Avian Monitoring On Private Ranches in Colorado, North Dakota, South Dakota and Wyoming: 2016 Field Season Report

October 2016

Connecting People, Birds and Land

Bird Conservancy of the Rockies
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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

Grasslands represent some of the most endangered ecosystems on the planet due to widespread conversion for agricultural use, energy development, and housing. The private ranchlands of the Great Plains hold some of the last remaining intact temperate grasslands in the world. As such, ranches provides important habitat for many declining species of grassland birds. Audubon Rockies (hereafter, Audubon) and partners have created a conservation ranching program to increase awareness to the conservation value and provide an economic incentive for bird-friendly beef production. This effort can improve management on private lands and prevent future conversion of ranchlands to suburban or other unsuitable habitats for birds and other wildlife. The Bird Conservancy of the Rockies (formerly the Rocky Mountain Bird Observatory; hereafter, the Bird Conservancy), in conjunction with Audubon, conducted landbird monitoring on private ranches within the Colorado portion of Bird Conservation Region (BCR) 18; the North Dakota, South Dakota, and Wyoming portions of BCR 17 and additional ranchland in North Dakota BCR 11 to demonstrate the relative habitat value of bird-friendly private ranches. This landbird monitoring effort used a spatially-balanced sampling design and a survey protocol consistent with a program entitled "Integrated Monitoring in Bird Conservation Regions" (IMBCR). The IMBCR design allows inferences regarding avian species occurrence and population sizes from local to regional scales; including states and Bird Conservation Regions (BCR). By using a design compatible with the IMBCR program, estimates for Audubon-affiliated ranches in Colorado, North Dakota, South Dakota and Wyoming can be compared to nearby regional estimates to determine if avian populations on the private Audubon-affiliated ranches are similar to regional populations. In this way, Audubon can evaluate the relative habitat value of privately-owned ranches which implement bird-friendly ranching practices compared to the surrounding landscape. In 2016, the Bird Conservancy surveyed 57 1-km^2 grid cells on Audubon-affiliated private ranches across 10 strata. These surveys resulted in 754 individual point counts completed in June 2016. Field technicians observed 11,821 individuals of 151 bird species during the surveys on Audubon-affiliated ranches. 2016 density and occupancy estimates will be produced and shared when the remainder of the IMBCR data is analyzed in early 2017.

ACKNOWLEDGEMENTS

We thank Audubon for providing the funding for this project. Stratification and allocation of survey effort were determined in collaboration with Alison Holloran of Audubon Rockies. Audubon Rockies also obtained permission from the private landowners incorporated in this study. Without the cooperation and assistance of the private landowners this project would not have been possible. 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. Alex Van Boer and 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 Colorado 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 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.

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INTRODUCTION

Grasslands represent some of the most endangered ecosystems on the planet (White et al. 2000). The temperate grasslands of the Great Plains are no exception, with less than 4% of tallgrass prairie in the Great Plains estimated to be intact as of 1994 (Sampson and Knopf 1994). More than two decades later, that number is likely further reduced. Habitat loss in the Great Plains has been largely linked to agricultural conversion, energy development, and urbanization (Hoekstra et al. 2005).

Much of the best remaining grassland within the Great Plains lies on private lands used for cattle ranching operations. Today, ranchers face new challenges resulting from an increasingly complex environment, competing against new crop technologies, significant economic pressures, and a changing climate. These new challenges to ranchers threaten the future of these remaining private, intact, grasslands as ranchers seek economic viability to support themselves and their families.

Audubon Rockies (hereafter, Audubon) is currently working with ranchers across the Great Plains (including Colorado, North Dakota, South Dakota, and Wyoming) to create a ranching program through a market-based conservation program,. To achieve this goal, Audubon has created a bird-friendly ranching initiative to bring awareness to the conservation value of properly managed ranchlands and to reward operators who follow Audubon's guidelines (still in development). Acknowledging the value of working ranches as wildlife habitat and raising awareness of this fact can result in economic incentives for ranching operations which can help them remain economically viable long-term. In doing so, remaining intact habitat within the Great Plains may be protected from agricultural conversion or other anthropogenic landscape changes and ranches enrolled in the program will be held to Audubon standards.

Together, with partners, Audubon has chosen to use avian populations as one measure of wildlife habitat quality. Birds have long been considered excellent indicators of biological integrity and ecosystem health (Morrison 1986, Hutto 1998, O'Connell et al. 2000, Rich 2002, US EPA 2002). They comprise a diverse group of niche specialists, occupy a broad range of habitats, are relatively easy to monitor and are sensitive to both physical and chemical impacts on the environment.

In order for avian population metrics to be used to accurately reflect habitat quality, 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 the use of 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 sampling and observation processes.

In order to provide Audubon and the bird-friendly ranching Initiative with unbiased and reliable information regarding avian communities on ranchlands and the surrounding landscape, the Bird Conservancy of the Rockies (formerly the Rocky Mountain Bird Observatory; hereafter the Bird Conservancy) utilized a probabilistic sampling design based on the "Integrated Monitoring in Bird Conservation Regions (IMBCR)" (White et al. 2014) program for this study. 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 (when available in early-2017).
- 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.

In order to evaluate the relative importance of private ranchlands within the Great Plains region in relation to the surrounding landscape, the Bird Conservancy conducted avian monitoring on private ranches using a design and methods consistent with, and in conjunction with, the annual monitoring efforts of the IMBCR program. The goals of this effort are to:

1) Directly compare species density and occupancy rates on private ranches to those of the surrounding landscape (when available in early-2017).
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.

METHODS

Study Area

Private ranchlands were surveyed in two counties of Colorado (El Paso and Prowers), four counties in North Dakota (Burleigh, Grant, Mountrail and Stutsman), Fall River county in South Dakota and three counties in Wyoming (Converse, Crook and Niobrara). Surveyed lands within each state fell within these Bird Conservation Regions (BCR):

Colorado ranch sampling occurred within BCR 18 (Shortgrass Prairie). BCR 18 lies in the rainshadow of the Rocky Mountains and is characterized by arid conditions that limit the stature and diversity of vegetation. Some of North America's highest priority birds breed in this region (US North American Bird Conservation Initiative 2000). BCR 18 runs north-south from the southwestern corner of South Dakota through western Nebraska, Kansas and Oklahoma down into northwest Texas and into eastern New Mexico.

North Dakota ranch sampling occurred within BCR 11 (Prairie Potholes), which consists of mixed grass prairie in the west, tall grass prairie in the east and thousands of small wetlands scattered across its geographical extent (US North American Bird Conservation Initiative 2000). About 70% of BCR 11's original grasslands have been converted to agriculture, but large tracts of grassland still exist on larger ranches and on preserved land (Prairie Pothole Joint Venture 2005). BCR 11 covers portions of six states and three Canadian provinces: Montana, Nebraska, South Dakota, Minnesota, North Dakota, Iowa, Alberta, Saskatchewan and Manitoba.

South Dakota, Wyoming and some North Dakota ranch sampling occurred within BCR 17 (Badlands and Prairies) which 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, Nebraska, North Dakota, South Dakota and Wyoming.

The Colorado portion of BCR 18 and BCR 17 have moderate to extensive on-going sampling under the IMBCR program.

Sampling Design

Sampling Frame and Stratification

Using a design consistent with the IMBCR program, the Bird Conservancy identified ten distinct strata for songbird monitoring on Audubon-affiliated ranches. Each stratum represented private ranches that were available for sampling within a single state. In Colorado and Wyoming, we further subdivided into strata associated with individual ranches.

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. (White et al. 2015)

For example, data from each individual stratum within the South Dakota portion of BCR 17 can be combined to produce avian population estimates for that geographic extent.

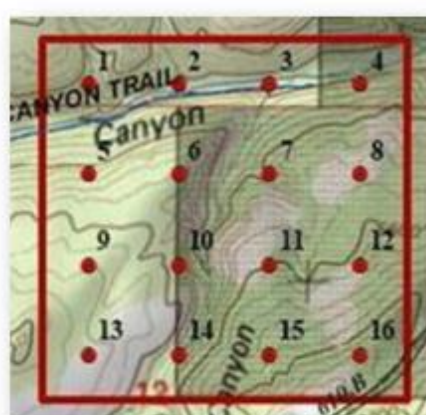
We defined IMBCR strata based on areas to which IMBCR partners wanted to make inferences. Smaller-order strata within BCRs were identified using fixed attributes such as land ownership boundaries, elevation zones, major river systems, and wilderness/roadless designations.
We combined smaller-order strata within a BCR (BCR 17), the intersection of BCR and state (the South Dakota portion of BCR 17), or sampled strata within the intersection of BCR and state to provide regional geographic area for comparison.

Sampling Units

The IMBCR design defined sampling units as 1 km^2 cells, each containing 16 evenly-spaced sample points, 250 meters apart (Figure 1). 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). (White et al. 2015)

Sample Selection

Within IMBCR strata and the three Audubon ranchland strata, the Bird Conservancy 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; (White et al. 2015)

- 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. (White et al. 2015)

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. 2015). 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.

Figure 1. IMBCR 1- km^2 sample cell containing 16 survey points arranged in a 4 X 4 matrix.

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 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_spacially_balanced_sampling.pdf (White et al. 2015)

Analysis Procedures

Bird Conservancy will produce density, population and occupancy estimates for Audubon-affiliated ranch strata and comparison strata in BCRs 11, 17 and 18 in early-2017. The information below is presented to be used in conjunction with the forthcoming results.

Density Analysis
Density analysis procedures are consistent with those of the IMBCR program:
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 estimate density for each species using a sequential framework where 1) year specific detection functions are applied to species with greater than or equal to 80 detections per year ($n \geq 80$), 2) global detection functions are 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 are 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 select 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 consider the most parsimonious model as the estimation model. We estimate population size N for each stratum as $N = D^*A$, where D is the estimated population density and A is the number of 1 km^2 sampling units in each stratum. We calculate Satterthwaite 90% Confidence Intervals (CI) for the estimates of density and population size for each stratum (Buckland et al. 2001). In addition, we combine 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 estimate 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 review 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 check the shape criteria of the histogram to ensure the detection data exhibited a “shoulder” that falls away at increasing distances from the observer. Second, we evaluate the fit of the model using the Kolmogorov-Smirnov goodness-of-fit test. Finally, we visually inspect the detection histograms to identify species that demonstrate evasive movement and/or measurement errors. We look for a type of measurement error involving the heaping of detections at certain distances that occurs when observers round detection distances. We also look for histograms with detections that are 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 use two sequential remedial measures. First, we truncate the data to the point where detection probability is approximately 0.1 [$g(w) \sim 0.1$] and include key functions with second order cosine series-expansion terms in the candidate set of models (Buckland et al. 2001). We do 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 continue to suggest evasive movement and/or measurement errors, we group the distance data into four to eight bins, and apply 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). (White et al. 2015)

Density results to accompany this report will be completed hereafter. Results from those analyses will be appended to a later version of this final report.

Occupancy Analysis
Occupancy analysis procedures are consistent with those of the IMBCR program:
Occupancy estimation is most commonly used to quantify the proportion of sample units (i.e., 1-km^2 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 use a removal design (MacKenzie et al. 2006), to estimate a detection probability for each species, in which we bin 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 is 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 serve as spatial replicates for estimating the proportion of points occupied within the sampled sampling units. We use 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).

We truncate the data, using only detections less than 125m from the sample points. Truncating the data at less than 125m allows us to use bird detections over a consistent plot size and ensure that the points are independent (points were spread 250m apart), which in turn allows us to estimate Theta (the proportion of points occupied within each sampling unit) (Pavlacky et al. 2012).

We expect that regional differences in the behavior, habitat use and local abundance of species correspond to regional variation in detection and the fraction of occupied points. Therefore, we estimate 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 are held constant across the BCRs and/or allowed to vary by BCR. Models are defined as follows:

Model 1: Constrains *p* and Theta by holding these parameters constant across BCRs;
Model 2: Holds *p* constant, but allows Theta to vary across BCRs;
Model 3: Allows *p* to vary across BCRs, but holds Theta constant across BCRs;
Model 4: Allows both *p* and Theta to vary across BCRs.

We run model 1 for species with less than 10 detections in all BCRs or less than 10 detections in all but 1 BCR. We run 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 pool data for BCRs with fewer than 10 detections into adjacent BCRs with sufficient numbers of detections. We use AIC corrected for small sample size (AIC_c) and model selection theory to evaluate models from which estimates of Psi are derived for each species (Burnham and Anderson 2002). We model average the estimates of Psi from models 1 through 4 and calculate unconditional standard errors (Burnham and Anderson 2002).

Our application of the multi-scale model is 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 consider both *p* and Theta to be nuisance variables that are 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). (White et al. 2015)

Density and occupancy results to accompany this report will be completed hereafter. Results from those analyses will be appended to a later version of this final report.

Automated Analysis

Both density and occupancy estimation will be completed with the use of a modified version of the RIMBCR package (R Core Team 2014; Paul Lukacs, University of Colorado, 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 allow 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 uses 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 provides 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

Due to the sensitive nature of avian data on private lands, counts of avian individuals by species, ranch, and strata will be provided to Audubon separate from this report.

Audubon-Affiliated Ranch Strata

Observers conducted avian point counts within 57 distinct grid cells resulting in a total of 754 individual point count stations surveyed across the ten strata (Table 1). Surveys were completed between 17 May and 21 July 2016. Collectively, the point counts resulted in a total of 11,821 observed individuals of 151 species.

Table 1. The number of grid cells visited, number of point counts conducted, average number of point counts conducted per grid, and the survey date range for each of the three strata surveyed in 2016.

Strata	Grid Cells	Point Counts	Average Counts/Grid	Survey Date Range
CO-RANCH-DM	6	68	11.3	5/17 - 5/23/2016
CO-RANCH-KC	2	21	10.5	6/6 - 6/7/2016
ND-RANCH-AU	5	42	8.4	7/15 - 7/21/2016
SD-RANCH-AU	4	42	10.5	6/24 - 6/29/2016
WY-RANCH-DH	6	84	14.0	5/20 - 6/3/2016
WY-RANCH-FI	7	104	14.9	5/19 - 5/25/2016
WY-RANCH-PE	6	92	15.3	5/21 - 5/27/2016
WY-RANCH-RE	7	103	14.7	5/18 - 5/23/2016
WY-RANCH-RI	7	106	15.1	5/18 - 5/26/2016
WY-RANCH-RO	7	92	13.1	5/18 - 5/29/2016
Total	57	754	13.2	5/17 - 7/21/2016

Figure 2. Survey locations on Audubon-affiliated ranches with Colorado inset maps

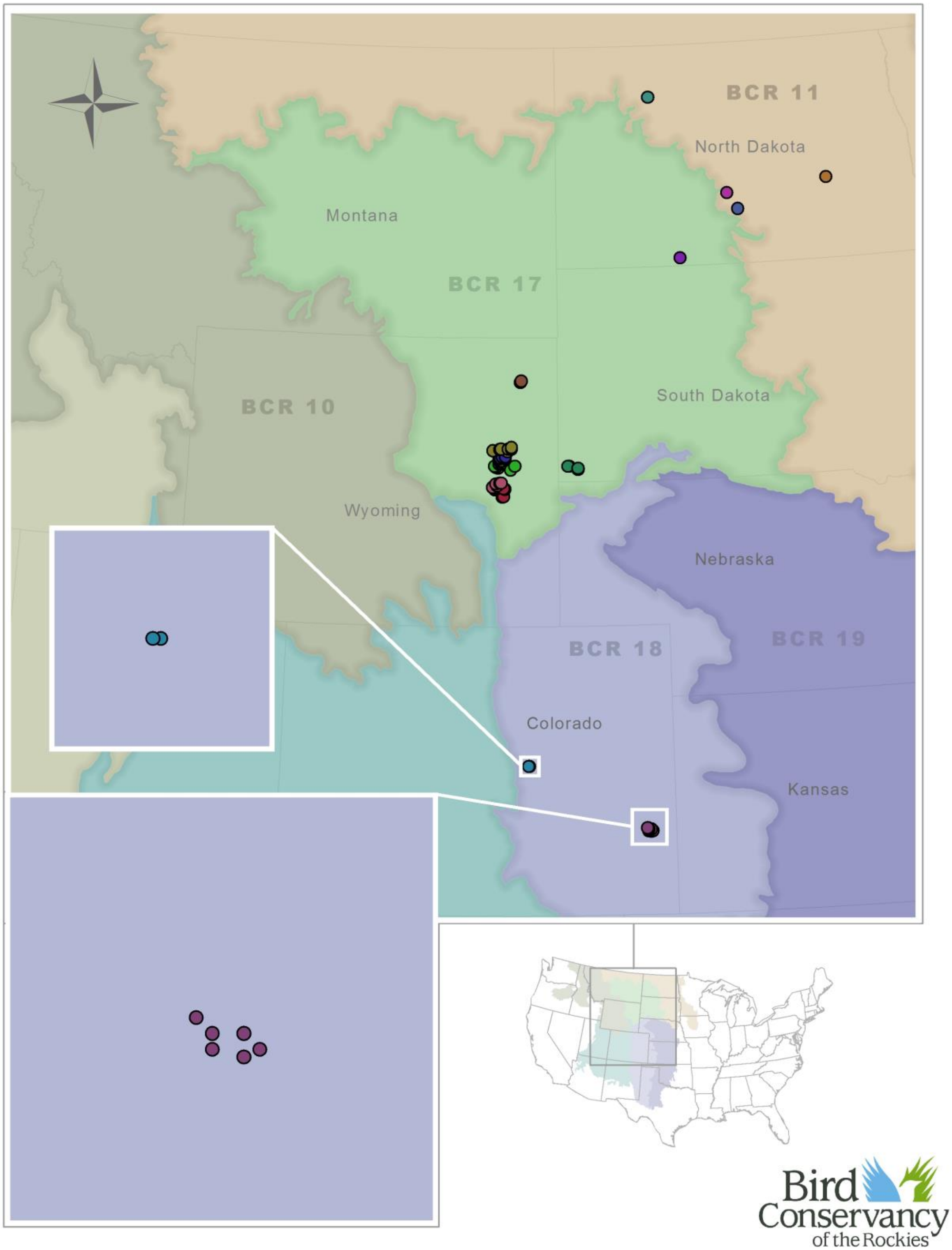


Figure 3. Survey locations on Audubon-affiliated ranches with South Dakota inset map

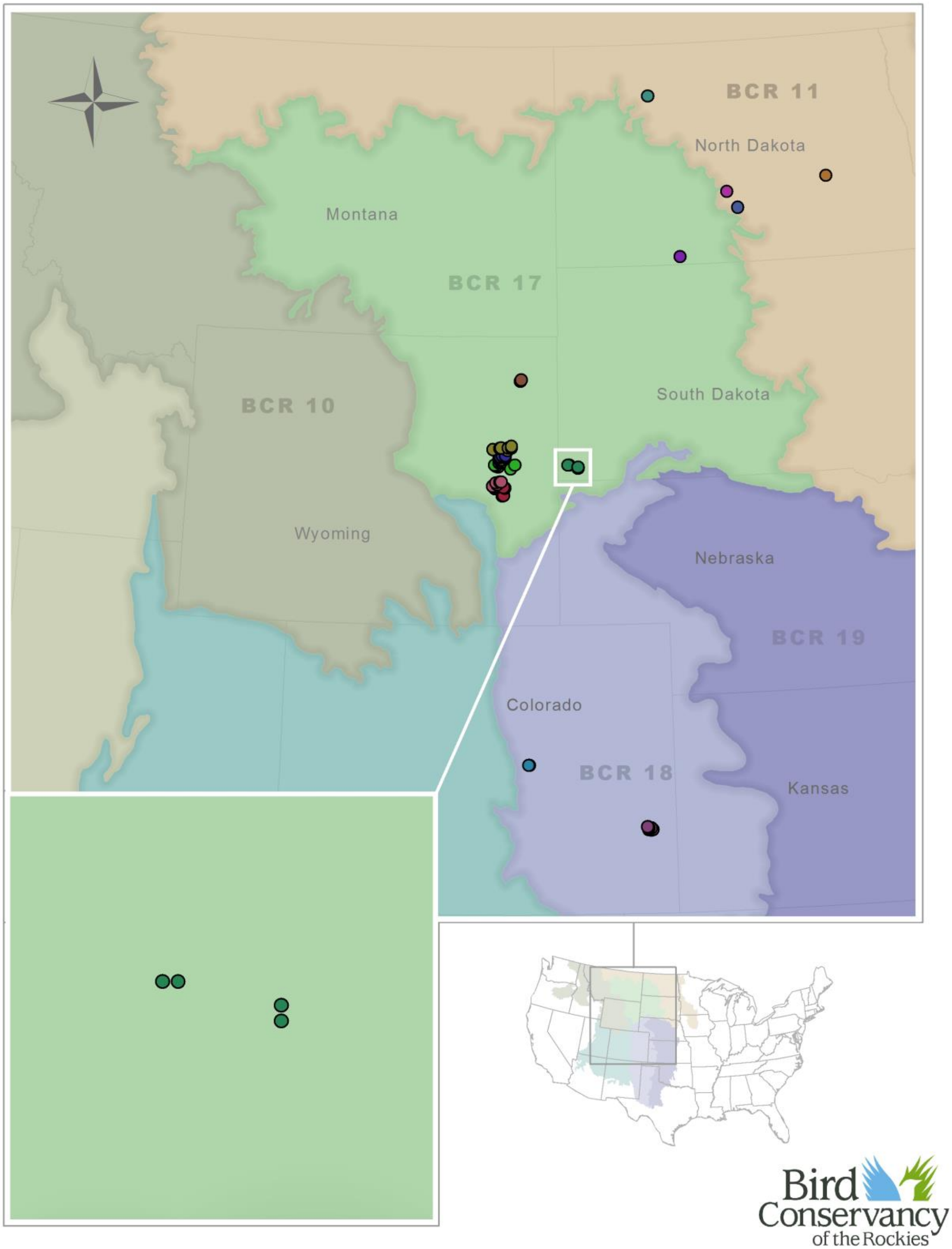
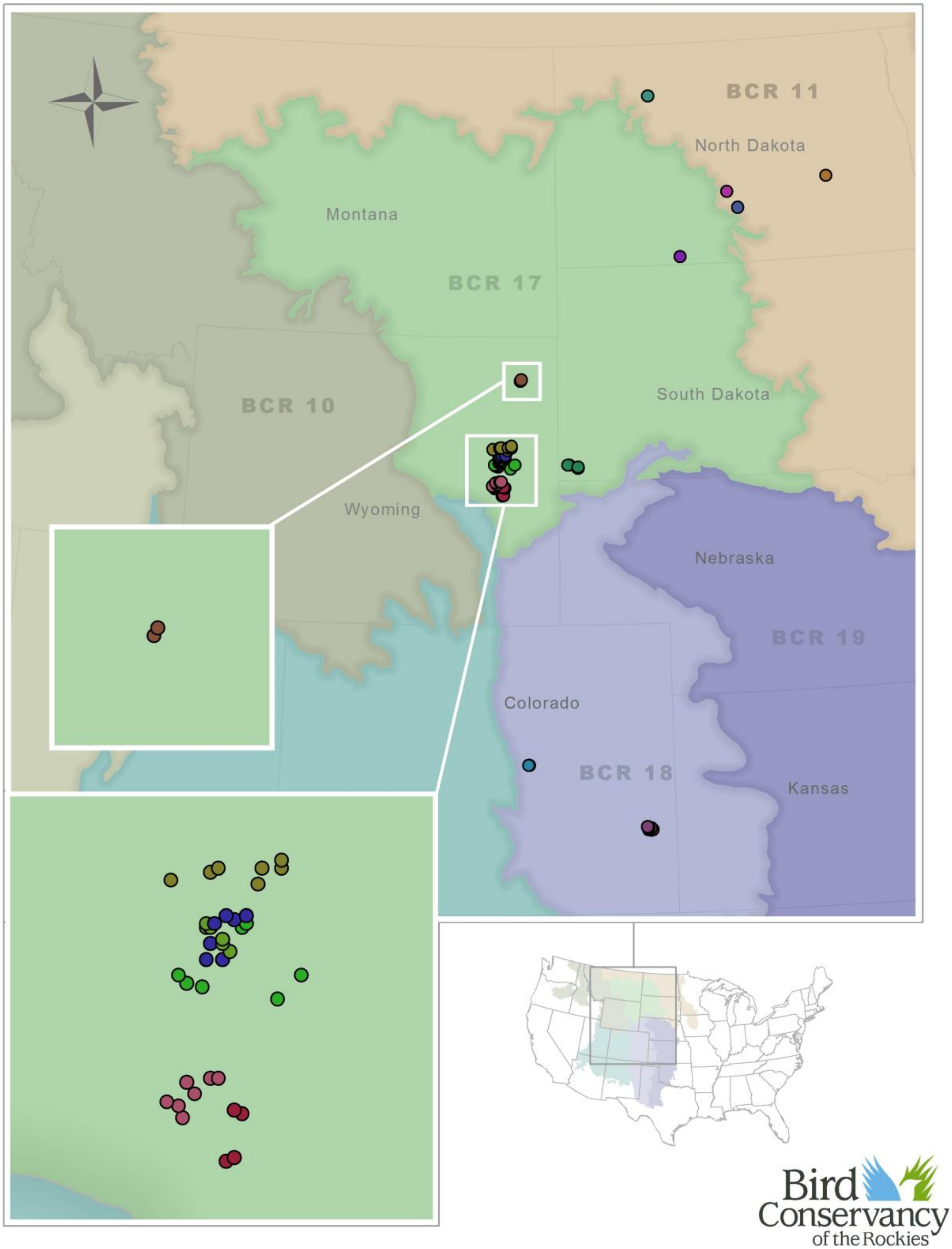


Figure 4. Survey locations on Audubon-affiliated ranches with Wyoming inset maps



The Bird Conservancy will estimate densities, population sizes and occupancy rates for Audubon-affiliated ranch and comparison strata in early 2017. We will present these estimates with information on accessing and querying results on our Avian Data Center website.

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. 2016 density, population and occupancy estimates will be produced in early-2017. 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 for Audubon-affiliated ranch strata can be compared to state and regional estimates to determine if local populations are above or below estimates for the region;
2) Population estimates can be used to make informed management decisions about where to focus conservation efforts. For example, strata with large population densities can be targeted for protection and strata with low densities can be prioritized for conservation action; a threshold could be set to trigger a management action when populations 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 km^2 and the occupancy estimate for Western Meadowlark is 0.57, managers can estimate that 68,400 km^2 (120,000 km^2 * 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, such as the monitoring effort on Audubon-affiliated ranches discussed in this report, 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, geographic regions. 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.

We have included a list of species recorded by state and year (Appendix B).

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APPENDIX A: 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.

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 – Mgmt Forest – 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

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 of the Rockies 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 field provided, 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 km^2 (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 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".

APPENDIX B: SPECIES COUNTS BY STATE AND YEAR

Common Name	CO	ND	SD	WY	Total
American Avocet		1		8	9
American Coot	2			2	4
American Crow	3	3		25	31
American Goldfinch		10		36	46
American Kestrel	4	1	1	26	32
American Pipit				1	1
American Robin	13	4		60	77
American White Pelican		6			6
American Wigeon				9	9
Baird's Sparrow		2		1	3
Bald Eagle				3	3
Baltimore Oriole		1			1
Bank Swallow	2	5		2	9
Barn Swallow	15	5	1	8	29
Black Tern		3			3
Black-billed Magpie	3			29	32
Black-capped Chickadee		1		28	29
Black-crowned Night-Heron		3			3
Black-headed Grosbeak				2	2
Blue Grosbeak	4	1	8		13
Blue Jay				4	4
Blue-gray Gnatcatcher				4	4
Blue-winged Teal		9	6	5	20
Bobolink		17			17
Brewer's Blackbird	7	5	8	61	81
Brewer's Sparrow	1		15	725	741
Broad-tailed Hummingbird	4				4
Brown Creeper	2				2
Brown Thrasher		1	2	4	7
Brown-headed Cowbird	4	52	34	122	212
Bullock's Oriole	7			7	14
Burrowing Owl	1			2	3
California Gull		3		3	6
Canada Goose	4	63		206	273
Canvasback				3	3
Canyon Wren				1	1
Cassin's Sparrow	115				115
Cedar Waxwing		1			1
Chestnut-collared Longspur		21		1	22
Chihuahuan Raven	1				1

Common Name	CO	ND	SD	WY	Total
Chipping Sparrow	17			47	64
Clay-colored Sparrow		62		3	65
Cliff Swallow	6			15	21
Common Grackle	19	4	4	59	86
Common Loon		1			1
Common Nighthawk	7	6	13	4	30
Common Poorwill				2	2
Common Raven				7	7
Common Yellowthroat	11	31			42
Dark-eyed Junco	6			1	7
Dickcissel		18			18
Double-crested Cormorant		421			421
Downy Woodpecker	2				2
Dusky Flycatcher				1	1
Eared Grebe		92		3	95
Eastern Kingbird	3	34	3	33	73
Eurasian Collared-Dove	4		3	2	9
European Starling	16	1	42	118	177
Evening Grosbeak	3				3
Field Sparrow			1	5	6
Franklin's Gull		54			54
Gadwall		8		6	14
Golden Eagle			1	4	5
Grasshopper Sparrow	16	49	22	97	184
Gray Flycatcher				26	26
Great Blue Heron	7	3		4	14
Great Horned Owl				4	4
Great-tailed Grackle	9				9
Green-tailed Towhee	6				6
Green-winged Teal				10	10
Hairy Woodpecker	5			3	8
Horned Lark	154	17	13	594	778
House Finch	4			2	6
House Wren	4	5		48	57
Killdeer	51	31	9	68	159
Lark Bunting	34		61	1335	1430
Lark Sparrow	32		16	102	150
Lazuli Bunting				1	1
Least Flycatcher		1			1
Lesser Goldfinch	1				1
Lesser Yellowlegs		6			6
Loggerhead Shrike	1		5	38	44

Common Name	CO	ND	SD	WY	Total
Mallard	19	10	20	61	110
Marbled Godwit		1			1
Marsh Wren		3			3
McCown's Longspur				7	7
Merlin				1	1
Mountain Bluebird				22	22
Mountain Chickadee	10				10
Mourning Dove	71	21	48	268	408
Nelson's Sparrow		1			1
Northern Flicker	5	3		79	87
Northern Harrier	5	1	2	14	22
Northern Mockingbird	3			5	8
Northern Pintail		1		18	19
Northern Rough-winged Swallow		3	1	9	13
Northern Shoveler		4		8	12
Orchard Oriole		3			3
Osprey				1	1
Pectoral Sandpiper		1			1
Pied-billed Grebe		1			1
Pine Siskin	4				4
Pinyon Jay				1	1
Plumbeous Vireo				4	4
Pygmy Nuthatch	4				4
Red Crossbill			5	48	53
Red-breasted Nuthatch				2	2
Redhead		1		3	4
Red-headed Woodpecker				19	19
Red-tailed Hawk	8	3	1	30	42
Red-winged Blackbird	96	105	20	79	300
Ring-billed Gull		6			6
Ring-necked Pheasant	26	18			44
Rock Pigeon				2	2
Rock Wren			4	23	27
Ruddy Duck		6		1	7
Sage Thrasher				19	19
Savannah Sparrow	5	41		2	48
Say's Phoebe		1	1	19	21
Scaled Quail	6				6
Sedge Wren		13			13
Sharp-tailed Grouse		2		1	3
Short-eared Owl				6	6
Solitary Sandpiper				2	2

Common Name	CO	ND	SD	WY	Total
Song Sparrow	1	16		1	18
Sora	1				1
Spotted Sandpiper	1				1
Spotted Towhee			4	13	17
Sprague's Pipit		13			13
Steller's Jay	4				4
Townsend's Solitaire				1	1
Tree Swallow	1			5	6
Turkey Vulture	2			10	12
Unknown Bird	54	218	11	221	504
Upland Sandpiper		7	2	53	62
Vesper Sparrow		3	31	276	310
Violet-green Swallow	5			19	24
Western Bluebird	3				3
Western Kingbird	20	3	4	87	114
Western Meadowlark	348	69	235	2543	3195
Western Wood-Pewee	15			21	36
White-breasted Nuthatch	6			5	11
White-faced Ibis	9				9
Wild Turkey	2			12	14
Willet		1			1
Willow Flycatcher		8			8
Wilson's Phalarope				49	49
Wilson's Snipe		2			2
Wood Duck	2				2
Yellow Warbler		6		30	36
Yellow-headed Blackbird	9	4		1	14
Yellow-rumped Warbler				17	17
Total	1355	1661	657	8148	11821