0	0	0	0.67
Chipping Sparrow	0	0	0	0.42

Common Name	Cedar Pass Route		Badlands Route	
	# of individuals 2011	Average # of Individuals 1997-2010	# of individuals 2010	Average # of Individuals 1997-2009
Cliff Swallow	0	6.09	90	149.67
Common Grackle	0	1.91	1	2.50
Common Nighthawk	7	1.63	0	1.25
Common Yellowthroat	0	0	0	0.33
Eastern Kingbird	0	0.09	1	1.67
European Starling	0	0	0	0.08
Ferruginous Hawk	0	0	0	0.08
Field Sparrow	0	0	0	7.67
Gadwall	0	0	0	0.75
Golden Eagle	0	0	1	0.00
Grasshopper Sparrow	3	0.55	22	24.17
Great Blue Heron	0	0	0	0.25
Great Horned Owl	3	0	0	0
Hairy Woodpecker	0	0	0	0.17
Horned Lark	0	0.09	30	13.00
House Finch	0	0	0	0.92
House Sparrow	0	0	0	0.83
House Wren	1	0.27	0	2.50
Killdeer	0	0.18	2	4.08
Lark Bunting	0	0.00	0	14.25
Lark Sparrow	0	0.18	0	4.75
Lazuli Bunting	0	0.09	18	0.83
Loggerhead Shrike	0	0.09	0	0.50
Long-billed Curlew	0	0.18	0	5.08
Mallard	0	0.18	2	3.67
Mountain Bluebird	0	0.54	0	0.83
Mourning Dove	19	19.82	21	39.00
Northern Flicker	0	0	0	0.25
Northern Harrier	0	0	0	0.42
Northern Shoveler	0	0	0	0.42
Orchard Oriole	0	0.09	0	0.25
Pied-billed Grebe	0	0	0	0.08
Prairie Falcon	0	0.09	0	0.00
Red-eyed Vireo	0	0	0	0.17
Red-tailed Hawk	0	0	0	0.17
Red-winged Blackbird	5	13.90	18	21.50
Ring-necked Pheasant	0	1.46	0	0.92
Rock Pigeon	0	0.27	0	0.33
Rock Wren	1	1.36	4	5.42

Common Name	Cedar Pass Route		Badlands Route	
	# of individuals 2011	Average # of Individuals 1997-2010	# of individuals 2010	Average # of Individuals 1997-2009
Say's Phoebe	0	0.09	0	1.33
Sharp-tailed Grouse	0	0	1	0.42
Short-eared Owl	0	0	0	0.08
Sora	0	0	0	0.08
Spotted Towhee	0	0.91	4	11.42
Swainson's Hawk	0	0	0	0.33
Turkey Vulture	0	1.55	1	1.92
Upland Sandpiper	0	1.00	1	1.08
Vesper Sparrow	2	0.23	0	2.50
Virginia Rail	0	0	0	0.08
Warbling Vireo	1	0.09	8	1.33
Western Kingbird	0	0.09	0	2.08
Western Meadowlark	31	50.80	136	203.92
White-throated Swift	0	0.18	0	1.00
Wild Turkey	0	0	6	3.42
Wilson's Phalarope	0	0	0	0.42
Wilson's Snipe	0	0	0	0.58
Wood Duck	0	0	0	0.50
Yellow Warbler	0	0	1	0.58
Yellow-breasted Chat	0	0	2	3.25
Yellow-headed Blackbird	0	0	20	1.42
Total individuals	75	114	417	611
Total species	12	40	29	80

Discussion

Grassland- and cliff-associated species were the most widespread and abundant bird species detected during the 2011 surveys in the North Unit of Badlands National Park. This is not surprising given that most of the area in the North Unit is grassland and cliff habitat (Von Loh et al. 1999). Two grassland species, Western Meadowlark and Grasshopper Sparrow, had the highest estimated densities and highest occupancy rates of any species in the park. Grasshopper Sparrow is a Species of Concern for several agencies (Appendix A). Based on a significant long-term negative trend and high breeding density in BCR 17, Partners In Flight (2012) identified Grasshopper Sparrow as a ‘Common bird in steep decline’ and recommended management or conservation actions to reverse the decline. Badlands National Park appears to be highly beneficial to Grasshopper Sparrows as evidenced by the higher estimated densities and occupancy rates in the park compared to the rest of the BCR, at least in 2011. Additional years of data collection will be needed to confirm the importance of the North Unit to this species. Western Meadowlark populations are not yet in such steep decline but BCR 17 does host approximately 47% of the continent’s breeding population (Partners In Flight 2012). Thus, this region, including Badlands National Park, is critical for keeping this common species common. Again, Badlands National Park seems to be beneficial for this species because the park’s population is at much higher densities and higher estimated occupancy rates than the entire BCR. Additional studies focused on the reasons for higher grassland bird populations in the park would provide valuable lessons that could be utilized in the rest of the region.

Cliff-dwelling aerial insectivores were another guild with relatively high estimated densities or occupancy rates in the park compared to the rest of the region. The much higher estimated densities and occupancy of three species (Cliff Swallow, Northern Rough-winged Swallow, Say’s Phoebe) observed in the park, most likely are due to the abundance of nesting habitat (cliffs), which is relatively rare in the rest of the BCR. Populations of this bird guild are declining in the northeast part of North America for unknown reasons (Nebel et al. 2010). For conservation of aerial insectivores in the northern Great Plains, population monitoring will be critical to detect when and if these species begin to decline so that conservation actions can be initiated in time.

One species of concern, Black-billed Magpie, was estimated to have much lower densities and occupancy rates in Badlands National Park compared to the rest of BCR 17. This species is at the extreme eastern edge of its range in the Badlands National Park (Trost 1999); it appears to be limited by climatic gradients, preferring dry cool climes (Bock and Lepthien 1975). Thus, most of BCR 17 has more preferred climatic conditions which may explain higher densities west of the Badlands National Park. Nevertheless, this species is negatively impacted by grassland conversion to row crops and needs to be monitored so that western South Dakota and Badlands National Park do not lose the few magpies that are present.

The 2011 GRTS-based point counts resulted in a species list that took many years to accumulate from BBS surveys within the park. Far fewer species were detected per year on the BBS surveys compared to the one year of data collection in the GRTS-based design. This most likely is because per-year survey effort in the GRTS-based design (581 point counts, 6 minutes per count) is much greater than per-year survey effort in the BBS (61 point counts, 3 minutes per count). When considering the BBS results summarized over the past 10 years of surveys (Table

4), the resulting species list and raw counts essentially reflect the results of the 2011 GRTS-based point counts. Thus, BBS surveys can produce an equivalent species list as GRTS-based point counts, but they cannot provide population density, size, occupancy, or trend estimates for any species at the individual national park level. Park BBS survey data do contribute to regional population trend estimates, but the data are less useful for park managers to monitor the health of bird populations within park boundaries and evaluate effects of management on park birds. In addition, BBS surveys only detect birds along roadsides and thus, managers cannot use BBS survey results for monitoring or evaluating issues concerning birds away from roads.

The 2011 GRTS-based point counts detected all of the species listed as ‘common’ on the Badlands National Park North Unit bird list, a publication given to park visitors to enhance their enjoyment and understanding of the park. The list and status codes were created from various ad-hoc data sources and vetted by experts. Based on our point count results and estimated density analyses, we recommend that the summer status of the following species on the park list be upgraded to ‘common’: Upland Sandpiper, Northern Rough-winged Swallow, Grasshopper Sparrow, Lark Bunting, Dickcissel, Red-winged Blackbird, Brewer’s Blackbird and Yellow Warbler. In addition, we recommend that Yellow-headed Blackbird and Bobolink be upgraded from ‘rare’ to ‘uncommon’ summer status.

Recommendations

The 2011 pilot project in Badlands National Park shows that the GRTS-based sampling design and field protocol developed by the Integrated Monitoring in Bird Conservation Regions (IMBCR) meets the goals and objectives of the NGPN bird monitoring program. Thus, we recommend that this sampling design and monitoring protocol be extended to all of the parks in the network. The advantages and issues are as follows:

- The GRTS sampling design and point count monitoring protocol allows for more precise population and occupancy estimates to be generated using detection probability. Spatially-balanced sampling generally is more efficient than simple random sampling of natural resources (Stevens and Olsen 2004). Incorporating information about spatial autocorrelation in the data can increase precision in density estimates.
- The GRTS approach has the flexibility to generate valid population estimates at scales relevant to land management agencies, as well as support conservation efforts at both local and regional scales. For instance, in 2011 at Badlands National Park, we had three examples (grassland species, cliff-nesting aerial insectivores, Black-billed Magpie) in which the ability to compare local estimates to regional estimates resulted in an ability to interpret bird populations at both scales, with just one year of data collection. More years of data collection will reveal more information on these and other species. This allows researchers to generate and test hypotheses on the reasons for these observations, which then allows managers to implement adaptive management to conserve park bird populations.
- Incorporating data collected at small scales to estimate parameters at larger scales allows this design to address the need for large-scale monitoring, which has been emphasized in bird conservation initiatives (Ruth et al. 2003). The region-wide population estimates generated

from these data can better assist managers in understanding trends in landbird populations (U.S. North American Bird Conservation Initiative 2009).

- Population size estimates presented in this report were produced from density estimates that account for spatial variation and incomplete detection, which allowed the population estimates to be extended over the entire area of interest (Pollock et al. 2002, Thompson 2002, Nichols et al. 2009). Avian population size estimates at the BCR level can also be found in the PIF Population Estimates Database, which are based on BBS surveys (http://rmbo.org/pif_db/laped/). Initial comparisons between IMBCR and PIF population size estimates for several species show substantial differences. For example, in 2010 the PIF population size estimates for Brewer's Sparrow and Horned Lark within BCR 17 were 670,000 and 8 million, while the IMBCR estimates were greater than 5 million and less than 6 million; respectively. The population size estimates presented by PIF were extrapolated to the BCR level from the road-based Breeding Bird Survey (BBS) after applying several *post hoc* correction factors in an attempt to account for incomplete detection (Blancher et al. 2007). While changes in population indices may or may not correspond to true trends in bird populations, direct inference about absolute populations are limited in the PIF database by non-random sampling with respect to roads and lack of information about detection probabilities (Pollock et al. 2002, Nichols et al. 2009).
- By analyzing data across both the North Unit of Badlands National Park and the BCR 17 sampling frames we can estimate common detection probabilities for species that would have otherwise had an insufficient number of detections. Simulations using 10 years of data from a similar avian monitoring program (J. Blakesley, RMBO, unpublished) indicated the IMBCR monitoring program would have 80% power to detect an average annual decline of 3% in a population within 25 years when % CVs of the estimates are $\leq 40\%$. A similar trend could be detected within 30 years with a % CV of $\leq 50\%$. The ability to detect population trends for any species is a function of the sampling effort, abundance and annual variation of abundance for individual species. Some grassland bird species such as Lark Bunting shift their breeding ranges from year to year based on environmental conditions (Shane 2000), resulting in abundance estimates that fluctuate significantly among years. More precise density estimates will be required to monitor population trends within 25-30 years for species exhibiting a larger degree of annual variation in density and abundance estimates.
- All sample units in the sampling frame are ordered, such that any set of consecutively numbered units is a spatially well-balanced sample (Stevens and Olsen 2004). In the case of fluctuating budgets, monitoring partners can adjust the sampling effort among years within each stratum while still preserving a random, spatially-balanced sampling design. In addition, although the importance of long-term and intensive population monitoring is well known, it is expensive, with costs typically determining the sampling effort. The IMBCR design reduces costs through cooperation with multiple partners; one of the stated goals of effective collaboration and coordinated bird monitoring (US North American Bird Conservation Initiative 2007). Partners and managers can investigate other priority species and taxa with only slight modifications to the IMBCR design, further reducing costs associated with developing new studies and monitoring programs. Ideally, these cost savings can be used to increase sample efforts, particularly in under-sampled strata, and conducting additional avian-habitat relationship analyses.

- Occupancy estimation increases the number of bird species that we are able to effectively monitor and provides managers with information about populations of rare and uncommon species (MacKenzie et al. 2005). For example, we were able to provide estimates for Sharp-tailed Grouse and Burrowing Owls in the North Unit of Badlands in 2011 by this method. By evaluating the strength of evidence for four occupancy estimation models, we accounted for regional variation in detection and availability, resulting in robust estimates of Psi. The 2011 analysis marked the first year occupancy estimates were produced using model-averaging. We feel this technique improved our estimates because all models with any probability of being the top-ranked model influenced the presented estimates. Although we only incorporated data collected in 2011 to produce this year's estimates we anticipate that our analyses will be further improved by incorporating multiple years of data to estimate detection probability in the future. Utilizing multiple years of data in the future will allow us to produce occupancy estimates for additional species, including some of the most difficult to detect and/or rare species encountered.
- The IMBCR design allows sampling of all habitats, allowing managers to relate changes in bird populations to landscape changes over time. Because all vegetation classes are available for sampling and samples are spatially balanced, rare habitats are sampled less frequently than others. Sampling of these rare habitats does appear to be proportional to land cover classifications. Further explorations of sampled habitat types can be done through post-stratification of the data by vegetation cover type and primary habitat to determine if some species and habitats are under-sampled. Additional analyses of avian-habitat relationships using the vegetation data collected during the point count can help guide future conservation and management.
- Whether a park creates substrata for surveys depends on park objectives. Monitoring in substrata is more expensive than not having substrata because a minimum number of samples is needed to generate adequate sample sizes for analyses. In 2011, two substrata based on soils (alluvial and non-alluvial) were created because vegetation between these substrata is substantially different in Badlands National Park. Although density and occupancy rate estimates were somewhat different between substrata for some bird species, the same bird species were found in both substrata. In this case, the small differences do not justify the cost of having substrata. Analysts can always post-stratify by habitat or other attributes to explore particular relationships of interest to the park.
- Data generated by this design also give a scientific basis for park bird lists and general breeding status of each species.

Literature Cited

- Alexander, J. D., J. L. Stevens, G. R. Geupel, and T. C. Will. 2008. Decision support tools: bridging the gap between science and management. *Proceedings of the Fourth International Partners in Flight Conference: Tundra to Tropics* 283-291.
- American Ornithologists' Union. 2007. Checklist of North American Birds, 7th Edition. American Ornithologists' Union. Available at: <http://checklist.aou.org/> (accessed 3 December 2013).
- Baron, J. S., S. H. Julius, J. M. West, L. A. Joyce, G. Blate, C. H. Peterson, M. Palmer, B. D. Keller, P. Kareiva, J. M. Scott, and B. Griffith. 2008. Some guidelines for helping natural resources adapt to climate change. *International Human Dimensions Programme on Global Environmental Change Update* 2:46-52.
- Blakesley, J. A., and D. J. Hanni. 2009. Monitoring Colorado's Birds, 2008. Technical Report M-MCB08-01. Rocky Mountain Bird Observatory, Brighton, Colorado, USA.
- Blancher, P. J., K. V. Rosenberg, A. O. Panjabi, B. Altman, J. Bart, C. J. Beardmore, G. S. Butcher, D. Demarest, R. Dettmers, E. H. Dunn, W. Easton, W. C. Hunter, E. E. Iñigo-Elias, D. N. Pashley, C. J. Ralph, T. D. Rich, C. M. Rustay, J. M. Ruth, and T. C. Will. 2007. Guide to the Partners in Flight Population Estimates Database. Version: North American Landbird Conservation Plan 2004. Partners in Flight Technical Series No 5.
- Bock, C. E., and L. W. Lepthien. 1975. Distribution and abundance of the Black-billed magpie (*Pica pica*) in North America. *Great Basin Naturalist* 35:269-272.
- 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 University Press, Oxford, UK.
- Burnham, K. P., and D. R. Anderson. 2002. Model selection and multimodel inference: a practical information-theoretic approach. Springer-Verlag, New York, New York, USA.
- Bystrak, D. 1981. The North American breeding bird survey. Pp. 34-41 in C. J. Ralph and J. M. Scott, editors. Estimating numbers of terrestrial birds. *Studies in Avian Biology*, No. 6, Cooper Ornithological Society, Lawrence, Kansas, USA.
- Dreitz, V. J., P. M. Lukacs, and F. L. Knopf. 2006. Monitoring low density avian populations: An example using Mountain Plovers. *Condor* 108:700-706.
- Environmental Systems Research Institute. 2006. ArcGIS, version 9.2. Environmental Systems Research Institute, Incorporated, Redlands, California, USA.
- 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.

- Geissler, P. H. and B. R. Noon. 1981. Estimates of avian population trends from the North American Breeding Bird Survey. *Studies in Avian Biology* 6: 42-51.
- Gitzen, R. A., M. Wilson, J. Brumm, M. Bynum, J. Wrede, J. J. Millspaugh, and K. J. Paintner. 2010. Northern Great Plains Network vital signs monitoring plan. Natural Resource Report NPS/NGPN/NRR-2010/186. National Park Service, Fort Collins, Colorado.
- Hanni, D. J., C. M. White, R. A. Sparks, J. A. Blakesley, J. J. Birek, N. J. Van Lanen, and J. A. Fogg. 2011. Field protocol for spatially-balanced sampling of landbird populations. Unpublished report. Rocky Mountain Bird Observatory, Brighton, Colorado, USA.
- Kincaid, T. 2008. Integrated Monitoring in Bird Conservation Regions: 2011 Annual Report. Unpublished report. United States Environmental Protection Agency, Washington, D. C., USA.
- Link, W. A., and J. R. Sauer. 2002. A hierarchical model of population change with application to Cerulean Warblers. *Ecology* 83:2832-2840.
- Lindenmayer, D. B., and G. E. Likens. 2009. Adaptive monitoring: a new paradigm for long-term research and monitoring. *Trends in Ecology and Evolution* 24:482-486.
- Lyons, J. E., M. C. Runge, H. P. Laskowski, and W. L. Kendall. 2008. Monitoring in the context of structured decision-making and adaptive management. *Journal of Wildlife Management* 72:1683-1692.
- 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 occurrence*. Elsevier, Burlington, Massachusetts, USA.
- MacKenzie, D. I., J. D. Nichols, N. Sutton, K. Kawanishi, and L. L. Bailey. 2005. Improving inferences in population studies of rare species that are detected imperfectly. *Ecology* 86:1101-1113.
- Marsh, D. M., and P. C. Trenham. 2008. Current trends in plant and animal population monitoring. *Conservation Biology* 22:647-655.
- Nebel, S., A. Mills, J.D. McCracken, and P.D. Taylor. 2010. Declines of aerial insectivores in North America follow a geographic gradient. *Avian Conservation and Ecology* 5(2):1.
- Nichols, J. D., L. L. Bailey, A. F. O'Connell, N. W. Talancy, E. H. C. Grant, A. T. Gilbert, E. M. Annand, T. P. Husband, and J. E. Hines. 2008. Multi-scale occupancy estimation and modelling using multiple detection methods. *Journal of Applied Ecology* 45:1321-1329.

- Nichols, J. D., L. Thomas, and P. B. Conn. 2009. Inferences about landbird abundance from count data: recent advances and future directions. Pages 1131 in D. L. Thomson, E. G. Cooch, and M. J. Conroy, editors. Modeling demographic processes in marked populations. Springer, New York.
- Partners In Flight. 2012. Species Assessment Database, version 2012. Available at: <http://rmbo.org/pifassessment> (accessed 3 December 2013).
- Patuxent Wildlife Research Center. 2012. About BBS. Available at: <https://www.pwrc.usgs.gov/bbs/about/> (accessed 3 December 2013).
- Pavlacky, D. C., Jr., J. A. Blakesley, G. C. White, D. J. Hanni, and P. M. Lukacs. 2012. Hierarchical multi-scale occupancy estimation for monitoring wildlife populations. *Journal of Wildlife Management* 76:154–162.
- Pollock, K. H., J. D. Nichols, T. R. Simons, G. L. Farnsworth, L. L. Bailey, and J. R. Sauer. 2002. Large scale wildlife monitoring studies: statistical methods for design and analysis. *Environmetrics* 13:105-119.
- Powell, L. A. 2007. Approximating variance of demographic parameters using the delta method: a reference for avian biologists. *Condor* 109:949-954.
- R Development Core Team. 2011. R: a language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Available at: <http://www.r-project.org/> (accessed 30 September 2011).
- Rich, T. D., C. J. Beardmore, H. Berlanga, P. J. Blancher, M. S. W. Bradstreet, G. S. Butcher, D. W. Demarest, E. H. Dunn, W. C. Hunter, E. E. Iñigo-Elias, J. A. Kennedy, A. M. Martell, A. O. Panjabi, D. N. Pashley, K. V. Rosenberg, C. M. Rustay, J. S. Wendt, and T. C. Will. 2004. Partners in Flight North American landbird conservation plan. Cornell Lab of Ornithology, Ithaca, New York, USA.
- Robbins, C. S. and W. T. Van Velzen. 1967. The Breeding Bird Survey, 1966. U.S. Department of Interior, Migratory Bird Populations Station, Special Scientific Report--Wildlife No. 10, Washington, D.C.
- 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.
- Ruth, J. M., D. R. Petit, J. R. Sauer, M. D. Samuel, F. A. Johnson, M. D. Fornwall, C. E. Korschgen, and J. P. Bennett. 2003. Science for avian conservation: Priorities for the new millennium. *Auk* 120:204-211.
- Sauer, J. R., and M. G. Knutson. 2008. Objectives and metrics for wildlife monitoring. *Journal of Wildlife Management* 72:1663-1664.
- Sauer, J. R., and W. A. Link. 2011. Analysis of the North American Breeding Bird Survey using hierarchical models. *Auk* 128 (1):87-98.

- Shane, T. G. 2000. Lark Bunting (*Calamospiza melanocorys*). Cornell Lab of Ornithology. Available at: <http://bna.birds.cornell.edu/bna/species/542> (accessed 15 February 2011).
- South Dakota Department of Game Fish and Parks (SDGFP). 2006. South Dakota Comprehensive Wildlife Conservation Plan. South Dakota Dept. of Game Fish and Parks. Wildlife Division Report 2006-2008.
- Stevens, D. L., Jr., and A. R. Olsen. 2004. Spatially balanced sampling of natural resources. *Journal of the American Statistical Association* 99:262-278.
- Thomas, L., S. T. Buckland, E. A. Rexstad, J. L. Laake, S. Strindberg, S. L. Hedley, J. R. B. Bishop, T. A. Marques, and K. P. Burnham. 2010. Distance software: design and analysis of distance sampling surveys for estimating population size. *J. Applied Ecology* 47:5-14.
- Thompson, W. L. 2002. Towards reliable bird surveys: accounting for individuals present but not detected. *Auk* 119:18-25.
- Thompson, W. L., G. C. White, and C. Gowan. 1998. Monitoring vertebrate populations. Academic Press, San Diego, California, USA.
- Trost, C. H. 1999. Black-billed Magpie (*Pica hudsonia*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online. Available at: <http://bna.birds.cornell.edu/bna/species/389> (accessed 19 November 2012).
- U.S. Fish and Wildlife Service (USFWS). 2008. Birds of Conservation Concern 2008. United States Department of Interior, Fish and Wildlife Service, Division of Migratory Bird Management, Arlington, Virginia.
- U.S. North American Bird Conservation Initiative. 2000. Bird Conservation Regions descriptions: a supplement to the North American Bird Conservation Initiative: Bird Conservation Regions map. U.S. Fish and Wildlife Service, Arlington, Virginia, USA.
- _____. 2007. Opportunities for improving avian monitoring. Division of Migratory Bird Management, U.S. Fish and Wildlife Service, Arlington, Virginia, USA.
- _____. 2009. The State of the Birds, United States of America, 2009. U.S. Department of Interior, Washington, D.C., USA.
- Von Loh, J., D. Cogan, D. Faber-Langendoen, D. Crawford, and M. J. Pucherelli. 1999. USGS-NPS Vegetation Mapping Program - Badlands National Park, South Dakota. Bureau of Reclamation's Remote Sensing and GIS Group, Denver, CO. 223 pp.
- White, G. C., and K. P. Burnham. 1999. Program MARK: survival estimation from populations of marked animals. *Bird Study* 46:120-139.
- Witmer, G. W. 2005. Wildlife population monitoring: some practical considerations. *Wildlife Research* 32:259-263.

Appendix A: List of Priority Species Detected in Badlands National Park in 2011

Species	USFWS*		PIF	South Dakota
	BCR 17	Region 6	BCR 17	SDGFP
Sharp-tailed Grouse			CS,RS	
American Bittern	BCC	BCC		
Northern Harrier			RC	
Swainson's Hawk			CC	
Ferruginous Hawk	BCC	BCC	RC,RS	SGCN
Golden Eagle	BCC	BCC	RC	
Prairie Falcon	BCC	BCC		
Upland Sandpiper	BCC	BCC		
Long-billed Curlew	BCC	BCC		SGCN
Wilson's Phalarope				SGCN
Black-billed Cuckoo	BCC	BCC	RC	
Burrowing Owl	BCC	BCC	RC	SGCN
Short-eared Owl	BCC	BCC	CC,RC	
White-throated Swift			CC	
Red-headed Woodpecker	BCC	BCC	CC,RC	
Say's Phoebe			RS	
Loggerhead Shrike	BCC	BCC	RC	
Bell's Vireo		BCC		
Black-billed Magpie			RC	
Northern Rough-winged Swallow			RC	
Mountain Bluebird			RC	
Sprague's Pipit	BCC	BCC	CC,RC	SGCN
Vesper Sparrow			RC,RS	
Lark Bunting			RC,CS,RS	SGCN
Grasshopper Sparrow	BCC	BCC	RC,CS,RS	
Dickcissel	BCC		CC,RC	
Western Meadowlark			RS	

* United States Fish and Wildlife Service (USFWS), Birds of Conservation Concern (BCC). Partners in Flight (PIF), Bird Conservation Region 17 (BCR 17; Badlands and Prairies), Continental Concern Species (CC), Regional Concern Species (RC), Continental Stewardship Species (CS), Regional Stewardship Species (RS), South Dakota Game, Fish and Parks (SDGFP), Species of Greatest Conservation Need (SGCN), Federally Endangered (LE), Federally Threatened (LT), State Endangered (SE), and State Threatened Species (ST). (Sources: USFWS 2008, Partners In Flight 2012, SDGFP 2006).

Species	USFWS*		PIF	South Dakota
	BCR 17	Region 6	BCR 17	SDGFP
Sharp-tailed Grouse			CS,RS	
American Bittern	BCC	BCC		
Northern Harrier			RC	
Swainson's Hawk			CC	
Ferruginous Hawk	BCC	BCC	RC,RS	SGCN
Golden Eagle	BCC	BCC	RC	
Prairie Falcon	BCC	BCC		
Upland Sandpiper	BCC	BCC		
Long-billed Curlew	BCC	BCC		SGCN
Wilson's Phalarope				SGCN
Black-billed Cuckoo	BCC	BCC	RC	
Burrowing Owl	BCC	BCC	RC	SGCN
Short-eared Owl	BCC	BCC	CC,RC	
White-throated Swift			CC	
Red-headed Woodpecker	BCC	BCC	CC,RC	
Say's Phoebe			RS	
Loggerhead Shrike	BCC	BCC	RC	
Bell's Vireo		BCC		
Black-billed Magpie			RC	
Northern Rough-winged Swallow			RC	
Mountain Bluebird			RC	
Sprague's Pipit	BCC	BCC	CC,RC	SGCN
Vesper Sparrow			RC,RS	
Lark Bunting			RC,CS,RS	SGCN
Grasshopper Sparrow	BCC	BCC	RC,CS,RS	
Dickcissel	BCC		CC,RC	
Western Meadowlark			RS	

* United States Fish and Wildlife Service (USFWS), Birds of Conservation Concern (BCC). Partners in Flight (PIF), Bird Conservation Region 17 (BCR 17; Badlands and Prairies), Continental Concern Species (CC), Regional Concern Species (RC), Continental Stewardship Species (CS), Regional Stewardship Species (RS), South Dakota Game, Fish and Parks (SDGFP), Species of Greatest Conservation Need (SGCN), Federally Endangered, Federally Threatened, State Endangered, and State Threatened Species. (Sources: USFWS 2008, Partners In Flight 2012, SDGFP 2006).

Appendix B: Avian Data Center Usage Tips

Overview

Rocky Mountain Bird Observatory's Avian Data Center (URL <http://rmbo.org/v3/avian/Home.aspx>) houses all of the bird survey data collected by RMBO staff and partners. It has been designed to provide information for specific questions and therefore works best when users select multiple filters for a query. To run a query, click the arrow for the drop down "Filter" menu (located in the extreme upper left corner of the screen) and select one of the following filter types (described below): Study Design, Species, Stratum, Super Stratum, BCR, State, County, Habitat, Year, Priority Species List, or Management Entity. After selecting the filter type, click the "Add" button immediately to the right of the drop down menu. A box will appear with options for the filter that you may select. Use the drop down menu in the box to select the specific filter and then click "Add filter". The selected filter will appear near the top of the screen. Users may add multiple filter types to view results for a very specific inquiry (e.g., to view IMBCR results for BRSP in CO you would apply the following filters: Study Design = IMBCR, Species = Brewer's Sparrow, and State = CO) or to view multiple outputs at once (e.g., to view data and results for Brewer's Sparrow and Vesper Sparrow at the same time select Species = Brewer's Sparrow and Species = Vesper Sparrow).

Filter Types

Study Design: To select data and results for IMBCR, Habitat-based, GRTS, or NPS study designs. Currently, only the IMBCR data and results are available.

Species: To select data and results for a particular species.

Stratum: To select data and results for a particular stratum.

Super Stratum: To select data and results for multiple stratum that were analyzed jointly (e.g., the entire Bridger-Teton National Forest which consists of 2 strata or the entire state of Colorado which consists of 29 strata).

BCR: To select data and results for a particular BCR.

State: To select data and results for a particular state.

County: To select data and results for a particular county. Please note that only raw count data and survey locations are available at the county level because we do not currently stratify based on state counties.

Habitat: To select data and results for a particular habitat type. When this filter is applied only data and results from habitat-based surveys are included.

Year: To select data and results for a particular year.

Priority Species List: To select data and results for multiple priority species at once. The query will display data and results for all species included on the selected management indicator list, species of conservation concern list, etc.

Management Entity: To select data and results for All Other Lands, Bureau of Land Management, National Park Service, Bureau of Indian Affairs, Department of Defense, US Fish and Wildlife Service, or US Forest Service. Once a management entity is chosen, additional filter types are available in the filters drop down list. These additional filter types, listed from most general to most specific, are customized for each management unit. Following is a list of options you will have for each management entity selected.

All Other Lands:

Tier One – All Other Lands

Bureau of Land Management (BLM):

Tier One – BLM

Tier Two – BLM Field Office

National Park Service (NPS):

Tier One – NPS

Tier Two – NPS Inventory and Monitoring Network

Tier Three – Individual Park Unit

US Bureau of Indian Affairs (BIA):

Tier One – BIA

Tier Two – Indian Reservation

US Department of Defense (DOD):

Tier One – DOD

Tier Two – Installation Unit

US Fish and Wildlife Service (USFWS):

Tier One – US Fish and Wildlife Service

Tier Two – USFWS Region

Tier Three – USFWS Unit

US Forest Service:

Tier One – US Forest Service

Tier Two – USFS Regions

Tier Three – National Forest or National Grassland Management Units

Tier Four – Individual National Forest or Grassland

Tier Five – Ranger Districts (Management District)

Clearing Filters

Filters can be cleared in one of two ways. You may click on the circled “X” to the left of an individual filter at the top of the screen to remove it or you may click the “clear all filters” button at the top of the screen to start building a new query.

Running Queries

Once you have selected your desired filters, click on the “Run Query” button located at the top of the screen. The amount of time it takes for the desired data and results to be displayed will depend on how specific your query is.

Comparing Multiple Queries

Users may view results of more than one query at once. To do this, run the first query as described above and then click the button “New Query Window” (located at the top of the screen). A new window will appear where a new query can be run and the two windows can then be viewed side by side.

Viewing Maps (Map Tab)

What is displayed?

By default, the map tab is the initial start-up page. After clicking the “Run Query” button, the ADC will display a map of all survey locations corresponding to your set of filters (surveyed grid cells are represented by blue semi-transparent circles) in Google Maps. If you have filtered by species, survey locations where that species was not detected will be represented by a blue circle. Locations where that species was detected will have a pink dot in the center of the blue circle. To see the specific name of a survey location, move the mouse arrow over the blue circle. After a moment the name of the surveyed grid cell should appear. You may view the bird detection info for a grid cell and the survey dates by left clicking your mouse on the blue circle.

By default, the zoom capability of the maps page is restricted to protect the privacy of private landowners. Partner organizations wishing for more precise location information should contact a RMBO staff member to obtain a password.

Adding boundary layers

You may add the following layers to the map: BCR boundaries, BIA boundaries, DOD boundaries, NPS boundaries, and USFS boundaries. To do this, left click on the drop down menu at the top left corner of the map, select the desired layer, and click the “add layer” button. It is possible to add multiple layers to the map by repeating this process. If you left click your mouse inside of any of these boundaries a text box will appear that contains the name of the region encompassed by the boundary.

Viewing Occupancy or Density Results (Occupancy and Density Tabs)

Viewing Tables

You may view a table of occupancy or density results and a chart for all appropriate strata (based on the set of filters) for which we have results by clicking on the tabs labeled “Occupancy” or

“Density”. These tabs are located just below the drop down filter menu in the upper left corner of the screen. The occupancy tables display the species for which the estimate was produced, the stratum the estimate pertains to, the year, Psi (proportion of grid cells expected to be occupied), the number of grid cells the species was detected on, the standard error (SE) of the estimate, and the percent coefficient of variation (% CV). The density tables display the species for which the estimate was produced, the stratum or habitat type that the estimate pertains to, the year, the number of birds expected per km² (D), the total number of individuals expected to reside within the stratum (N), the percent coefficient of variation (% CV), and the number of individuals used in analysis (n). You may view a description of the column headings by moving the mouse arrow over the column heading. You may also sort the table by clicking on any of the column headings.

Viewing Charts

When viewing the occupancy and density charts, the point estimate of Psi or D is indicated with a dot. Additionally, short horizontal dashes above and below the point estimate represent values one standard error away from the point estimate. To view the species, stratum, and year that correspond to an estimate on the chart, simply move your mouse arrow over the point estimate or standard error bar. A message will pop up with the appropriate information. If you have queried out multiple years of data the point estimates for each year will be connected with a solid line. You may remove an individual estimate from the chart by clicking on the corresponding row of the table on the left side of the screen. Estimates that are not displayed on the chart will turn a peach color in the table. You may add the estimate back onto the chart simply by clicking on the peach colored row in the table.

Knowing which species have estimates

To restrict the species filter to display only those species for which occupancy or density estimates have been produced, click on the “View Options” button at the very top of the screen and then check the box next to “Only show species for which occupancy/density results are available”. This will prevent you from querying out numerous species for which occupancy or density estimates are not available.

Viewing Raw Count Statistics (Species Counts Tab)

You may view the raw count of detections for each species (left table) and the effort (expressed as the number of points surveyed) (right table) for your query by clicking on the “Species Counts” tab located next to the “Density Tab” in the upper left corner of your screen. Both the counts and effort tables may be sorted by clicking on the row header. Additionally, you may view the counts and effort by BCR, State, County, Stratum, or Management Entity by clicking on the “Count by” drop down menu located above the counts table. If you have filtered using “Super Strata”, viewing counts by Stratum is an excellent way of getting a list of all the strata that comprise a Super Strata. If you would prefer to view effort expressed as the number of grid cells surveyed, click on the “View Options” button located at the top of the screen and check the box labeled “Show effort by number of grid cells instead of by point”.

Saving Results of Your Query

You may easily save the results of your query by clicking the “Copy to clipboard” button and pasting the results into another program such as excel or by clicking the “Save to CSV” button.

Similarly, to save a chart click on the “View Image” button below the chart, right click anywhere on the image and select “Copy image” or “Save image as”.

Functionality

Please keep in mind that queries with very generic filters will result in long wait times and may not function optimally (your browser may end up crashing). For instance, if a user selects only the IMBCR filter, occupancy results will be displayed for every species and strata/super strata combination for which there are occupancy and/or density results. If your query is not specific enough, the chart on the right side of the screen will not be displayed or a pop-up box will appear asking if you would like to continue. This pop-up box is designed to prevent your web browser from crashing while the ADC attempts to create a chart that would be extremely difficult to interpret. We recommend that you cancel the proposed query and add additional filters to make your query less generic.

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.

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National Park Service
U.S. Department of the Interior



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