

Avian Monitoring in the Badlands and Prairies Bird Conservation Region for the Ranching for Conservation Project: 2015 Field Season Report



January 2016



Connecting People, Birds and Land

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The Bird Conservancy of the Rockies

Connecting people, birds and land

Mission: Conserving birds and their habitats through science, education and land stewardship

Vision: Native bird populations are sustained in healthy ecosystems

Bird Conservancy of the Rockies conserves birds and their habitats through an integrated approach of science, education and land stewardship. Our work radiates from the Rockies to the Great Plains, Mexico and beyond. Our mission is advanced through sound science, achieved through empowering people, realized through stewardship and sustained through partnerships. Together, we are improving native bird populations, the land and the lives of people.

Core Values:

1. **Science** provides the foundation for effective bird conservation.
2. **Education** is critical to the success of bird conservation.
3. **Stewardship** of birds and their habitats is a shared responsibility.

Goals

1. Guide conservation action where it is needed most by conducting scientifically rigorous monitoring and research on birds and their habitats within the context of their full annual cycle.
2. Inspire conservation action in people by developing relationships through community outreach and science-based, experiential education programs.
3. Contribute to bird population viability and help sustain working lands by partnering with landowners and managers to enhance wildlife habitat.
4. Promote conservation and inform land management decisions by disseminating scientific knowledge and developing tools and recommendations.

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EXECUTIVE SUMMARY

The Bird Conservancy of the Rockies, in conjunction with its partners, conducted landbird monitoring for the eighth year in a row for the “Integrated Monitoring in Bird Conservation Regions” (IMBCR) program (White et al. 2011). IMBCR uses a spatially balanced, probabilistic sampling design which allows inferences to avian species occurrence and population sizes at various scales, from local management units to entire Bird Conservation Regions (BCRs) or states, facilitating conservation at local and national levels. The sampling design allows for the estimation of density, population size, and occupancy for individual strata or biologically meaningful combinations of strata. The collaboration across organizations and spatial scales increased sample sizes and improved the accuracy and precision of the population estimates. Analyzing the data collectively allowed the estimation of detection probabilities for species that would have otherwise had insufficient numbers of detections at local scales.

Audubon Rockies Prairie Bird Initiative is focused on partnering with ranchers and farmers on private lands to make “working lands work for birds, people, and communities” (Audubon Rockies 2015). They have spent years researching agricultural methods that are beneficial both for farmers and ranchers as well as birds. Audubon is working with the World Wildlife Fund (WWF) on their Sustainable Ranching Initiative to promote practices that result in healthy grasslands, viable wildlife populations, and economic and cultural benefits for ranchers in order to prevent the conversion of rangelands to agriculture, energy development, urbanization, or other anthropogenic uses. The goal of this initiative is to bring awareness to the conservation value of rangelands. They have chosen to use avian populations as one measure of wildlife habitat quality in the Northern Great Plains.

Audubon and WWF have teamed up with the Bird Conservancy to create an avian monitoring project that utilizes the IMBCR program to leverage their data and provide a regional context. Audubon provided financial support allowing the Bird Conservancy to increase sampling throughout the Badlands and Prairies Bird Conservation Region (BCR 17). BCR 17 contains large, continuous, tracts of intact dry grassland managed predominately as rangeland (US North American Bird Conservation Initiative 2000) and this regional scale provides an excellent context for measuring the health of bird populations on private ranches. This report summarizes the results of the monitoring effort throughout the BCR 17 portion of the IMBCR program.

The Bird Conservancy and Intermountain Bird Observatory surveyed 241 1-km² grid cells this summer throughout BCR 17. Audubon provided funding for 50 of these 241 surveys. Technicians conducted a total of 2,652 individual point counts on the 241 surveyed grids between May 16th and July 14th. They detected a total of 40,065 individuals of 226 avian species. The Bird Conservancy will produce density and occupancy estimates for all species with a sufficient number of detections to allow for a robust analysis. We anticipate being able to produce occupancy and/or density estimates for 169 avian species within BCR 17 for 2015.

This program will supply Audubon with species occurrence maps as well as abundance and occupancy estimates that will document baseline information at local and region scales throughout BCR 17. These estimates will be compared to ranch level estimates in the future. In addition, Audubon will have access to raw data collected throughout BCR 17 from 2009 to present. Using these data, they will be able to generate abundance distribution maps for priority grassland species that further allow Audubon to compare population estimates at a variety of scales for bird species of interest. The data will also be used to create decision support tools to support and inform conservation actions implemented through Audubon’s Prairie Bird Initiative.

ACKNOWLEDGEMENTS

We thank Audubon Rockies for providing supplemental funding for this project. Stratification and allocation of survey efforts were determined in collaboration with partner agencies and organizations, each of which provided funding or in-kind assistance: US Forest Service; US Bureau of Land Management; US National Park Service; Northern Great Plains Joint Venture; Wyoming Game and Fish Department; Montana Fish, Wildlife and Parks, and National Fish and Wildlife Foundation. We thank Intermountain Bird Observatory and Wyoming Natural Diversity Database for planning and implementing field work in their study areas. We thank Jenny Berven of the Bird Conservancy of the Rockies, who contacted county assessors to determine land ownership of survey locations. We also wish to thank the landowners for their hospitality and insight regarding accessing survey locations. We acknowledge the Bird Conservancy of the Rockies IT personnel who managed and updated the secure database where data are stored and created the data entry system used to input data. Rob Sparks of the Bird Conservancy of the Rockies implemented the GRTS sample selection. Brittany Woiderski produced the maps presented in this report. We thank Gary White, professor emeritus of Colorado State University, who wrote the initial SAS code and implemented the multi-scale occupancy model in program MARK and Paul Lukacs of the University of Montana who wrote code in program R to automate data analysis for density and occupancy estimates. We thank Jeff Laake for implementing the multi-scale occupancy model in the RMark package which aided in the automation of the analyses. We thank Kelli Turner and Bob Paulson of The Nature Conservancy for providing excellent new training facilities at the Whitney Preserve for the northern monitoring effort. We also thank all of the field technicians that collected data for this project. Finally, this report benefited from review by staff at Bird Conservancy of the Rockies and Audubon Rockies.

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INTRODUCTION

The Bird Conservancy of the Rockies (formerly the Rocky Mountain Bird Observatory; hereafter the Bird Conservancy), in conjunction with its partners, including Audubon Rockies, Intermountain Bird Observatory (IBO), and Wyoming Natural Diversity Database (WYNDD) conducted landbird monitoring for the eighth year in a row for the “Integrated Monitoring in Bird Conservation Regions” (IMBCR) program (White et al. 2011). IMBCR uses a spatially balanced, probabilistic sampling design which allows inferences to avian species occurrence and population sizes at various scales, from local management units to entire Bird Conservation Regions (BCRs) or states, facilitating conservation at local and national levels. The sampling design allows for the estimation of density, population size, and occupancy for individual strata or biologically meaningful combinations of strata. The collaboration across organizations and spatial scales increased sample sizes and improved the accuracy and precision of the population estimates. Analyzing the data collectively allowed the estimation of detection probabilities for species that would have otherwise had insufficient numbers of detections at local scales.

Bird Conservation Regions (BCRs) provide a spatially consistent framework for bird conservation in North America (Figure 1, US North American Bird Conservation Initiative 2007). The BCRs represent distinct ecological regions with similar bird communities, vegetation types and resource management interests (US North American Bird Conservation Initiative 2000). Population monitoring within BCRs can be implemented with a flexible hierarchical framework of nested units, where information on status of bird populations can be partitioned into smaller units for small-scale conservation planning, or aggregated to support large-scale conservation efforts throughout 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 various scales applicable to land managers (Ruth et al. 2003).

The IMBCR program is well positioned to address conservation and management needs for a wide range of stakeholders, landowners and government entities at various spatial scales. By focusing on multiple scales from local management units to BCRs, IMBCR can easily be integrated within an interdisciplinary approach to bird conservation that combines monitoring, research and management. Recently developed habitat analyses and species distribution maps can be used as the basis of decision support tools for avian conservation.

Audubon Rockies (hereafter Audubon) Prairie Bird Initiative is focused on partnering with ranchers and farmers on private lands to make “working lands work for birds, people, and communities” (Audubon Rockies 2015). They have spent years researching agricultural methods that are beneficial both for farmers and ranchers as well as birds. Audubon is working with the World Wildlife Fund (WWF) on their Sustainable Ranching Initiative to promote practices that result in healthy grasslands, viable wildlife populations, and economic and cultural benefits for ranchers in order to prevent the conversion of ranchlands to agriculture, energy development, urbanization, or other anthropogenic uses. The goal of this initiative is to bring awareness to the conservation value of ranchlands. They have chosen to use avian populations as one measure of wildlife habitat quality in the Northern Great Plains.

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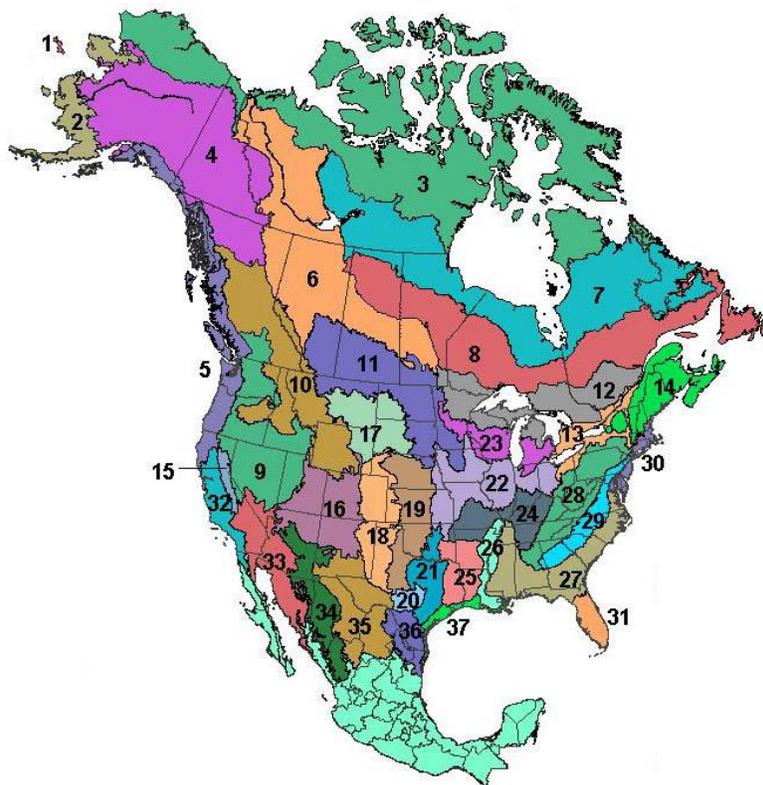


Figure 1. Bird Conservation Regions throughout North America, excluding Hawaii and Mexico (Source: <http://www.nabci-us.org/map.html>).

Audubon and WWF have teamed up with the Bird Conservancy to create an avian monitoring project that utilizes the IMBCR program to leverage their data and provide a regional context. Audubon provided financial support allowing the Bird Conservancy to increase sampling throughout the Badlands and Prairies Bird Conservation Region (BCR 17). BCR 17 contains large, continuous, tracts of intact dry grassland managed predominately as rangeland (US North American Bird Conservation Initiative 2000) and this regional scale provides an excellent context for measuring the health of bird populations on private ranches. Important properties of the IMBCR design and program that relate to this study are:

- Samples are placed on the landscape irrespective of roadways and other landscape features.
- Sampling methods and analytical procedures account for the incomplete detection of individuals on the landscape.
- Local population estimates and trends can be directly compared to regional scales.
- Leveraging data from the entire IMBCR program increases the number of species for which robust population estimates can be derived.
- Population estimates produced while leveraging data from the IMBCR program are more precise than what could be estimated with an isolated, stand-alone, monitoring effort due to the extensive data set incorporated in analyses.

The funding provided by Audubon increases the amount of data collected for this program, which in turn increases the accuracy of analyses results. Results generated from this program

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can be used by Audubon to evaluate the health of grassland bird populations in relation to both public and private lands in the following ways:

- 1) Directly compare species density and occupancy rates on private ranches to those of the surrounding landscape.
- 2) Provide the raw data necessary to compare variation in habitat variables and avian populations across ranches.
- 3) Provide the raw avian and habitat data necessary to develop habitat relationship models and predictive distribution maps.

This program will supply Audubon with species occurrence maps as well as abundance and occupancy estimates that will document baseline information at local and region scales throughout BCR 17. These estimates will be compared to ranch level estimates in the future. In addition, Audubon will have access to raw data collected throughout BCR 17 from 2009 to present. Using these data, they will be able to generate abundance distribution maps for priority grassland species that further allow Audubon to compare population estimates at a variety of scales for bird species of interest. The data will also be used to create decision support tools to support and inform conservation actions implemented through Audubon's Prairie Bird Initiative.

This report summarizes the results of the monitoring effort throughout the BCR 17 portion of the IMBCR program. For results of avian monitoring specific to WWF-affiliated ranchlands in northern and western portions of BCR 17, refer to the "Avian Monitoring on Private Ranches in Montana, Nebraska, and South Dakota: 2015 Field Season Report" (Van Lanen, in prep.).

METHODS

Study Area

BCR 17 is characterized by rolling plains and mixed-grass prairie that contain large, continuous, tracts of intact dry grassland managed predominately as ranchland (US North American Bird Conservation Initiative 2000). The Black Hills and western portions of BCR 17 contain pine and spruce forests at higher elevations. BCR 17 covers portions of five states: Montana; North Dakota; South Dakota; Wyoming; and Nebraska.

Sampling Design

Sampling Frame and Stratification

In 2015, IMBCR encompassed three entire states (Colorado, Montana, and Wyoming) and portions of 10 additional states (Arizona, Idaho, Kansas, North Dakota, Nebraska, New Mexico, Oklahoma, South Dakota, and Texas), two entire USFS Regions (Regions 1 and 2) and portions of Regions 3 and 4, all of the Badlands and Prairies BCR and portions of many other BCRs (Great Basin, Northern Rockies, Prairie Potholes, Southern Rockies/Colorado Plateau, Shortgrass Prairie, Central Mixed-grass Prairie, Sonoran and Mohave Deserts, and Sierra Madre Occidental).

A key component of the IMBCR design is the ability to infer across spatial scales, from small management units, such as individual national forests or BLM field offices, to entire states and BCRs. This is accomplished through hierarchical (nested) stratification, which allows data from smaller-order strata to be combined to make inferences about higher-order strata. For example, data from each individual national forest stratum in USFS Region 2 are combined to produce Region-wide avian population estimates; data from each individual stratum in Montana are

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combined to produce statewide estimates; data from each individual stratum in BCR 17 are combined to produce BCR-wide estimates.

We defined strata based on areas to which IMBCR partners wanted to make inferences. We defined the sampling frame as the intersection of state and BCR boundaries (e.g., Wyoming BCR 10). We based the strata within state-BCR boundaries on fixed attributes such as land ownership boundaries, elevation zones, major river systems, and wilderness/roadless designations.

BCR 17 intersects five states – Montana, North Dakota, South Dakota, Nebraska, and Wyoming. There are a total of 37 strata within the BCR 17 boundary with a combined area of inference of 364,430 km². Strata within this sampling frame were largely delineated based on land ownership and these 37 strata represent private lands, Bureau of Land Management, US Forest Service, US Fish and Wildlife Service, National Park Service, and Tribal Lands. In the Montana portion of BCR 17, large order rivers (Yellowstone, Tongue, Musselshell, and Missouri) were stratified as well.

Sampling Units

The IMBCR design defined sampling units as 1-km² cells, each containing 16 evenly-spaced sample points, 250 m apart (Figure 2). We defined potential sampling units by superimposing a uniform grid of cells over each state in the study area, then we assigned each cell to a stratum using ARCGIS versions 9.2 and higher (Environmental Systems Research Institute 2006).

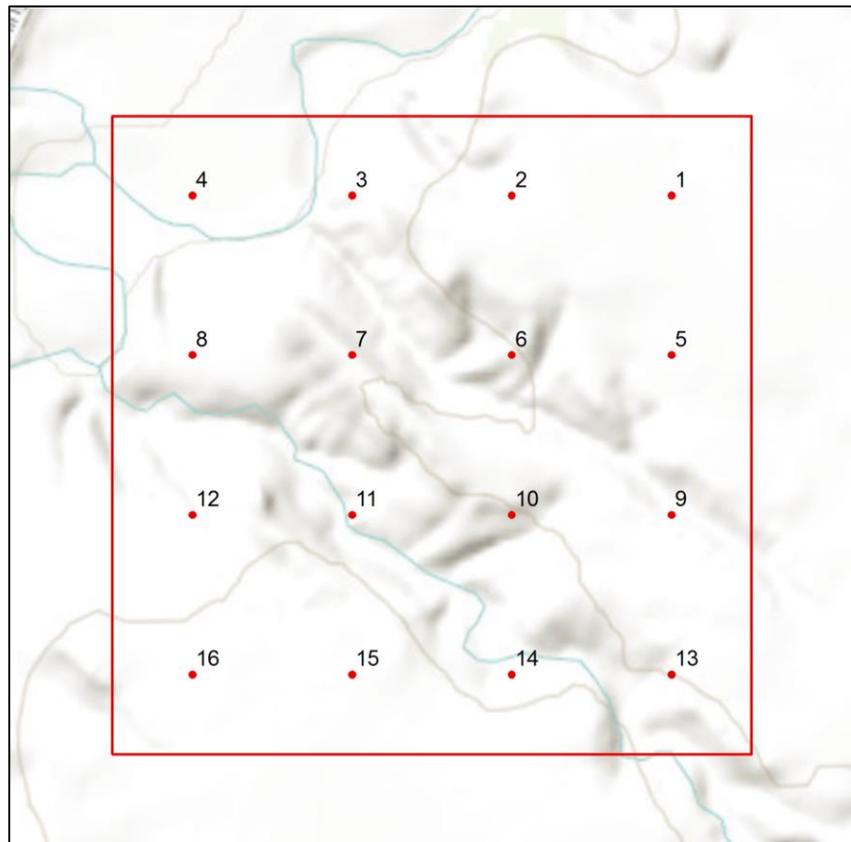


Figure 2. . Example 1-km² sampling unit using the IMBCR design.

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Sample Selection

Within each stratum, the IMBCR design used generalized random-tessellation stratification (GRTS), a spatially-balanced sampling algorithm, to select sample units (Stevens and Olsen 2004). The GRTS design has several appealing properties with respect to long-term monitoring of birds at large spatial scales:

- Spatially-balanced sampling is generally 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;
- 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, IMBCR partners can adjust the sampling effort among years within each stratum while still preserving a random, spatially-balanced sampling design.

A minimum of two sampling units were required within each stratum to estimate the variances of population parameters. The remaining allocation of sampling effort among strata was based on the priorities of the funding partners.

Sampling Methods

Observers with excellent aural and visual bird-identification skills conducted field work. Prior to conducting surveys, surveyors completed an intensive training program to ensure they had a complete understanding of field protocols and sufficient knowledge of bird identification.

Observers attempted to survey all points within a grid cell each morning; however, not all 16 points were surveyed within every grid cell. Inclement weather, no access to private land and decreased bird activity during the survey window were the most common reasons for all 16 points not being visited during a survey.

Point counts (Buckland et al. 2001) were conducted following protocol established by IMBCR partners (Hanni et al. 2011). Observers conducted surveys in the morning, beginning 30 minutes before local sunrise and concluding no later than 5 hours after local sunrise. For every bird detected during the six-minute count period, observers recorded the species, sex, horizontal distance from the observer, minute and type of detection (e.g., 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 a nearby object. Observers recorded birds flying over but not using the immediate surrounding landscape. While observers traveled between points within a grid cell they recorded the presence of any species that had not been previously detected during one of the six-minute counts that morning. The opportunistic detections of these species were used for the creation of a species inventory and distribution mapping purposes. Opportunistic detections between point count stations were not included in the occupancy and density analyses.

Observers 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. They recorded the number of birds detected within each cluster along with a letter code to distinguish between multiple clusters.

At the start and end of each survey, observers recorded time, ambient temperature, cloud cover, precipitation and wind speed. Observers navigated to each point using hand-held Global Positioning System (GPS) units. Before beginning each six-minute count, observers recorded vegetation data within a 50-meter radius of the point. Vegetation data included the dominant

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habitat type; structural stage and the relative abundance; percent cover and mean height of trees and shrubs by species; grass height; and ground cover types. Observers recorded vegetation data quietly to allow birds the time to return to normal habits prior to beginning each avian point count.

For more detailed information about survey methods, refer to the Bird Conservancy of the Rockies' Field Protocol for Spatially Balanced Sampling of Landbird Populations on the Rocky Mountain Avian Data Center website:

http://rmbo.org/v3/Portals/5/Protocols/2015%20Field_protocol_for_spatially_balanced_sampling.pdf

Analysis Procedures

Density Analysis

Distance sampling theory was developed 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). The detection probability is used to adjust the count of birds to account for birds that were present but undetected. Application of distance theory requires that five critical assumptions be met: 1) all birds at and near the sampling location (distance = 0) are detected; 2) distances to birds are measured accurately; 3) birds do not move in response to the observer's presence; 4) cluster sizes are recorded without error; and 5) the sampling units are representative of the entire survey region (Buckland et al. 2001, Thomas et al. 2010).

Analysis of distance data includes fitting a detection function to the distribution of recorded distances (Buckland et al. 2001). 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 these data separately for each species. We attempted to estimate densities of all species detected. The development of robust density estimates typically requires 80 or more independent detections ($n \geq 80$) within the entire sampling area. We excluded birds flying over, but not using the immediate surrounding landscape, birds detected while migrating (not breeding), juvenile birds, and birds detected between points from analyses.

We estimated density for each species using a sequential framework where 1) year specific detection functions were applied to species with greater than or equal to 80 detections per year ($n \geq 80$), 2) global detection functions were applied to species with less than 80 detections per year ($n < 80$) and greater than or equal to 80 detections over the life of the project ($n \geq 80$), and 3) remedial measures were used for species with moderate departures from the assumptions of distance sampling (Buckland et al. 2001).

We fit models with no series expansions to all species using the recommended 10% truncation for point transects. For the year specific detection functions, we fit Conventional Distance Sampling models using the half-normal and hazard-rate key functions with no series expansions (Thomas et al. 2010). We fit the two models described above, in addition to Multiple-Covariate Distance Sampling models using half-normal and hazard-rate key function with a categorical year covariate and no series expansions (Thomas et al. 2010). We selected the most parsimonious detection function for each species using Akaike's Information Criterion adjusted for sample size (AIC_c , Burnham and Anderson 2002; Thomas et al. 2010), and considered the most parsimonious model as the estimation model. We estimated population size N for each

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stratum as $N = D \cdot A$, where D was the estimated population density and A was the number of 1 km² sampling units in each stratum. We calculated Satterthwaite 90% Confidence Intervals (CI) for the estimates of density and population size for each stratum (Buckland et al. 2001). In addition, we combined the stratum-level density estimates at various spatial scales, such as the intersection of BCR and State using an area-weighted mean. For the combined density estimates, we estimated the variance for detection and cluster size using the delta method (Powell 2007, Thomas et al. 2010) and variance for the encounter rate using the design-based estimator of Fewster et al. (2009).

We reviewed the highest ranking detection function for each species to check the shape criteria, evaluate the fit of the model and identify species with moderate departure from the assumptions of distance sampling (Buckland et al. 2001). First, we checked the shape criteria of the histogram to ensure the detection data exhibited a “shoulder” that fell away at increasing distances from the observer. Second, we evaluated the fit of the model using the Kolmogorov-Smirnov goodness-of-fit test. Finally, we visually inspected the detection histograms to identify species that demonstrated evasive movement and/or measurement errors. We looked for a type of measurement error involving the heaping of detections at certain distances that occurs when observers round detection distances. We also looked for histograms with detections that were highly skewed to the right, potentially indicating a pattern of evasive movement (Buckland et al. 2001).

For species with moderate departures from the assumptions and shape criteria, we used two sequential remedial measures. First, we truncated the data to the point where detection probability was approximately 0.1 [$g(w) \sim 0.1$] and included key functions with second order cosine series-expansion terms in the candidate set of models (Buckland et al. 2001). We did not include detection function models with a single cosine expansion term because the half-normal and hazard-rate models require the order of the terms are >1 (Buckland et al. 2001). Second, when the goodness-of-fit test and/or inspection of the detection histogram continued to suggest evasive movement and/or measurement errors, we grouped the distance data into four to eight bins, and applied custom truncation and second order expansion terms. These remedial measures can ameliorate problems associated with moderate levels of evasive movement and/or distance measurement errors (Buckland et al. 2001).

Occupancy Analysis

Occupancy estimation is most commonly used to quantify the proportion of sample units (i.e., 1-km² cells) occupied by an organism (MacKenzie et al. 2002). The application of occupancy modeling 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). We used a removal design (MacKenzie et al. 2006), to estimate a detection probability for each species, in which 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 target species was detected at a point, we set all subsequent sampling intervals at that point to “missing data” (MacKenzie et al. 2006).

The 16 points in each sampling unit served as spatial replicates for estimating the proportion of points occupied within the sampled sampling units. We used a multi-scale occupancy model 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 sampling units (Θ , Theta) and 3) the proportion of sampling units occupied by a species (Ψ , Psi).

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We truncated the data, using only detections less than 125 m from the sample points. Truncating the data at less than 125 m 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 sampling unit) (Pavlacky et al. 2012).

We expected that regional differences in the behavior, habitat use and local abundance of species would correspond to regional variation in detection and the fraction of occupied points. Therefore, we estimated the proportion of sampling units occupied (Psi) for each stratum by evaluating four models with different structure for detection (p) and availability (represented by the proportion of points occupied within a grid cell) (Theta). Within these models, the estimates of p and Theta were held constant across the BCRs and/or allowed to vary by BCR. Models are defined as follows:

- Model 1: Constrained p and Theta by holding these parameters constant across BCRs;
- Model 2: Held p constant, but allowed Theta to vary across BCRs;
- Model 3: Allowed p to vary across BCRs, but held Theta constant across BCRs;
- Model 4: Allowed both p and Theta to vary across BCRs.

We ran model 1 for species with less than 10 detections in all BCRs or less than 10 detections in all but 1 BCR. We ran models 1 through 4 for species with greater than 10 detections in more than 1 BCR. For the purpose of estimating regional variation in detection (p) and availability (Theta), we pooled data for BCRs with fewer than 10 detections into adjacent BCRs with sufficient numbers of detections. We used AIC corrected for small sample size (AIC_c) and model selection theory to evaluate models from which estimates of Psi were derived for each species (Burnham and Anderson 2002). We model averaged the estimates of Psi from models 1 through 4 and calculated unconditional standard errors (Burnham and Anderson 2002).

Our application of the multi-scale model was analogous to a within-season robust design (Pollock 1982) where the two-minute intervals at each point were the secondary samples for estimating p and the points were the primary samples for estimating Theta (Nichols et al. 2008, Pavlacky et al. 2012). We considered both p and Theta to be nuisance variables that were important for generating unbiased estimates of Psi. Theta can be considered an availability parameter or the probability a species was present and available for sampling at the points (Nichols et al. 2008, Pavlacky et al. 2012).

Automated Analysis

Both density and occupancy estimation was completed with the use of a modified version of the RIMBCR package (R Core Team 2014; Paul Lukacs, University of Montana, Missoula). The RIMBCR package streamlined analyses by calling the raw data from the IMBCR Structured Query Language (SQL) server database and incorporating the R code created in previous years. We allowed the input of all data collected in a manner consistent with the IMBCR design to increase the number of detections available for estimating p and Theta. The RIMBCR package used package *mrds* (Thomas et al. 2010, R Core Team 2014) to fit the point transect distance sampling model, the program MARK (White and Burnham 1999) and package RMark (Laake 2013, R Core Team 2014) to fit the multi-scale occupancy model. The RIMBCR package provided an automated framework for combining strata-level estimates, as well as corresponding standard errors and confidence intervals, of population density and site occupancy at multiple spatial scales.

RESULTS

The Bird Conservancy, IBO, and WYNDD surveyed 241 1-km² grid cells this summer throughout BCR 17 (Figure 3, Table 1). Audubon provided funding for 50 of these 241 surveys. Technicians conducted a total of 2,653 individual point counts on the 241 surveyed grids between May 16th and July 14th. They detected a total of 38,427 individuals of 196 avian species (Table 2).

The Bird Conservancy estimated densities and population sizes for 157 species within BCR 17 in 2015. The data yielded robust density estimates (CV < 50%) for 68 of these species. The Bird Conservancy estimated the proportion of 1 km² sampling units occupied (Psi) within BCR 17 for 155 species. The data yielded robust occupancy estimates (CV < 50%) for 75 of these species.

Results from all strata and all biologically meaningful super strata associated with the IMBCR program can be found on the Rocky Mountain Avian Data Center. Instructions for using the Avian Data Center are included in the Appendix of this report and are available on the Avian Data Center website itself. To view a map of survey locations, density and occupancy results (once they are complete), and species counts within BCR 17 across all years of the project follow the web link below and hit the “Run Query” button highlighted in red located near the top of the page. If you want to limit results to 2015, after you click on the link below select “Year” from the Filter drop down box on the top left of the screen. Hit the “Add” button, select 2015, hit “Add Filter”, and then “Run Query”.

[BCR 17 Results](#)

All bird species' names listed in this report are from the American Ornithologists' Union Checklist of North and Middle American Birds, seventh edition (2007).

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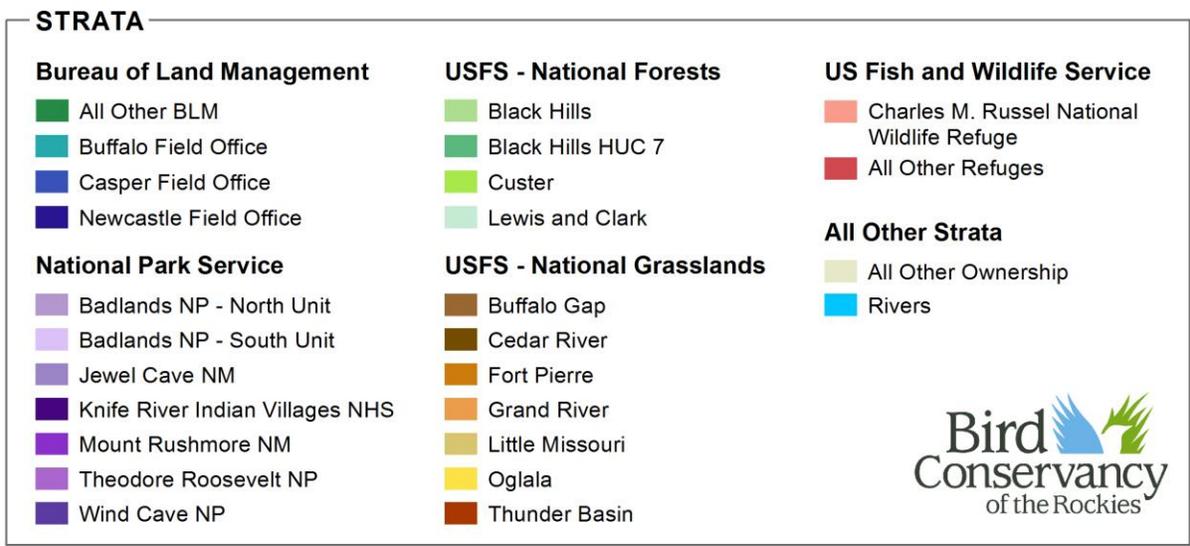
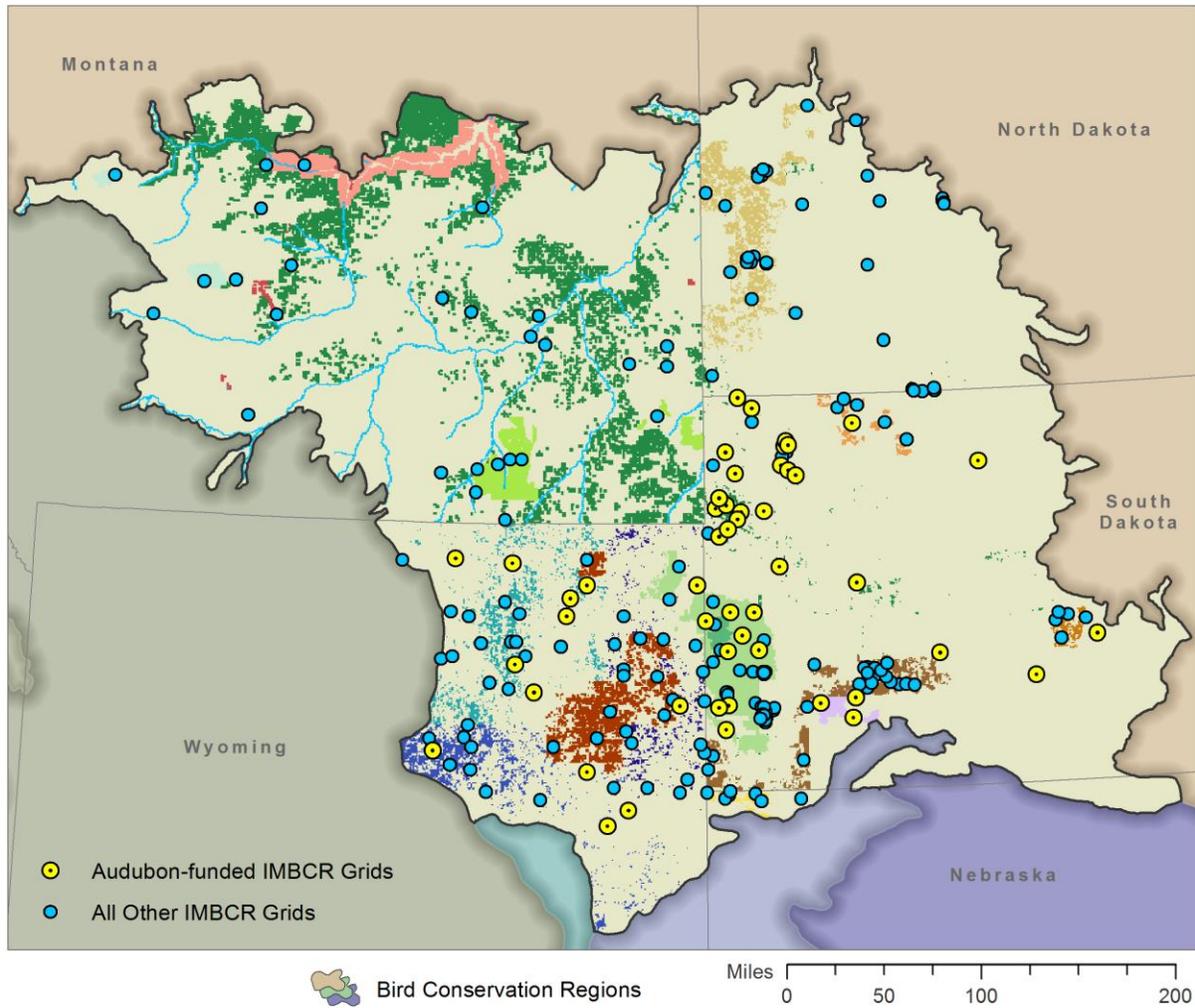


Figure 3. Survey locations in the Badlands and Prairies Bird Conservation Region (BCR 17), 2015.

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Table 1. The number of grid cells funded by Audubon Rockies, total number of grid cells completed, visited, number of point counts conducted, and average number of point counts conducted per grid within the Badlands and Prairies Bird Conservation Region (BCR 17), 2015.

Stratum	Stratum Name	Audubon Funded Grids	Total Grids	Point Counts	Average Counts/Grid
MT-BCR17-AO	All Other Lands		8	88	11.0
MT-BCR17-BL	Bureau of Land Management		4	59	14.8
MT-BCR17-CM	Charles M. Russell National Wildlife Refuge		2	14	7.0
MT-BCR17-CU	Custer National Forest		6	68	11.3
MT-BCR17-FO	All other USFWS lands		2	31	15.5
MT-BCR17-LC	Lewis and Clark National Forest		3	37	12.3
MT-BCR17-RI	Rivers - Yellowstone; Tongue; Musselshell; and Missouri		2	18	9.0
ND-BCR17-BM	Bureau of Land Management		2	26	13.0
ND-BCR17-KR	Knife River Indian Villages National Historic Site		5	55	11.0
ND-BCR17-MG	Little Missouri National Grassland		5	46	9.2
ND-BCR17-OW	All Other Lands		4	37	9.3
ND-BCR17-RG	Cedar River National Grassland		5	55	11.0
ND-BCR17-TB	Select Tribal Lands		2	19	9.5
ND-BCR17-TN	Theodore Roosevelt National Park - North Unit		6	45	7.5
ND-BCR17-TS	Theodore Roosevelt National Park - South Unit		8	88	11.0
NE-BCR17-LG	Oglala National Grassland		4	45	11.3
NE-BCR17-OW	All Other Lands		3	35	11.7
SD-BCR17-BF	Black Hills National Forest - All other Watersheds	7	13	131	10.1
SD-BCR17-BM	Bureau of Land Management	11	13	150	11.5
SD-BCR17-BN	Badlands National Park - North Unit		15	161	10.7
SD-BCR17-BS	Badlands National Park - South Unit	2	2	24	12.0
SD-BCR17-GG	Buffalo Gap National Grassland		5	53	10.6
SD-BCR17-HU	Black Hills National Forest - Hydrologic Code 7 Watersheds		3	32	10.7
SD-BCR17-JC	Jewel Cave National Monument		5	57	11.4
SD-BCR17-MR	Mount Rushmore National Monument		6	55	9.2
SD-BCR17-OW	All Other Lands	7	8	77	9.6
SD-BCR17-PG	Fort Pierre National Grassland		5	62	12.4
SD-BCR17-RG	Grand River National Grassland		5	55	11.0

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Stratum	Stratum Name	Audubon Funded Grids	Total Grids	Point Counts	Average Counts/Grid
SD-BCR17-TB	Select Tribal Lands	2	2	28	14
SD-BCR17-UF	Custer National Forest	8	13	153	11.8
SD-BCR17-WC	Wind Cave National Park		14	159	11.4
WY-BCR17-AO	All Other Lands	13	25	280	11.2
WY-BCR17-BH	Black Hills National Forest		3	23	7.7
WY-BCR17-BU	Bureau of Land Management - Buffalo Field Office		7	81	11.6
WY-BCR17-CA	Bureau of Land Management - Casper Field Office		8	108	13.5
WY-BCR17-NE	Bureau of Land Management - Newcastle Field Office		8	75	9.4
WY-BCR17-TB	Thunder Basin National Grassland		10	123	12.3
Grand Total		50	241	2652	11.0

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Table 2. The number of individuals detected by species throughout the Badlands and Prairies Bird Conservation Region (BCR 17), 2015.

Species	Count	Species	Count
American Avocet	6	Bullock's Oriole	37
American Bittern	3	Burrowing Owl	7
American Coot	25	California Gull	3
American Crow	402	Canada Goose	336
American Goldfinch	360	Canvasback	2
American Kestrel	65	Canyon Wren	13
American Redstart	70	Cassin's Finch	11
American Robin	700	Cassin's Kingbird	4
American Three-toed Woodpecker	1	Cedar Waxwing	91
American Tree Sparrow	1	Chestnut-collared Longspur	486
American White Pelican	35	Chimney Swift	1
American Wigeon	17	Chipping Sparrow	561
Ash-throated Flycatcher	1	Chukar	2
Baird's Sparrow	96	Cinnamon Teal	2
Bald Eagle	3	Clark's Nutcracker	12
Baltimore Oriole	4	Clay-colored Sparrow	264
Bank Swallow	55	Cliff Swallow	635
Barn Swallow	91	Common Grackle	90
Bell's Vireo	10	Common Nighthawk	160
Belted Kingfisher	1	Common Poorwill	3
Bewick's Wren	1	Common Raven	36
Black Tern	31	Common Yellowthroat	167
Black-and-white Warbler	21	Cooper's Hawk	8
Black-backed Woodpecker	6	Cordilleran Flycatcher	38
Black-billed Cuckoo	1	Dark-eyed Junco	220
Black-billed Magpie	314	Dickcissel	7
Black-capped Chickadee	285	Double-crested Cormorant	9
Black-headed Grosbeak	45	Downy Woodpecker	24
Blue Grosbeak	24	Dusky Flycatcher	96
Blue Jay	19	Eastern Bluebird	24
Blue-gray Gnatcatcher	19	Eastern Kingbird	143
Blue-winged Teal	63	Eastern Phoebe	2
Bobolink	558	Eastern Wood-Pewee	6
Brewer's Blackbird	317	Eurasian Collared-Dove	14
Brewer's Sparrow	777	European Starling	60
Brown Creeper	21	Ferruginous Hawk	4
Brown Thrasher	54	Field Sparrow	505
Brown-headed Cowbird	2,235	Fox Sparrow	4
		Gadwall	29

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Species	Count
Golden Eagle	11
Grasshopper Sparrow	1,769
Gray Catbird	24
Gray Flycatcher	2
Gray Jay	19
Gray Partridge	4
Great Blue Heron	18
Great Horned Owl	12
Greater Prairie-Chicken	50
Greater Sage-Grouse	65
Green-tailed Towhee	16
Green-winged Teal	2
Hairy Woodpecker	65
Hammond's Flycatcher	4
Hermit Thrush	61
Hooded Merganser	5
Horned Grebe	7
Horned Lark	1,139
House Finch	13
House Sparrow	10
House Wren	599
Indigo Bunting	11
Killdeer	196
Lark Bunting	2,096
Lark Sparrow	778
Lazuli Bunting	75
Least Flycatcher	60
Lesser Scaup	1
Lewis's Woodpecker	2
Lincoln's Sparrow	2
Loggerhead Shrike	47
Long-billed Curlew	27
Long-eared Owl	1
MacGillivray's Warbler	7
Mallard	140
Marbled Godwit	25
McCown's Longspur	39
Merlin	4
Mountain Bluebird	131
Mountain Chickadee	32
Mountain Plover	1
Mourning Dove	1,814

Species	Count
Northern Flicker	487
Northern Goshawk	1
Northern Harrier	73
Northern Mockingbird	1
Northern Pintail	33
Northern Rough-winged Swallow	49
Northern Shoveler	22
Northern Waterthrush	1
Olive-sided Flycatcher	2
Orange-crowned Warbler	1
Orchard Oriole	8
Osprey	2
Ovenbird	99
Pied-billed Grebe	5
Pileated Woodpecker	1
Pine Siskin	50
Pinyon Jay	18
Plumbeous Vireo	63
Prairie Falcon	6
Red Crossbill	378
Red-breasted Nuthatch	271
Red-eyed Vireo	64
Red-headed Woodpecker	137
Red-naped Sapsucker	69
Red-necked Phalarope	1
Red-tailed Hawk	57
Red-winged Blackbird	1,053
Redhead	2
Ring-billed Gull	1
Ring-necked Pheasant	580
Rock Pigeon	150
Rock Wren	430
Ruby-crowned Kinglet	77
Ruffed Grouse	1
Sage Thrasher	84
Sandhill Crane	36
Savannah Sparrow	85
Say's Phoebe	120
Sedge Wren	51
Sharp-tailed Grouse	56
Short-eared Owl	58

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Species	Count
Song Sparrow	88
Sora	9
Spotted Sandpiper	9
Spotted Towhee	1,170
Sprague's Pipit	1
Stilt Sandpiper	1
Swainson's Hawk	21
Swainson's Thrush	40
Townsend's Solitaire	42
Townsend's Warbler	4
Tree Swallow	60
Turkey Vulture	68
Unknown Sapsucker	1
Upland Sandpiper	410
Vesper Sparrow	830
Violet-green Swallow	103
Warbling Vireo	85
Western Bluebird	2
Western Kingbird	147
Western Meadowlark	8,431
Western Scrub-Jay	1
Western Tanager	234
Western Wood-Pewee	414
White-breasted Nuthatch	93
White-crowned Sparrow	1
White-throated Swift	69
Wild Turkey	61
Willet	4
Willow Flycatcher	9
Wilson's Phalarope	74
Wilson's Snipe	28
Wood Duck	1
Yellow Warbler	339
Yellow-breasted Chat	205
Yellow-headed Blackbird	40
Yellow-rumped Warbler	412

DISCUSSION

Temporal and Spatial Comparisons

The IMBCR program's ability to make comparisons between small-scale locations, large regions, and across years can provide managers with important information about the lands they manage. Data collected and results produced in this study can be used in the following ways to inform avian conservation:

- 1) Population estimates can be compared in space and time. For example, estimates within a stratum can be compared to state and regional estimates to determine if local populations are above or below estimates for the region;
- 2) Density estimates can be used to make informed management decisions about where to focus conservation efforts. For example, strata with higher densities can be targeted for protection and strata with lower densities can be prioritized for conservation action; a threshold could be set to trigger a management action when densities reach a predetermined level;
- 3) Annual estimates of density and occupancy can be compared over time to determine if population changes are a result of population growth or decline and/or range expansion or contraction. For example, if population densities of a species declined over time, but the occupancy rates remained constant, then the population change was due to declines in local abundance. In contrast, if both density and occupancy rates of a species declined, then population change was due to range contraction;
- 4) Occupancy rates can be multiplied by the land area in a region of interest to estimate the area occupied by a species. For example, if a stratum comprises 120,000 km² and the occupancy estimate for Western Meadowlark is 0.57, managers can estimate that 68,400 km² (120,000 km² * 0.57) of habitat within that stratum is occupied by Western Meadowlarks.

Advantages of collaboration and the IMBCR program

Auxiliary, or "overlay", projects are a growing component of the IMBCR program that improve efficiency and can be tailored to address specific management questions. Auxiliary projects utilize the IMBCR sampling design and field methods but are not integrated into the nested stratification of the IMBCR program. These projects benefit from the IMBCR program by incorporating detection data from relevant IMBCR surveys in their analyses. Leveraging IMBCR data in analyses improves the number of species for which results can be obtained and the precision of the resulting estimates. Utilizing the IMBCR design also allows the resulting population estimates to be placed in a regional context. In this way, the collaborative efficiency of the IMBCR program is extended to auxiliary projects by improving the accuracy and precision of population estimates for infrequently detected species as well as allowing those estimates to be compared to larger, regional populations. In a similar fashion, data collected as part of auxiliary projects contribute to the efficiency of the IMBCR program by increasing the overall size of the bird detection data set. Audubon could create its own overlay strata at the ranch-level as one method to assess the effectiveness of Prairie Bird Initiative projects.

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APPENDIX: AVIAN DATA CENTER USAGE TIPS

The Avian Data Center 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: 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). Below is an explanation of the different filter types you may choose from.

Study Design: This filter will allow users to select data and results for IMBCR, GRTS, NEON, Migration Phenology or NPS study designs.

Species: This filter allows users to select data and results for a particular species.

Stratum: This filter allows users to select data and results for a particular stratum.

Super Stratum: This filter allows users to select data and results for multiple stratum that were analyzed jointly (e.g., the entire Bridger-Teton National Forest which is broken up into 2 strata or the entire state of Colorado which is broken up into 29 strata).

BCR: This filter will allow users to select data and results for a particular BCR.

State: This filter will allow users to select data and results for a particular state.

County: This filter will allow users 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.

Year: This filter will allow users to select data and results for a particular year.

Priority Species List: This filter will allow users to select data and results for multiple 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: This filter will allow users to select data and results for All Other Lands, US Forest Service (USFS), Bureau of Land Management (BLM), National Park Service (NPS), Bureau of Indian Affairs (BIA), Department of Defense (DOD), or US Fish and Wildlife Service (USFWS). Once a management entity is chosen, users may notice that additional filter types are available in the filters drop down list. These additional filter types, listed from most general to most specific, are management regions (e.g., USFS Region 1), management units (e.g., Dakota Prairie Grasslands), management forests (e.g., Shoshone National Forest), or management districts (e.g., North Kaibab district within Kaibab National Forest). Below is the filter hierarchy for the different management entities.

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USFS:

- Tier One – Management Entity – US Forest Service
- Tier Two – Management Region – USFS Regions (correct!)
- Tier Three – Management Unit – NF or NG management units
- Tier Four – National Forest or Grassland – NF or NG
- Tier Five – Management District – NF or NG Ranger Districts

NPS:

- Tier One – Management Entity – National Park Service
- Tier Two – Management Region – Inventory and Monitoring Network
- Tier Three – Management Unit – Individual Park Units
- Tier Four – National Forest or Grassland – Not applicable
- Tier Five – Management District – Not applicable

BLM:

- Tier One – Management Entity – Bureau of Land Management
- Tier Two – Management Region – BLM Field Office
- Tier Three – Management Unit – Not applicable
- Tier Four – National Forest or Grassland – Not applicable
- Tier Five – Management District – Not applicable

DOD:

- Tier One – Management Entity – US Department of Defense
- Tier Two – Management Region – Installation Unit
- Tier Three – Management Unit – Not applicable
- Tier Four – National Forest or Grassland – Not applicable
- Tier Five – Management District – Not applicable

Tribal Lands:

- Tier One – Management Entity – US Bureau of Indian Affairs
- Tier Two – Management Region – Reservation Region
- Tier Three – Management Unit – Reservation
- Tier Four – National Forest or Grassland – Not applicable
- Tier Five – Management District – Not applicable

All Other Lands:

- Tier One – Management Entity – All Other Lands
- Tier Two – Management Region – Not applicable
- Tier Three – Management Unit – Not applicable
- Tier Four – National Forest or Grassland – Not applicable
- Tier Five – Management District – Not applicable

USFWS:

- Tier One – Management Entity – US Fish and Wildlife Service
- Tier Two – Management Region – USFWS Region
- Tier Three – Management Unit – USFWS Unit
- Tier Four – National Forest or Grassland – Not applicable
- Tier Five – Management District – Not applicable

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The Nature Conservancy:

- Tier One – Management Entity – The Nature Conservancy
- Tier Two – Management Region – Cherry Creek
- Tier Three – Management Unit – Not applicable
- Tier Four – National Forest or Grassland – Not applicable
- Tier Five – Management District – Not applicable

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, please 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 Earth. If you have filtered by species, survey locations where that species was not detected will be represented by the 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. Partners wishing for more precise location information to be displayed should request a password from the Bird Conservancy via email (it@birdconservancy.org). Once a user has a password, click on the “View Options” button at the top of the screen, enter the password in the “Password for RMBO staff and partners” field, and click “Save”. If you have run a query prior to entering the password, you will need to click the “Run Query” button again in order to utilize the enhanced zooming features now available to you.

Adding boundary layers

You may add the following layers to the map: Bird Conservation Region 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/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 will 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 will 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 detected (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 the 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 on 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.

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. To save images, the best option is to take a screenshot. Use the Print Screen key on Windows or Command-Shift-3 on a Mac.

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'd 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

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to interpret. We recommend that you cancel the proposed query and add additional filters to make your query less generic.

What is available?

Currently, occupancy results are available for 2010 to 2013 via the ADC as well as density results for 2009 thru 2013.

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”.