Avian Monitoring on Private Ranches in Colorado, North Dakota, South Dakota and Wyoming: 2017 Field Season Report

February 2018

Bird Conservancy of the Rockies

Connecting People, Birds and Land

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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 provide 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.

Bird Conservancy of the Rockies (hereafter, 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 were 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 that implement bird-friendly ranching practices compared to the surrounding landscape.

In 2017, Bird Conservancy surveyed 82 1-km^2 grid cells on Audubon-affiliated private ranches across 15 strata. These surveys resulted in 1,085 individual point counts completed between May and July 2017. Field technicians observed 18,600 individuals of 164 bird species during the surveys on Audubon-affiliated ranches. We produced density estimates for 134 species, and occupancy estimates for 123 species. The number of species for which Bird Conservancy was able to produce estimates is dependent on the IMBCR design. Were data for Audubon-affiliated ranches analyzed outside of the IMBCR multi-scale density and occupancy models, estimates would have been produced for only 30 and 75 species for density and occupancy, respectively.

These estimates allowed us to compare Audubon-affiliated ranch strata to background strata where available. Results of these comparisons suggest that Audubon-affiliated ranches in North Dakota and Wyoming represent islands of important, intact grassland habitat, as densities for key grassland-dependent species such as Chestnut-collared Longspurs and Grasshopper Sparrows were significantly higher on these lands compare to background strata. Comparison of Audubon-affiliated ranch strata to background strata in South Dakota showed grassland bird species densities approximately equal to those of surrounding lands. This may be attributed to the high proportion of intact grassland habitat in western South Dakota.

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 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 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 that 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 Conservation Ranching Program Protocols. 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, Bird Conservancy of the Rockies (hereafter Bird Conservancy) utilized a probabilistic sampling design based on the "Integrated Monitoring in Bird Conservation Regions (IMBCR)" (Pavlacky et

al. 2017) 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.
- 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, 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.
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 El Paso county in Colorado, three counties in North Dakota (Burleigh, Grant, and McLean), three counties in South Dakota (Fall River, McPherson and Pennington) and three counties in Wyoming (Converse, Crook and Niobrara).

Colorado ranch sampling occurred within Bird Conservation Region 18 (BCR 18, Shortgrass Prairie) (Figure 1). BCR 18 lies in the rain shadow 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) (Figure 2), 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 (Figures 3 and 4) and some North Dakota (Figure 3) 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.

Figure 1. Survey locations on Audubon-affiliated ranches in Colorado

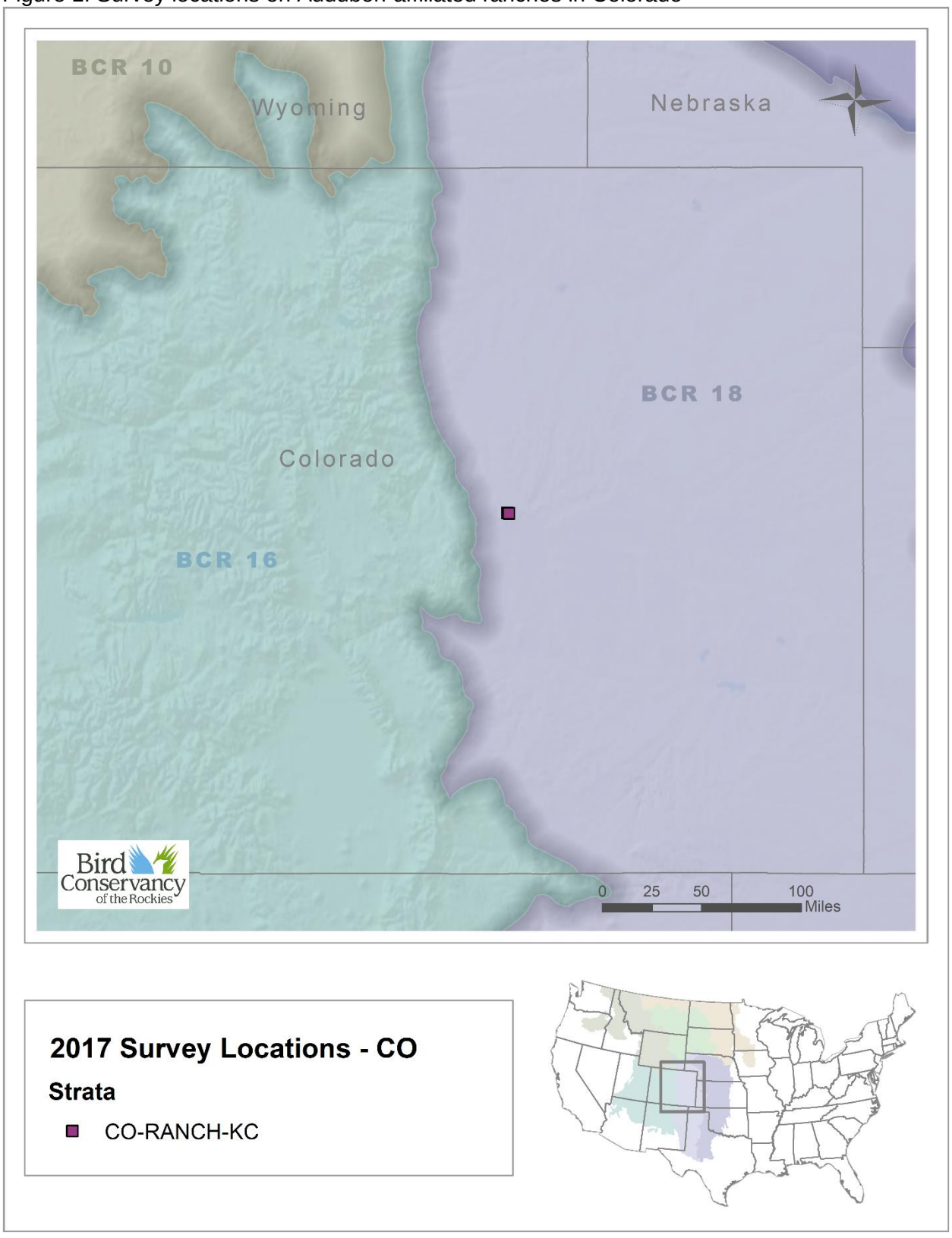


Figure 2. Survey locations on Audubon-affiliated ranches in North Dakota

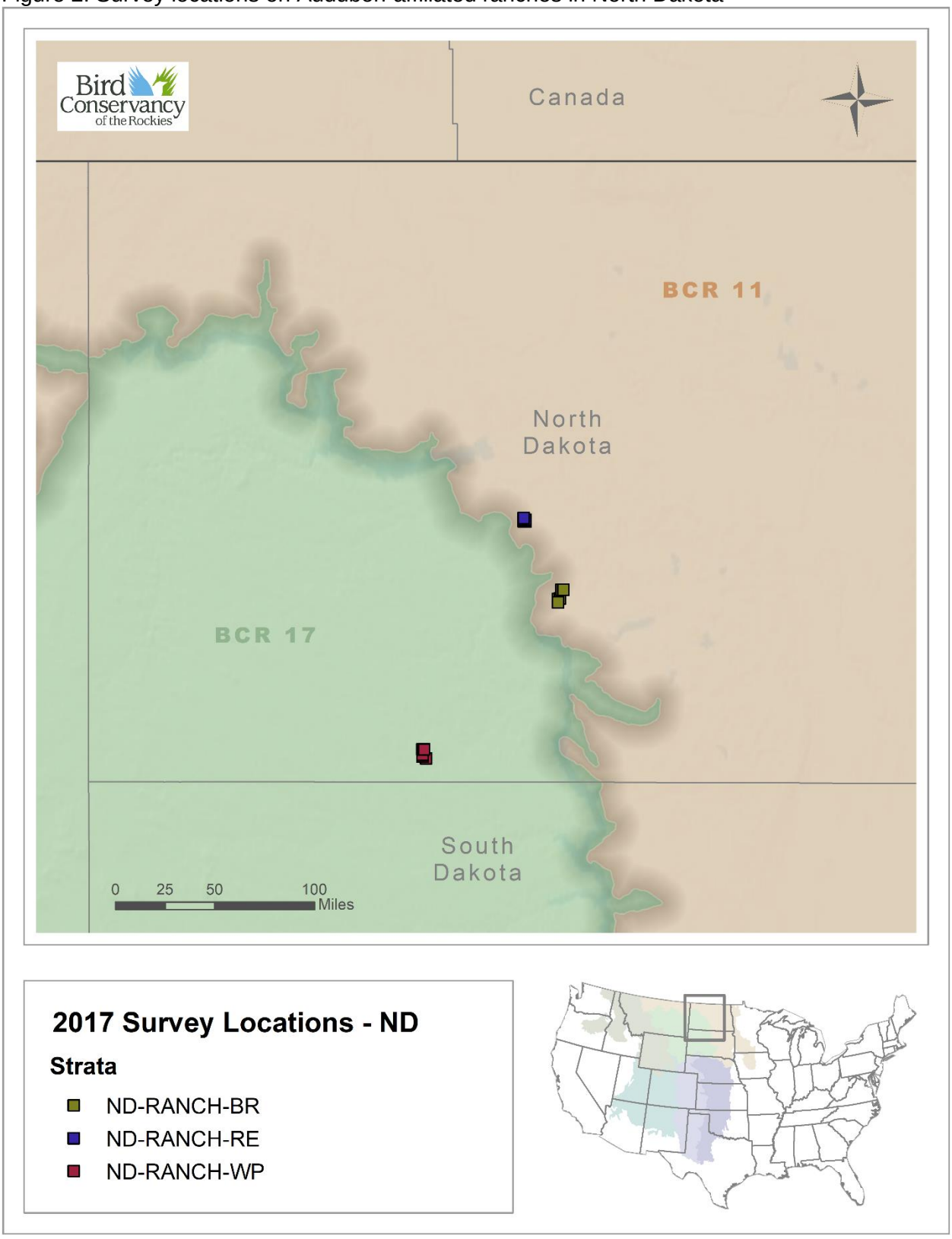


Figure 3. Survey locations on Audubon-affiliated ranches in South Dakota

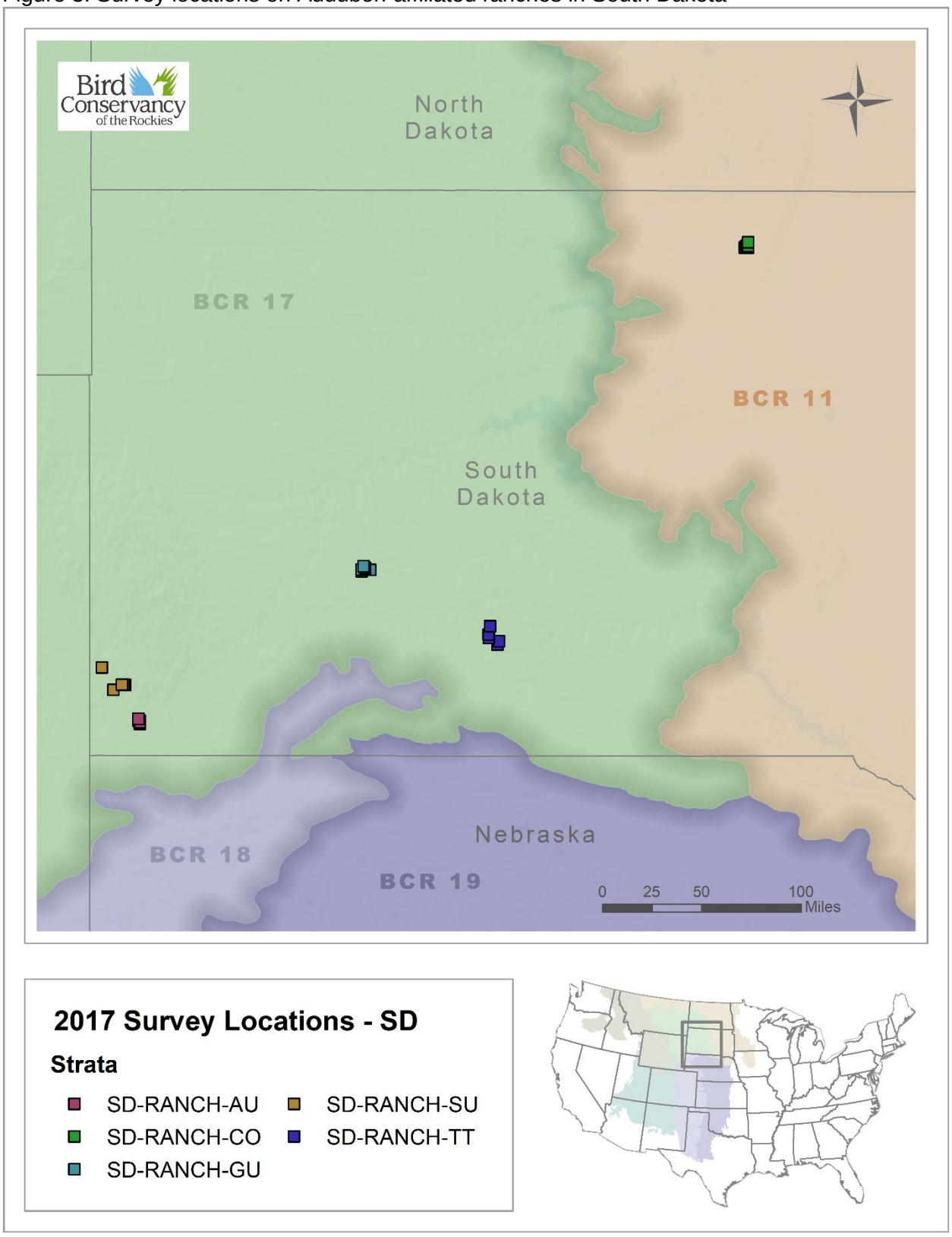
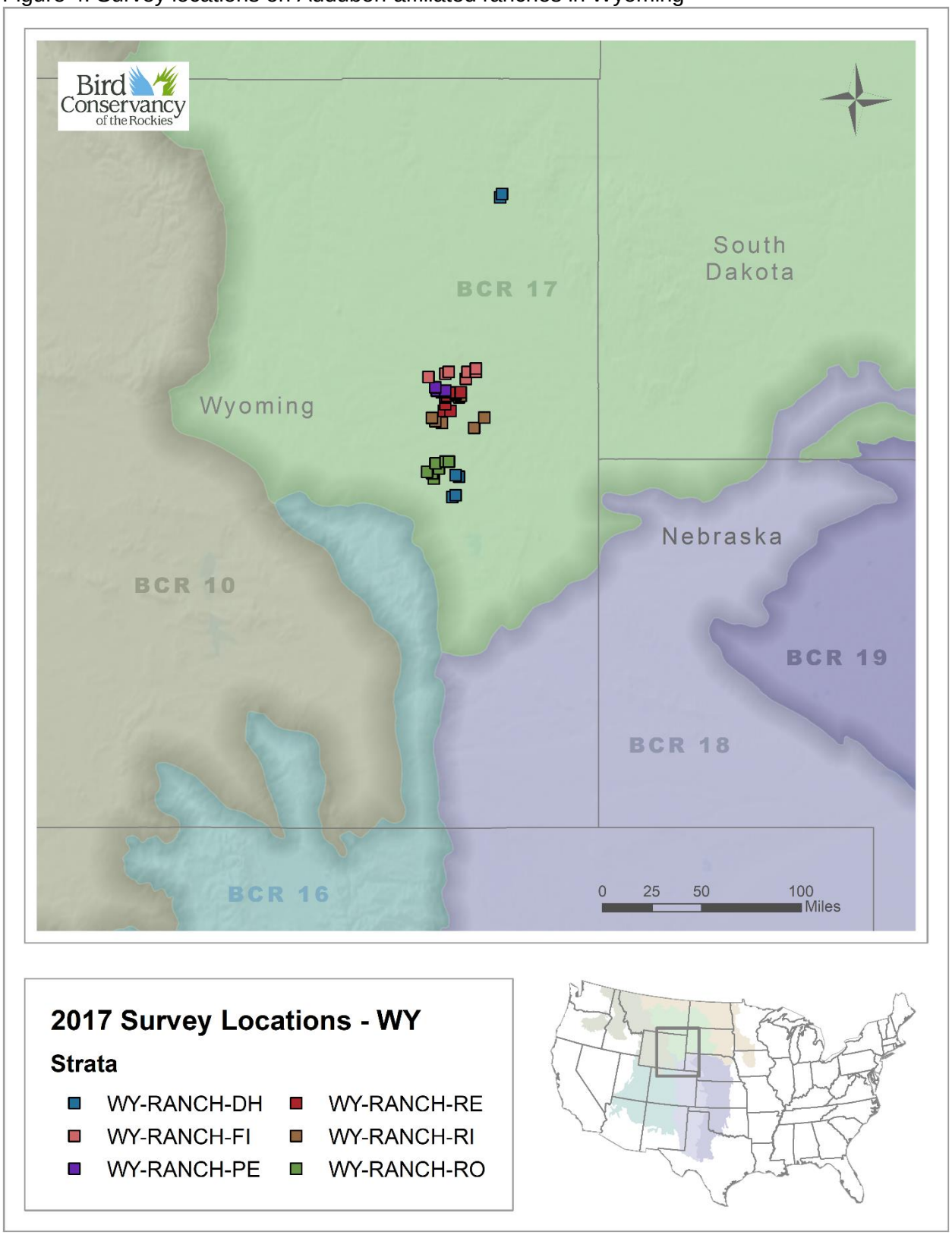


Figure 4. Survey locations on Audubon-affiliated ranches in Wyoming



Sampling Design

Sampling Frame and Stratification

Using a design consistent with the IMBCR program, Bird Conservancy and Audubon identified ten distinct strata for songbird monitoring on Audubon-affiliated ranches. Each stratum represented private ranches within distinct state and BCR boundaries. In Colorado and Wyoming, we further subdivided into strata associated with individual ranches. The following sampling design is based on the Sampling Design section of the IMBCR 2012 Annual Report (White et al. 2012).

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. 2012)

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. (White et al. 2012). 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).

Sample Selection

Within IMBCR strata and the three Audubon ranchland strata, 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;

- 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. 2012)

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.

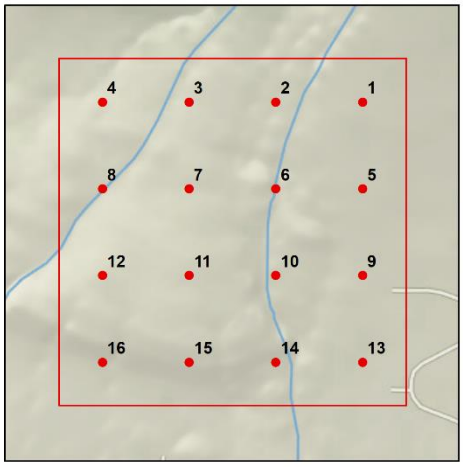


Figure 5. IMBCR 1- km^2 sample cell containing 16 survey points arranged in a 4 X 4 matrix.

Point counts (Buckland et al. 2001) were conducted following protocol established by IMBCR partners (Hanni et al. 2012) 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. Opportunistic detections between point count stations were not included in the occupancy and density analyses.

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. (White et al. 2012). For more detailed information about survey methods, refer to Bird Conservancy's Field Protocol for Spatially Balanced Sampling of Landbird Populations on the Rocky Mountain Avian Data Center website: http://rmbo.org/v3/Portals/5/Protocols/2017%20Field%20Protocol%20for%20Spatially%20Balanced%20Sampling.pdf

Analysis Procedures

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 ≥ 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. 2012)

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. 2012)

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, names of ranches corresponding to stratum code will be provided separate from this report.

Observers conducted avian point counts within 82 distinct grid cells resulting in a total of 1,085 point count stations surveyed across 15 strata (Table 1). Surveys were completed between 24 May and 5 July 2017. Collectively, the point counts resulted in a total of 18,600 observed individuals of 164 species (Table 2). We produced density estimates for 134 species, and occupancy estimates for 123 species. We produced estimates for several Audubon Priority Species: Bobolink, Grasshopper Sparrow, Lark Bunting, and Sage Thrasher. We also produced estimates for other important grassland bird species including Baird's Sparrow, Chestnut-collared Longspur, McCown's Longspur, and Sprague's Pipit (Tables 3-8).

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 15 strata surveyed in 2017.

Strata	Grid Cells	Point Counts	Average Counts/Grid	Survey Date Range
CO-RANCH-KC	2	24	12.0	6/6 – 6/7
ND-RANCH-BR	5	54	10.8	6/29 – 7/2

ND-RANCH-RE	5	65	13.0	7/1 – 7/5
ND-RANCH-WP	5	69	13.8	6/30 – 7/4
SD-RANCH-AU	5	65	13.0	6/24 – 6/29
SD-RANCH-CO	5	64	12.8	6/16 – 6/20
SD-RANCH-GU	5	67	13.4	6/24 – 6/28
SD-RANCH-SU	5	61	12.2	6/22 – 6/28
SD-RANCH-TT	5	58	11.6	6/28 – 7/2
WY-RANCH-DH	6	68	11.3	5/31 – 6/7
WY-RANCH-FI	7	100	14.3	5/31 – 6/6
WY-RANCH-PE	6	85	14.2	5/31 – 6/6
WY-RANCH-RE	7	112	16.0	5/24 – 6/3
WY-RANCH-RI	7	104	14.9	5/23 – 6/8
WY-RANCH-RO	7	89	12.7	5/24 – 6/3
Total	82	1,085	13.2	5/23 – 7/5

Table 2. Number of birds and species detected for each of the 15 strata surveyed in 2017.

	Birds		Species	
Stratum	# Detected	Avg. # per grid cell	# detected	Avg. # per grid cell
CO-RANCH-KC	259	130	37	30
ND-RANCH-BR	1890	378	66	37
ND-RANCH-RE	1373	275	56	35
ND-RANCH-WP	1312	262	30	21
SD-RANCH-AU	573	115	30	14
SD-RANCH-CO	1269	254	47	31
SD-RANCH-GU	838	168	44	27
SD-RANCH-SU	645	129	52	28
SD-RANCH-TT	1611	322	67	37
WY-RANCH-DH	1229	205	78	33
WY-RANCH-FI	1638	234	55	24
WY-RANCH-PE	1263	211	39	20
WY-RANCH-RE	1658	237	48	19
WY-RANCH-RI	1625	232	39	17
WY-RANCH-RO	1417	202	35	14
All Strata	18600	227	164	25

Of the 37 species detected in the Colorado BCR 18 ranch stratum (CO-RANCH-KC), we produced density estimates for 35 of them. We then compared these estimates to estimates from CO-BCR18-IA (Area between I-70 and the Arkansas River in Colorado BCR 18) (Table 3). We selected this stratum for comparison because of the geographic overlap between it and the ranch stratum. Not all species detected in the ranch stratum were detected in the background stratum, and therefore were not available for comparison. We were unable to produce estimates for some species that were detected either because there were not enough detections, or because they could not be included for analysis for other reasons. Estimated densities for some

grassland species were significantly higher in the ranch stratum than the background stratum. These include Brewer's Blackbird, Savannah Sparrow, and Vesper Sparrow. Some species, such as Western Meadowlark had significantly lower densities than the background stratum (Table 3).

Table 3. . Estimated densities per km2 (D), percent coefficient of variation of estimates (% CV), and number of independent detections used in analyses (n) of breeding birds in Audubon conservation ranch strata and a background stratum in Colorado BCR 18 for 20.

Species	Stratum	D	%CV	n
American Kestrel	CO-RANCH-KC	0.558	100	1
American Robin	CO-BCR18-IA	1.171	69	5
	CO-RANCH-KC	14.701	9	11
Black-billed Magpie	CO-RANCH-KC	2.103	15	6
Brewer's Blackbird	CO-BCR18-IA	0.520	104	1
	CO-RANCH-KC	38.553	55	12
Broad-tailed Hummingbird	CO-RANCH-KC	79.469	67	6
Brown Creeper	CO-RANCH-KC	16.301	100	2
Brown-headed Cowbird	CO-BCR18-IA	5.503	35	17
	CO-RANCH-KC	14.781	100	8
Canada Goose	CO-RANCH-KC	0.236	100	1
Chipping Sparrow	CO-RANCH-KC	27.449	50	8
Cooper's Hawk	CO-RANCH-KC	5.094	106	1
Dark-eyed Junco	CO-RANCH-KC	22.770	67	6
Eurasian Collared-Dove	CO-BCR18-IA	0.929	81	4
	CO-RANCH-KC	2.650	101	2
European Starling	CO-BCR18-IA	7.400	54	12
	CO-RANCH-KC	2.112	100	1
Hairy Woodpecker	CO-RANCH-KC	7.012	100	3
House Finch	CO-BCR18-IA	2.855	89	7
	CO-RANCH-KC	11.640	60	5
House Wren	CO-BCR18-IA	1.096	99	3
	CO-RANCH-KC	12.516	100	6
Lesser Goldfinch	CO-RANCH-KC	41.425	80	8
Mallard	CO-BCR18-IA	0.264	101	1
Mallard, cont.	CO-RANCH-KC	12.046	103	3
Mountain Chickadee	CO-RANCH-KC	34.096	12	9
Mourning Dove	CO-BCR18-IA	8.776	21	90
	CO-RANCH-KC	6.134	50	12
Northern Flicker	CO-BCR18-IA	0.237	99	2
	CO-RANCH-KC	4.051	34	6
Pygmy Nuthatch	CO-RANCH-KC	22.543	56	8
Red-tailed Hawk	CO-BCR18-IA	0.314	70	5
	CO-RANCH-KC	0.358	103	1
Red-winged Blackbird	CO-BCR18-IA	7.795	78	40
	CO-RANCH-KC	22.250	70	19

Species	Stratum	D	%CV	n
Savannah Sparrow	CO-BCR18-IA	0.399	99	1
	CO-RANCH-KC	4.551	100	2
Sora	CO-RANCH-KC	0.667	104	1
Steller's Jay	CO-RANCH-KC	3.156	100	3
Vesper Sparrow	CO-BCR18-IA	0.969	70	7
	CO-RANCH-KC	9.479	33	12
Violet-green Swallow	CO-RANCH-KC	35.664	78	6
Western Bluebird	CO-RANCH-KC	5.476	100	2
Western Kingbird	CO-BCR18-IA	15.831	61	37
	CO-RANCH-KC	3.063	100	2
Western Meadowlark	CO-BCR18-IA	36.596	6	486
	CO-RANCH-KC	12.239	10	29
Western Wood-Pewee	CO-BCR18-IA	0.508	99	3
	CO-RANCH-KC	16.417	41	17
White-breasted Nuthatch	CO-RANCH-KC	3.654	5	2
Wilson's Snipe	CO-RANCH-KC	0.471	102	1

We detected 79 species in Audubon conservation ranch strata in BCR 11 in North Dakota (ND-RANCH-BR and ND-RANCH-RE), and were able to produce density estimates for 61 of the species detected across both strata (Table 4). We were unable to produce estimates for some species that were detected either because there were not enough detections, or because they could not be included for analysis for other reasons. No background strata exists for comparison in BCR 11.

Table 4. Estimated densities per km^2 (D), percent coefficient of variation of estimates (% CV), and number of independent detections used in analyses (n) of breeding birds in Audubon conservation ranch strata in North Dakota BCR 11 for 2017.

Species	Stratum	D	%CV	n
American Goldfinch	ND-RANCH-BR	27.915	66	20
	ND-RANCH-RE	2.485	67	3
American Kestrel	ND-RANCH-RE	0.206	102	1
American Robin	ND-RANCH-BR	30.886	45	36
	ND-RANCH-RE	1.480	69	3
Bank Swallow	ND-RANCH-BR	8.523	66	2
	ND-RANCH-RE	8.851	75	5
Barn Swallow	ND-RANCH-BR	20.735	65	4
	ND-RANCH-RE	8.613	71	4
Black-billed Magpie	ND-RANCH-RE	0.222	102	2
Black-capped Chickadee	ND-RANCH-BR	4.113	93	3
Brown-headed Cowbird	ND-RANCH-BR	66.516	21	55
	ND-RANCH-RE	46.390	25	47
Bobolink	ND-RANCH-BR	7.280	38	15
	ND-RANCH-RE	6.048	54	16
Brewer's Blackbird	ND-RANCH-BR	31.633	73	14

Species	Stratum	D	%CV	n
California Gull	ND-RANCH-BR	14.956	58	15
Canada Goose	ND-RANCH-BR	0.210	76	2
Chestnut-collared Longspur	ND-RANCH-RE	5.003	38	10
Clay-colored Sparrow	ND-RANCH-BR	63.637	15	82
	ND-RANCH-RE	19.109	39	30
Chipping Sparrow	ND-RANCH-BR	18.299	93	12
Cliff Swallow	ND-RANCH-BR	12.208	67	4
	ND-RANCH-RE	10.142	45	5
Common Grackle	ND-RANCH-BR	26.300	33	15
	ND-RANCH-RE	9.364	43	9
Common Nighthawk	ND-RANCH-RE	0.234	100	1
Common Yellowthroat	ND-RANCH-BR	7.356	57	12
	ND-RANCH-RE	7.130	47	14
Double-crested Cormorant	ND-RANCH-BR	0.812	88	3
Eastern Bluebird	ND-RANCH-RE	0.380	98	1
Eastern Kingbird	ND-RANCH-BR	9.259	47	11
	ND-RANCH-RE	12.087	19	22
Great Blue Heron	ND-RANCH-BR	0.311	70	2
	ND-RANCH-RE	0.129	103	1
Gray Catbird	ND-RANCH-BR	2.612	104	1
	ND-RANCH-RE	4.340	102	3
Grasshopper Sparrow	ND-RANCH-BR	160.128	26	119
	ND-RANCH-RE	109.749	12	99
Horned Lark	ND-RANCH-BR	12.990	59	16
	ND-RANCH-RE	6.983	61	10
House Wren	ND-RANCH-RE	1.540	100	2
Killdeer	ND-RANCH-BR	23.241	30	44
	ND-RANCH-RE	4.224	68	14
Lark Sparrow	ND-RANCH-BR	1.582	93	2
Marbled Godwit	ND-RANCH-BR	2.347	107	8
	ND-RANCH-RE	0.244	107	1
Mallard	ND-RANCH-BR	12.046	57	8
Marsh Wren	ND-RANCH-RE	17.932	89	17
Mourning Dove	ND-RANCH-BR	9.542	42	30
	ND-RANCH-RE	3.963	24	16
Northern Cardinal	ND-RANCH-BR	0.982	93	2
Northern Flicker	ND-RANCH-RE	2.742	42	10
Northern Harrier	ND-RANCH-BR	1.386	31	7
	ND-RANCH-RE	0.144	97	1
Northern Rough-winged Swallow	ND-RANCH-BR	6.049	108	2
Orchard Oriole	ND-RANCH-BR	2.156	95	1
	ND-RANCH-RE	1.791	66	2
Ring-billed Gull	ND-RANCH-BR	12.266	88	8
Red-eyed Vireo	ND-RANCH-BR	0.685	93	1

Species	Stratum	D	%CV	n
Ring-neck Pheasant	ND-RANCH-BR	5.631	22	81
	ND-RANCH-RE	1.483	15	26
Rock Pigeon	ND-RANCH-BR	39.525	67	7
Red-winged Blackbird	ND-RANCH-BR	37.083	32	59
	ND-RANCH-RE	12.734	28	30
Savannah Sparrow	ND-RANCH-BR	68.773	27	67
	ND-RANCH-RE	62.176	23	74
Sedge Wren	ND-RANCH-BR	0.674	102	1
	ND-RANCH-RE	1.680	67	3
Sora	ND-RANCH-BR	0.296	106	1
	ND-RANCH-RE	0.492	105	2
Song Sparrow	ND-RANCH-BR	13.129	58	18
	ND-RANCH-RE	10.333	52	18
Sprague's Pipit	ND-RANCH-RE	2.900	37	14
Spotted Sandpiper	ND-RANCH-BR	0.705	103	1
Swainson's Hawk	ND-RANCH-BR	0.314	40	3
Tree Swallow	ND-RANCH-BR	3.571	111	1
	ND-RANCH-RE	44.504	76	4
Upland Sandpiper	ND-RANCH-BR	8.705	27	48
	ND-RANCH-RE	2.170	46	15
Vesper Sparrow	ND-RANCH-BR	0.351	102	1
	ND-RANCH-RE	0.292	100	1
Warbling Vireo	ND-RANCH-BR	0.840	98	1
Western Kingbird	ND-RANCH-BR	6.808	40	8
	ND-RANCH-RE	3.959	45	5
Western Meadowlark	ND-RANCH-BR	28.698	30	144
	ND-RANCH-RE	24.932	12	158
Willow Flycatcher	ND-RANCH-BR	2.844	103	2
	ND-RANCH-RE	2.363	101	1
Wilson's Phalarope	ND-RANCH-BR	1.084	103	1
	ND-RANCH-RE	1.802	64	2
Wilson's Snipe	ND-RANCH-RE	2.086	49	10
Yellow Warbler	ND-RANCH-RE	1.483	102	2
Yellow-headed Blackbird	ND-RANCH-BR	23.773	100	6
	ND-RANCH-RE	68.576	92	6

We detected 30 bird species in Audubon-affiliated ranch strata in BCR 17 in North Dakota in 2017. Of these, we produced density estimates for 27 species. We then compared these estimates to estimates from ND-BCR17-ON, All other Lands in North Dakota BCR 17 (Table 5). This stratum represents lands not owned by the Bureau of Land Management, National Park Service, U.S. Forest Service, and U.S. Fish and Wildlife Service in BCR 17 in North Dakota. We selected this stratum for comparison because of the geographic overlap between it and the ranch stratum. Not all species detected in the ranch stratum were detected in the background stratum, and therefore were not available for comparison. We were unable to produce estimates for some species that were detected either because there were not enough detections, or because they could not be included for analysis for other reasons. Generally, densities for

grassland bird species were comparable to those of the background stratum, with the notable exceptions of Chestnut-collared Longspur and Lark Bunting. We estimated the density of Chestnut-collared Longspur on the ranch stratum at nearly 40 times the density of the background strata. Similarly, Lark Bunting density on the ranch stratum was estimated at more than 20 times that of the background stratum (Table 5).

Table 5. Estimated densities per km^2 (D), coefficient of variation of estimates (% CV), and number of independent detections used in analyses (n) of breeding birds in Audubon conservation ranch strata and selected background strata in North Dakota BCR 17 for 2017.

Species	Stratum	D	%CV	n
American Goldfinch	ND-BCR17-ON	15.478	28	22
	ND-RANCH-WP	3.901	69	5
American Robin	ND-BCR17-ON	4.811	52	12
	ND-RANCH-WP	0.465	103	1
Baird's Sparrow	ND-RANCH-WP	0.506	96	1
Barn Swallow	ND-BCR17-ON	19.245	50	8
	ND-RANCH-WP	10.142	104	4
Brewer's Blackbird	ND-BCR17-ON	17.794	97	7
	ND-RANCH-WP	1.032	104	1
Brown Thrasher	ND-BCR17-ON	0.489	102	1
	ND-RANCH-WP	0.567	109	1
Brown-headed Cowbird	ND-BCR17-ON	74.276	54	69
	ND-RANCH-WP	95.114	32	102
Chestnut-collared Longspur	ND-BCR17-ON	4.472	73	11
	ND-RANCH-WP	173.450	26	316
Common Grackle	ND-RANCH-WP	2.940	72	3
Common Nighthawk	ND-BCR17-ON	0.380	97	2
	ND-RANCH-WP	0.661	36	3
Common Yellowthroat	ND-BCR17-ON	6.620	60	16
	ND-RANCH-WP	0.959	67	2
Eastern Kingbird	ND-BCR17-ON	12.053	36	22
	ND-RANCH-WP	3.105	67	6
Grasshopper Sparrow	ND-BCR17-ON	34.227	42	38
	ND-RANCH-WP	33.418	22	32
Horned Lark	ND-BCR17-ON	14.958	53	28
	ND-RANCH-WP	31.097	24	51
Killdeer	ND-BCR17-ON	6.373	61	11
	ND-RANCH-WP	7.957	57	28
Lark Bunting	ND-BCR17-ON	0.438	96	2
	ND-RANCH-WP	10.421	95	41
Mallard	ND-RANCH-WP	2.095	73	3
Mourning Dove	ND-BCR17-ON	18.402	27	96
	ND-RANCH-WP	4.800	41	25
Red-winged Blackbird	ND-BCR17-ON	41.050	39	91
	ND-RANCH-WP	48.369	48	117

Species	Stratum	D	%CV	n
Ring-neck Pheasant	ND-BCR17-ON	3.152	28	66
	ND-RANCH-WP	1.343	51	25
Savannah Sparrow	ND-BCR17-ON	38.230	50	55
	ND-RANCH-WP	5.541	61	7
Song Sparrow	ND-BCR17-ON	16.792	44	36
	ND-RANCH-WP	0.541	104	1
Swainson's Hawk	ND-BCR17-ON	0.495	66	7
	ND-RANCH-WP	0.984	64	12
Upland Sandpiper	ND-BCR17-ON	2.350	67	20
	ND-RANCH-WP	9.674	29	71
Western Kingbird	ND-BCR17-ON	2.298	98	5
	ND-RANCH-WP	2.131	47	4
Western Meadowlark	ND-BCR17-ON	9.875	47	73
	ND-RANCH-WP	22.606	9	150
Wilson's Phalarope	ND-RANCH-WP	1.697	103	2

We detected 52 bird species in Audubon-affiliated ranch strata in BCR 11 in South Dakota, and were able to produce density estimates for 40 species (Table 6). Not all species detected in the ranch stratum were detected in the background stratum, and therefore were not available for comparison. We were unable to produce estimates for some species that were detected either because there were not enough detections, or because they could not be included for analysis for other reasons. No background stratum exists for BCR 11 in South Dakota.

Table 6. Estimated densities per km^2 (D), percent coefficient of variation of estimates (% CV), and number of independent detections used in analyses (n) of breeding birds in Audubon conservation ranch strata in South Dakota BCR 11 for 2017.

Species	Stratum	D	%CV	n
American Goldfinch	SD-RANCH-CO	3.365	45	3
American Wigeon	SD-RANCH-CO	0.242	98	1
Barn Swallow	SD-RANCH-CO	4.374	96	1
Brown-headed Cowbird	SD-RANCH-CO	60.973	16	63
Bobolink	SD-RANCH-CO	19.962	18	52
Blue-winged Teal	SD-RANCH-CO	0.534	98	1
Canada Goose	SD-RANCH-CO	2.255	57	5
Chestnut-collared Longspur	SD-RANCH-CO	14.228	29	27
Clay-colored Sparrow	SD-RANCH-CO	12.938	42	18
Common Grackle	SD-RANCH-CO	26.417	32	18
Common Yellowthroat	SD-RANCH-CO	7.758	36	15
Double-crested Cormorant	SD-RANCH-CO	0.960	101	1
Dickcissel	SD-RANCH-CO	6.227	51	14
Eastern Kingbird	SD-RANCH-CO	3.906	51	6
Grasshopper Sparrow	SD-RANCH-CO	82.191	14	72
Horned Lark	SD-RANCH-CO	10.961	34	15
House Wren	SD-RANCH-CO	0.782	108	1

Species	Stratum	D	%CV	n
Killdeer	SD-RANCH-CO	14.707	27	39
Mallard	SD-RANCH-CO	7.341	44	8
Marsh Wren	SD-RANCH-CO	5.357	70	5
Mourning Dove	SD-RANCH-CO	1.150	72	6
Northern Harrier	SD-RANCH-CO	0.146	98	1
Northern Rough-winged Swallow	SD-RANCH-CO	5.104	112	2
Northern Shoveler	SD-RANCH-CO	1.183	44	3
Orchard Oriole	SD-RANCH-CO	0.910	97	1
Ring-neck Pheasant	SD-RANCH-CO	3.592	10	62
Red-tailed Hawk	SD-RANCH-CO	1.074	74	7
Red-winged Blackbird	SD-RANCH-CO	58.405	16	123
Savannah Sparrow	SD-RANCH-CO	67.414	17	78
Song Sparrow	SD-RANCH-CO	6.414	49	11
Upland Sandpiper	SD-RANCH-CO	9.695	17	64
Vesper Sparrow	SD-RANCH-CO	0.296	108	1
Western Kingbird	SD-RANCH-CO	0.574	108	1
Western Meadowlark	SD-RANCH-CO	18.358	7	112
Willow Flycatcher	SD-RANCH-CO	2.399	65	2
Willet	SD-RANCH-CO	1.540	55	10
Wilson's Phalarope	SD-RANCH-CO	0.915	96	1
Wilson's Snipe	SD-RANCH-CO	1.589	57	9
Yellow Warbler	SD-RANCH-CO	0.753	108	1
Yellow-headed Blackbird	SD-RANCH-CO	4.457	61	8

We detected 89 bird species in Audubon-affiliated ranch strata in South Dakota BCR 17 in 2017, and produced estimates for 81 species. We then compared these estimates to estimates from SD-BCR17-ON, All other Lands in South Dakota BCR 17 (Table 7). This stratum represents lands not owned by the Bureau of Land Management, National Park Service, U.S. Forest Service, and U.S. Fish and Wildlife Service in BCR 17 in South Dakota. We selected this stratum for comparison because of the geographic overlap between it and the ranch stratum. Not all species detected in the ranch stratum were detected in the background stratum, and therefore were not available for comparison. We were unable to produce estimates for some species that were detected either because there were not enough detections, or because they could not be included for analysis for other reasons. Generally, densities of grassland species on Audubon-affiliated ranch strata were comparable to those of the background strata.

Table 7. Estimated densities per km^2 (D), percent coefficient of variation of estimates (% CV), and number of independent detections used in analyses (n) of breeding birds in Audubon conservation ranch strata and selected background strata in South Dakota BCR 17 for 2017.

Species	Stratum	D	%CV	n
American Crow	SD-BCR17-ON	0.471	45	11
	SD-RANCH-SU	0.444	78	5
	SD-RANCH-TT	2.102	40	23
American Goldfinch	SD-BCR17-ON	7.496	42	11
	SD-RANCH-GU	1.607	54	2

Species	Stratum	D	%CV	n
American Goldfinch, cont.	SD-RANCH-SU	9.708	44	10
	SD-RANCH-TT	33.415	46	30
American Kestrel	SD-RANCH-AU	0.206	95	1
	SD-RANCH-GU	0.799	63	4
	SD-RANCH-SU	0.877	101	4
	SD-RANCH-TT	0.692	40	3
American Robin	SD-BCR17-ON	3.654	107	9
	SD-RANCH-SU	4.206	49	8
	SD-RANCH-TT	1.106	60	2
Bank Swallow	SD-RANCH-SU	1.886	101	1
Baltimore Oriole	SD-RANCH-TT	0.731	95	1
Barn Swallow	SD-BCR17-ON	3.543	91	2
	SD-RANCH-AU	2.153	96	1
	SD-RANCH-SU	2.294	108	1
	SD-RANCH-TT	4.826	62	2
Black-billed Magpie	SD-BCR17-ON	0.639	94	6
	SD-RANCH-AU	0.555	95	5
	SD-RANCH-SU	0.355	68	2
	SD-RANCH-TT	0.124	104	1
Black-capped Chickadee	SD-BCR17-ON	3.514	71	5
	SD-RANCH-AU	3.417	95	1
	SD-RANCH-SU	3.641	52	4
	SD-RANCH-TT	5.744	61	6
Bell's Vireo	SD-BCR17-ON	2.584	95	6
	SD-RANCH-TT	7.625	53	13
Blue-gray Gnatcatcher	SD-RANCH-AU	2.056	95	1
	SD-RANCH-SU	8.763	63	4
	SD-RANCH-TT	20.738	87	9
Brown-headed Cowbird	SD-BCR17-ON	78.023	25	106
	SD-RANCH-AU	17.738	39	17
	SD-RANCH-GU	47.653	10	48
	SD-RANCH-SU	17.447	33	21
	SD-RANCH-TT	80.278	19	67
Black-headed Grosbeak	SD-RANCH-SU	0.717	101	2
Blue Grosbeak	SD-BCR17-ON	1.567	74	7
	SD-RANCH-GU	1.320	60	5
	SD-RANCH-TT	6.099	37	20
Blue Jay	SD-BCR17-ON	0.987	94	3
	SD-RANCH-SU	0.852	102	2
	SD-RANCH-TT	2.241	82	5
Bobolink	SD-BCR17-ON	2.177	92	5
	SD-RANCH-GU	1.833	70	4
	SD-RANCH-TT	0.847	104	2
Brewer's Blackbird	SD-RANCH-GU	2.125	96	2

Species	Stratum	D	%CV	n
Brewer's Sparrow	SD-RANCH-AU	1.520	95	2
	SD-RANCH-SU	0.810	101	1
Brown Thrasher	SD-BCR17-ON	3.959	66	8
	SD-RANCH-GU	0.584	112	1
	SD-RANCH-TT	2.696	75	4
Bullock's Oriole	SD-RANCH-SU	2.585	102	4
Burrowing Owl	SD-RANCH-SU	0.370	93	3
Chestnut-collared Longspur	SD-BCR17-ON	8.233	99	19
	SD-RANCH-TT	2.804	72	5
Cedar Waxwing	SD-BCR17-ON	4.495	94	2
	SD-RANCH-TT	8.163	77	2
Chipping Sparrow	SD-BCR17-ON	1.042	107	1
	SD-RANCH-SU	13.499	76	10
	SD-RANCH-TT	7.099	99	5
Cliff Swallow	SD-RANCH-GU	7.871	70	4
	SD-RANCH-TT	190.948	59	26
Common Grackle	SD-BCR17-ON	5.992	78	6
	SD-RANCH-GU	4.038	96	3
Common Nighthawk	SD-BCR17-ON	0.770	48	4
	SD-RANCH-AU	3.043	28	13
	SD-RANCH-GU	0.681	101	3
	SD-RANCH-TT	6.033	52	20
Common Yellowthroat	SD-RANCH-TT	1.141	95	2
Dickcissel	SD-BCR17-ON	17.826	92	52
	SD-RANCH-GU	0.397	107	1
	SD-RANCH-TT	33.900	53	74
Downy Woodpecker	SD-BCR17-ON	1.806	109	2
	SD-RANCH-SU	3.508	71	3
Eastern Bluebird	SD-BCR17-ON	0.313	95	1
	SD-RANCH-SU	2.024	81	5
Eastern Kingbird	SD-BCR17-ON	4.973	37	11
	SD-RANCH-GU	7.462	43	14
	SD-RANCH-SU	10.538	49	18
	SD-RANCH-TT	5.542	45	9
European Starling	SD-BCR17-ON	0.642	105	1
	SD-RANCH-GU	0.757	96	1
Field Sparrow	SD-BCR17-ON	3.414	49	25
	SD-RANCH-TT	11.627	49	65
Great Blue Heron	SD-RANCH-GU	0.125	96	1
Great Crested Flycatcher	SD-RANCH-TT	1.270	65	3
Great Horned Owl	SD-RANCH-GU	0.391	110	1
Gray Catbird	SD-RANCH-TT	1.216	97	1
Grasshopper Sparrow	SD-BCR17-ON	101.245	34	111
	SD-RANCH-AU	29.932	41	27

Species	Stratum	D	%CV	n
Grasshopper Sparrow, cont.	SD-RANCH-GU	27.963	33	26
	SD-RANCH-SU	17.719	63	15
	SD-RANCH-TT	141.630	25	114
Hairy Woodpecker	SD-RANCH-SU	1.839	68	2
	SD-RANCH-TT	0.967	95	1
House Finch	SD-RANCH-AU	1.719	95	2
	SD-RANCH-TT	6.743	95	2
Horned Lark	SD-BCR17-ON	15.670	79	28
	SD-RANCH-AU	19.045	45	26
	SD-RANCH-GU	3.079	61	4
	SD-RANCH-SU	1.353	56	2
	SD-RANCH-TT	7.826	56	11
House Wren	SD-BCR17-ON	5.703	69	9
	SD-RANCH-AU	2.311	95	3
	SD-RANCH-GU	17.933	29	24
	SD-RANCH-SU	13.131	66	16
	SD-RANCH-TT	14.674	73	17
Killdeer	SD-BCR17-ON	1.241	87	5
	SD-RANCH-AU	0.603	64	2
	SD-RANCH-GU	1.463	31	5
	SD-RANCH-SU	1.929	74	5
	SD-RANCH-TT	0.676	64	2
Lark Bunting	SD-BCR17-ON	6.216	73	28
	SD-RANCH-GU	8.376	63	32
	SD-RANCH-TT	0.302	99	1
Lark Sparrow	SD-BCR17-ON	7.027	73	12
	SD-RANCH-AU	33.506	33	46
	SD-RANCH-GU	0.637	95	1
	SD-RANCH-SU	41.304	42	56
	SD-RANCH-TT	40.495	50	51
Long-billed Curlew	SD-BCR17-ON	0.341	86	6
	SD-RANCH-AU	0.069	95	1
Loggerhead Shrike	SD-BCR17-ON	0.217	94	1
	SD-RANCH-GU	0.256	96	1
	SD-RANCH-TT	0.296	100	1
Mallard	SD-BCR17-ON	0.457	110	1
	SD-RANCH-TT	0.623	102	1
Mountain Bluebird	SD-BCR17-ON	1.904	90	3
	SD-RANCH-AU	1.157	95	2
	SD-RANCH-SU	2.466	55	4
	SD-RANCH-TT	7.781	72	12
Mourning Dove	SD-BCR17-ON	10.560	27	63
	SD-RANCH-AU	9.248	15	38
	SD-RANCH-GU	10.620	13	52

Species	Stratum	D	%CV	n
Mourning Dove, cont.	SD-RANCH-SU	5.430	37	24
	SD-RANCH-TT	15.441	25	72
Northern Bobwhite	SD-RANCH-TT	0.968	100	6
Northern Flicker	SD-BCR17-ON	0.205	90	1
	SD-RANCH-AU	0.748	95	3
	SD-RANCH-GU	3.144	66	13
	SD-RANCH-SU	6.640	73	24
	SD-RANCH-TT	0.838	64	3
Northern Rough-winged Swallow	SD-BCR17-ON	2.068	92	1
	SD-RANCH-SU	2.678	103	1
	SD-RANCH-TT	98.564	52	17
Orchard Oriole	SD-BCR17-ON	1.474	96	2
	SD-RANCH-GU	20.851	41	24
	SD-RANCH-SU	2.863	103	3
	SD-RANCH-TT	8.029	56	8
Plumbeous Vireo	SD-RANCH-SU	0.465	101	1
Rose-breasted Grosbeak	SD-RANCH-TT	1.892	104	2
Red-breasted Nuthatch	SD-RANCH-AU	2.220	95	2
Red Crossbill	SD-RANCH-AU	10.228	95	3
	SD-RANCH-SU	10.217	80	5
Red-eyed Vireo	SD-RANCH-TT	0.638	104	1
Red-headed Woodpecker	SD-RANCH-GU	0.310	54	2
	SD-RANCH-SU	1.021	64	6
	SD-RANCH-TT	1.969	84	10
Ring-neck Pheasant	SD-BCR17-ON	1.643	48	35
	SD-RANCH-AU	0.057	101	1
	SD-RANCH-GU	0.332	33	6
Rock Pigeon	SD-RANCH-GU	0.468	102	1
Rock Wren	SD-BCR17-ON	0.464	90	3
	SD-RANCH-AU	0.563	95	3
	SD-RANCH-SU	2.802	63	14
	SD-RANCH-TT	4.630	69	19
Red-tailed Hawk	SD-BCR17-ON	0.326	64	3
	SD-RANCH-GU	0.641	99	5
	SD-RANCH-SU	0.845	75	6
	SD-RANCH-TT	0.296	106	2
Red-winged Blackbird	SD-BCR17-ON	8.111	30	23
	SD-RANCH-AU	0.822	64	2
	SD-RANCH-GU	7.970	23	20
	SD-RANCH-SU	1.313	59	3
	SD-RANCH-TT	18.413	33	40
Say's Phoebe	SD-RANCH-GU	0.206	96	1
	SD-RANCH-TT	6.190	44	26
Spotted Towhee	SD-BCR17-ON	16.725	48	33

Species	Stratum	D	%CV	n
Spotted Towhee	SD-RANCH-SU	6.564	42	10
	SD-RANCH-TT	26.922	39	38
Sharp-tailed Grouse	SD-RANCH-TT	1.943	75	5
Tree Swallow	SD-RANCH-GU	28.784	42	10
	SD-RANCH-TT	3.325	108	1
Upland Sandpiper	SD-BCR17-ON	4.165	36	35
	SD-RANCH-AU	0.289	101	2
	SD-RANCH-GU	5.052	41	35
	SD-RANCH-SU	0.462	60	3
	SD-RANCH-TT	1.783	52	11
Vesper Sparrow	SD-BCR17-ON	2.400	105	10
	SD-RANCH-AU	12.250	30	42
	SD-RANCH-SU	3.108	43	10
Violet-green Swallow	SD-RANCH-TT	1.640	100	1
Warbling Vireo	SD-RANCH-GU	0.677	95	1
	SD-RANCH-SU	0.744	101	1
	SD-RANCH-TT	0.782	95	1
White-breasted Nuthatch	SD-BCR17-ON	1.110	107	2
	SD-RANCH-TT	0.756	95	1
Western Kingbird	SD-RANCH-GU	10.425	38	18
	SD-RANCH-SU	3.616	55	6
Western Meadowlark	SD-BCR17-ON	35.258	12	269
	SD-RANCH-AU	35.217	17	214
	SD-RANCH-GU	20.711	9	137
	SD-RANCH-SU	24.741	13	147
	SD-RANCH-TT	42.610	26	230
Western Wood-Pewee	SD-RANCH-AU	0.713	95	2
	SD-RANCH-SU	7.219	41	19
Yellow-breasted Chat	SD-BCR17-ON	0.339	93	1
	SD-RANCH-SU	0.877	101	2
	SD-RANCH-TT	14.293	44	31
Yellow-billed Cuckoo	SD-RANCH-TT	0.767	107	2
Yellow Warbler	SD-BCR17-ON	4.880	93	8
	SD-RANCH-GU	9.350	26	13
	SD-RANCH-SU	3.950	101	5
	SD-RANCH-TT	0.831	104	1

We detected 117 bird species on Audubon-affiliated ranch strata in Wyoming BCR 17 in 2017, and produced estimates for 88 of those species. We then compared these estimates to estimates from SD-BCR17-ON, All other Lands in Wyoming BCR 17 (Table 8). This stratum represents lands not owned by the Bureau of Land Management, National Park Service, U.S. Forest Service, and U.S. Fish and Wildlife Service in BCR 17 in Wyoming. We selected this stratum for comparison because of the geographic overlap between it and the ranch stratum. Not all species detected in the ranch stratum were detected in the background stratum, and therefore were not available for comparison. We were unable to produce estimates for some

species that were detected either because there were not enough detections, or because they could not be included for analysis for other reasons. Densities for some grassland birds were higher on Audubon-affiliated ranch strata than surround lands. These species included Grasshopper Sparrow, Horned Lark, Lark Bunting, Western Meadowlark, and Loggerhead Shrike.

Table 8. Estimated densities per km^2 (D), percent coefficient of variation of estimates (% CV), and number of independent detections used in analyses (n) of breeding birds in Audubon conservation ranch strata and selected background strata in Wyoming BCR 17 for 2017.

Species	Stratum	D	%CV	n
American Crow	WY-BCR17-AO	0.074	56	3
	WY-RANCH-DH	0.946	70	15
	WY-RANCH-FI	0.068	62	2
	WY-RANCH-PE	0.040	101	1
	WY-RANCH-RI	0.033	99	1
American Goldfinch	WY-BCR17-AO	3.511	68	9
	WY-RANCH-DH	19.001	34	23
	WY-RANCH-FI	1.077	62	2
	WY-RANCH-RO	0.605	107	1
American Kestrel	WY-BCR17-AO	0.194	99	2
	WY-RANCH-DH	0.590	48	3
	WY-RANCH-FI	1.606	34	12
	WY-RANCH-PE	0.315	67	2
	WY-RANCH-RI	0.257	99	2
	WY-RANCH-RO	0.150	96	1
American Redstart	WY-RANCH-FI	1.550	68	2
American Robin	WY-BCR17-AO	7.205	60	31
	WY-RANCH-DH	12.735	66	27
	WY-RANCH-FI	2.245	69	7
Bald Eagle	WY-BCR17-AO	0.070	102	1
	WY-RANCH-DH	0.143	101	1
Barn Swallow	WY-BCR17-AO	1.014	98	1
	WY-RANCH-DH	4.117	101	1
	WY-RANCH-PE	3.293	99	1
	WY-RANCH-RI	2.692	100	2
	WY-RANCH-RO	4.718	97	3
Black-billed Magpie	WY-BCR17-AO	1.045	74	16
	WY-RANCH-DH	0.424	72	4
	WY-RANCH-FI	0.937	28	13
	WY-RANCH-PE	0.170	60	2
	WY-RANCH-RE	0.386	82	3
Black-capped Chickadee	WY-BCR17-AO	1.609	77	3
	WY-RANCH-DH	13.065	48	15
Blue-gray Gnatcatcher	WY-RANCH-DH	1.965	110	1
	WY-RANCH-FI	1.336	98	1

Species	Stratum	D	%CV	n
Blue-gray Gnatcatcher, cont.	WY-RANCH-RE	1.193	100	1
Brown-headed Cowbird	WY-BCR17-AO	19.280	43	51
	WY-RANCH-DH	14.347	42	22
	WY-RANCH-FI	3.104	69	7
	WY-RANCH-PE	4.174	102	5
	WY-RANCH-RE	3.167	86	7
	WY-RANCH-RI	2.132	51	5
	WY-RANCH-RO	5.481	34	11
Black-headed Grosbeak	WY-RANCH-DH	0.643	60	2
	WY-RANCH-FI	0.656	105	3
	WY-RANCH-RE	0.195	100	1
Blue Jay	WY-RANCH-FI	0.520	106	2
Brewer's Blackbird	WY-BCR17-AO	15.988	59	25
	WY-RANCH-DH	4.187	67	3
	WY-RANCH-FI	6.406	41	8
	WY-RANCH-PE	20.096	49	14
	WY-RANCH-RE	19.700	65	15
	WY-RANCH-RI	2.737	51	4
	WY-RANCH-RO	11.996	70	10
Brewer's Sparrow	WY-BCR17-AO	35.086	35	97
	WY-RANCH-DH	23.977	51	32
	WY-RANCH-FI	11.857	105	24
	WY-RANCH-PE	8.137	64	14
	WY-RANCH-RE	41.025	37	89
	WY-RANCH-RI	56.532	23	116
	WY-RANCH-RO	101.033	23	173
Brown Thrasher	WY-RANCH-FI	0.391	104	1
	WY-RANCH-PE	1.840	68	4
Bullock's Oriole	WY-BCR17-AO	0.857	75	3
	WY-RANCH-DH	2.319	73	4
	WY-RANCH-FI	3.154	54	7
	WY-RANCH-PE	0.464	101	1
	WY-RANCH-RE	1.056	71	3
	WY-RANCH-RI	1.516	100	4
Burrowing Owl	WY-RANCH-PE	0.089	106	1
Canada Goose	WY-BCR17-AO	0.328	84	4
	WY-RANCH-DH	0.208	96	4
	WY-RANCH-FI	0.028	99	1
	WY-RANCH-RE	0.910	56	9
Chestnut-collared Longspur	WY-RANCH-RO	1.096	96	2
Clay-colored Sparrow	WY-RANCH-RE	0.370	100	1
	WY-RANCH-RI	1.194	68	3
Cedar Waxwing	WY-BCR17-AO	6.004	100	4
	WY-RANCH-DH	5.222	73	3

Species	Stratum	D	%CV	n
Chipping Sparrow	WY-BCR17-AO	3.580	83	6
	WY-RANCH-DH	24.219	39	20
	WY-RANCH-RE	7.352	65	9
	WY-RANCH-RO	2.776	64	3
Cliff Swallow	WY-BCR17-AO	1.911	66	2
	WY-RANCH-RO	4.444	97	2
Common Grackle	WY-BCR17-AO	4.411	100	8
	WY-RANCH-FI	4.734	77	7
	WY-RANCH-RO	0.760	107	1
Common Nighthawk	WY-BCR17-AO	0.441	79	4
	WY-RANCH-FI	0.152	105	1
	WY-RANCH-PE	1.074	98	6
	WY-RANCH-RE	0.951	100	7
	WY-RANCH-RO	0.342	67	2
Common Raven	WY-BCR17-AO	0.224	80	10
	WY-RANCH-DH	0.045	100	1
	WY-RANCH-RO	0.035	96	1
Common Yellowthroat	WY-BCR17-AO	2.159	68	9
	WY-RANCH-DH	0.487	96	1
Eastern Kingbird	WY-BCR17-AO	3.623	52	10
	WY-RANCH-DH	3.151	80	6
	WY-RANCH-FI	9.285	46	23
	WY-RANCH-PE	0.840	101	1
	WY-RANCH-RE	0.957	70	3
	WY-RANCH-RI	2.404	71	7
Eurasian Collared-Dove	WY-BCR17-AO	2.074	90	8
	WY-RANCH-PE	0.374	99	1
European Starling	WY-BCR17-AO	2.938	100	7
	WY-RANCH-DH	14.908	52	7
	WY-RANCH-FI	49.166	46	39
	WY-RANCH-PE	4.771	59	3
	WY-RANCH-RE	0.453	100	1
Field Sparrow	WY-RANCH-DH	0.153	105	1
Great Blue Heron	WY-BCR17-AO	0.061	101	1
	WY-RANCH-DH	0.494	79	3
Great Horned Owl	WY-BCR17-AO	0.190	113	1
	WY-RANCH-FI	0.524	87	2
	WY-RANCH-RE	0.234	114	1
Golden Eagle	WY-BCR17-AO	0.175	82	3
	WY-RANCH-FI	0.081	106	1
	WY-RANCH-RE	0.288	107	2
Gray Flycatcher	WY-BCR17-AO	1.016	99	2
	WY-RANCH-DH	3.092	73	3
Grasshopper Sparrow	WY-BCR17-AO	4.699	58	9

Species	Stratum	D	%CV	n
Grasshopper Sparrow	WY-RANCH-DH	34.969	94	33
	WY-RANCH-FI	4.323	55	6
	WY-RANCH-PE	4.239	64	5
	WY-RANCH-RE	7.077	62	11
	WY-RANCH-RI	50.579	45	73
	WY-RANCH-RO	49.388	33	61
Hairy Woodpecker	WY-RANCH-DH	1.650	68	2
	WY-RANCH-FI	1.122	68	2
Horned Lark	WY-BCR17-AO	11.661	49	39
	WY-RANCH-DH	4.248	94	7
	WY-RANCH-FI	46.215	34	109
	WY-RANCH-PE	36.409	44	70
	WY-RANCH-RE	23.211	39	61
	WY-RANCH-RI	15.077	26	36
	WY-RANCH-RO	32.455	15	66
House Wren	WY-BCR17-AO	3.265	88	9
	WY-RANCH-DH	24.295	47	33
	WY-RANCH-FI	4.506	105	9
Killdeer	WY-BCR17-AO	1.137	67	8
	WY-RANCH-DH	0.288	110	1
	WY-RANCH-FI	0.392	99	2
	WY-RANCH-PE	0.923	101	4
	WY-RANCH-RE	2.276	77	9
	WY-RANCH-RI	2.828	72	13
	WY-RANCH-RO	1.102	55	5
Lark Bunting	WY-BCR17-AO	24.653	43	182
	WY-RANCH-DH	14.442	76	49
	WY-RANCH-FI	13.503	49	66
	WY-RANCH-PE	33.630	45	138
	WY-RANCH-RE	35.230	41	188
	WY-RANCH-RI	45.360	36	248
	WY-RANCH-RO	55.567	12	262
Lark Sparrow	WY-BCR17-AO	3.713	73	9
	WY-RANCH-DH	16.956	46	24
	WY-RANCH-FI	2.135	64	5
	WY-RANCH-PE	3.517	21	7
	WY-RANCH-RE	14.870	48	35
	WY-RANCH-RI	13.550	44	29
Lazuli Bunting	WY-BCR17-AO	2.769	89	9
	WY-RANCH-DH	0.624	100	1
Long-billed Curlew	WY-RANCH-RO	0.050	107	1
Loggerhead Shrike	WY-BCR17-AO	0.498	44	4
	WY-RANCH-DH	0.253	100	1
	WY-RANCH-FI	1.546	56	9

Species	Stratum	D	%CV	n
Loggerhead Shrike, cont.	WY-RANCH-PE	2.425	33	12
	WY-RANCH-RE	1.380	42	8
	WY-RANCH-RO	0.193	107	1
Mallard	WY-BCR17-AO	0.524	103	1
	WY-RANCH-PE	2.976	76	4
	WY-RANCH-RE	1.291	69	3
	WY-RANCH-RI	1.042	72	2
McCown's Longspur	WY-BCR17-AO	0.461	99	1
	WY-RANCH-RI	2.753	105	9
Mountain Bluebird	WY-BCR17-AO	1.908	99	7
	WY-RANCH-DH	12.167	29	21
	WY-RANCH-FI	0.376	98	1
Mourning Dove	WY-BCR17-AO	1.333	36	15
	WY-RANCH-DH	4.330	32	24
	WY-RANCH-FI	11.164	21	87
	WY-RANCH-PE	6.062	39	39
	WY-RANCH-RE	4.710	21	36
	WY-RANCH-RI	2.359	42	20
	WY-RANCH-RO	1.103	67	5
Northern Flicker	WY-BCR17-AO	0.470	56	4
	WY-RANCH-DH	2.859	41	12
	WY-RANCH-FI	6.967	49	40
	WY-RANCH-PE	0.191	101	1
	WY-RANCH-RE	0.868	70	5
	WY-RANCH-RI	0.312	63	2
Northern Harrier	WY-BCR17-AO	0.271	44	4
	WY-RANCH-FI	0.094	99	1
Northern Pintail	WY-RANCH-RO	0.442	97	1
Northern Rough-winged Swallow	WY-BCR17-AO	1.184	105	1
.	WY-RANCH-FI	3.267	100	1
Orchard Oriole	WY-RANCH-DH	0.856	98	1
	WY-RANCH-FI	1.746	70	3
Osprey	WY-RANCH-DH	0.203	96	2
Ovenbird	WY-BCR17-AO	0.364	100	2
	WY-RANCH-DH	0.739	105	2
Pinyon Jay	WY-RANCH-RE	0.651	102	4
Plumbeous Vireo	WY-RANCH-DH	0.417	105	1
Prairie Falcon	WY-RANCH-RE	0.138	104	1
	WY-RANCH-RI	0.149	103	1
Ring-billed Gull	WY-RANCH-DH	1.538	98	2
Red-breasted Nuthatch	WY-BCR17-AO	1.045	100	3
	WY-RANCH-DH	3.536	53	5
Red Crossbill	WY-RANCH-DH	23.831	77	11
	WY-RANCH-RE	1.113	100	1

Species	Stratum	D	%CV	n
Red-headed Woodpecker	WY-RANCH-FI	1.246	38	12
	WY-RANCH-PE	0.244	101	2
Rock Pigeon	WY-RANCH-DH	1.846	65	2
Rock Wren	WY-BCR17-AO	1.592	66	18
	WY-RANCH-DH	1.077	66	6
	WY-RANCH-FI	0.732	80	6
	WY-RANCH-RE	0.436	75	4
Red-tailed Hawk	WY-BCR17-AO	0.062	101	1
	WY-RANCH-DH	0.632	91	5
	WY-RANCH-FI	0.430	49	4
	WY-RANCH-RE	0.230	103	2
Red-winged Blackbird	WY-BCR17-AO	6.191	51	29
	WY-RANCH-DH	2.356	80	3
	WY-RANCH-FI	10.413	40	39
	WY-RANCH-PE	7.539	28	23
	WY-RANCH-RE	1.907	52	8
	WY-RANCH-RI	6.675	90	24
	WY-RANCH-RO	0.300	96	1
Say's Phoebe	WY-BCR17-AO	0.100	97	1
	WY-RANCH-DH	0.203	96	1
	WY-RANCH-PE	0.325	98	2
	WY-RANCH-RE	0.740	54	6
	WY-RANCH-RI	0.797	99	5
Sage Thrasher	WY-BCR17-AO	0.300	45	5
	WY-RANCH-FI	0.662	105	8
	WY-RANCH-RE	0.591	75	8
	WY-RANCH-RI	0.716	56	9
	WY-RANCH-RO	1.208	70	13
Song Sparrow	WY-RANCH-PE	0.439	102	1
Spotted Towhee	WY-BCR17-AO	4.642	70	16
	WY-RANCH-DH	5.888	62	10
Swainson's Hawk	WY-RANCH-RI	0.054	99	1
Swainson's Thrush	WY-RANCH-PE	0.383	100	1
Tree Swallow	WY-RANCH-FI	1.929	110	1
	WY-RANCH-RI	1.854	104	1
Turkey Vulture	WY-RANCH-DH	1.718	77	3
	WY-RANCH-FI	1.168	103	2
Upland Sandpiper	WY-BCR17-AO	0.613	81	9
	WY-RANCH-DH	0.415	94	3
	WY-RANCH-FI	0.470	77	5
	WY-RANCH-RI	1.175	67	13
Vesper Sparrow	WY-BCR17-AO	10.166	32	74
	WY-RANCH-DH	11.988	33	42
	WY-RANCH-RE	4.570	62	27

Species	Stratum	D	%CV	n
Vesper Sparrow, cont.	WY-RANCH-RI	8.932	39	49
	WY-RANCH-RO	7.668	24	36
Violet-green Swallow	WY-RANCH-DH	19.580	51	11
White-breasted Nuthatch	WY-RANCH-DH	0.645	96	1
Western Kingbird	WY-RANCH-FI	6.249	51	15
	WY-RANCH-PE	5.190	55	7
	WY-RANCH-RE	4.923	93	12
	WY-RANCH-RI	3.535	48	8
	WY-RANCH-RO	0.413	107	1
Western Meadowlark	WY-BCR17-AO	33.836	20	452
	WY-RANCH-DH	35.897	30	241
	WY-RANCH-FI	62.190	6	612
	WY-RANCH-PE	51.716	8	425
	WY-RANCH-RE	50.191	10	543
	WY-RANCH-RI	59.603	10	599
	WY-RANCH-RO	44.384	6	387
Western Wood-Pewee	WY-BCR17-AO	0.672	67	4
	WY-RANCH-DH	6.476	41	19
	WY-RANCH-FI	1.159	84	5
Wild Turkey	WY-BCR17-AO	0.077	68	3
	WY-RANCH-DH	0.312	71	7
White-throated Swift	WY-RANCH-DH	1.952	103	1
Yellow-breasted Chat	WY-BCR17-AO	0.388	100	2
	WY-RANCH-FI	0.267	99	1
Yellow Warbler	WY-BCR17-AO	1.048	100	3
	WY-RANCH-DH	6.378	85	9
	WY-RANCH-FI	9.156	55	19
Yellow-rumped Warbler	WY-RANCH-DH	4.040	77	5

DISCUSSION

Analysis of Overlay Projects

Auxiliary, or "overlay", projects , such as the Audubon sustainable ranching initiative bird monitoring discussed in this report, are a growing component of the IMBCR program. They utilize the IMBCR sampling design and field methods but are not integrated into the nested stratification of the IMBCR program. 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. Overlay projects benefit from the IMBCR program by incorporating detection data from relevant IMBCR surveys in their analyses.

In addition, utilizing the IMBCR design allows the overlay's species population estimates to be placed in a regional context. Comparing 2017 Audubon ranch data to their surrounding areas yields some interesting insights. In North Dakota, surveyed Audubon-affiliated ranches had 2.4 times higher densities of Western Meadowlarks than surrounding areas, 3.5 times higher densities of Upland Sandpipers, 2.2 times higher densities of Grasshopper Sparrows, and 22.2 times higher densities of Chestnut-collared Longspurs. This suggests that Audubon-affiliated ranches in North Dakota are islands of high quality grasslands very important to many declining grassland bird species in a sea of cropland (Dyke et al 2015). Surveyed Audubon-affiliated ranches in Wyoming also appear to be important to grassland species, with higher densities of Grasshopper Sparrows, Horned Larks, Lark Buntings, Western Meadowlarks, and Loggerhead Shrikes compared to the surrounding region. In contrast, 2017 densities of grassland species on South Dakota Audubon-affiliated ranches were approximately equal to those of the surrounding region. This is not surprising as a high percentage of western South Dakota is still grasslands and the area has some of the most extensive intact tracts of grasslands in the region (World Wildlife Fund 2017). The comparisons could be improved by post-stratifying the IMBCR regional data by habitat type or conducting analyses that include habitat covariates, which may provide more insight into differences among species, years, and treatments.

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. For example, in the discussion above we compared density estimates from Audubon-affiliated ranch strata to regional estimates. In some cases, this showed that densities for species of interest were higher on ranch strata versus regional background strata, and in some cases densities for species of interest were not appreciably different than background strata. In addition to making these regional comparisons, other opportunities exist to use IMBCR overlay data to inform bird conservation:

1) 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;
2) 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;

3) 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. For example, were data for Audubon-affiliated ranches analyzed outside of the IMBCR multi-scale density and occupancy models, estimates would have been produced for only 30 and 75 species for density and occupancy, respectively. 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.

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