Avian Monitoring On Colorado State Land Board's Lowry Range: 2012 Interim Report

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ROCKY MOUNTAIN BIRD OBSERVATORY

***Mission**: To conserve birds and their habitats*

***Vision**: Native bird populations are sustained in healthy ecosystems*

***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.*

RMBO accomplishes its mission by:

- ***Monitoring** long-term bird population trends to provide a scientific foundation for conservation action.*
- ***Researching** bird ecology and population response to anthropogenic and natural processes to evaluate and adjust management and conservation strategies using the best available science.*
- ***Educating** people of all ages through active, experiential programs that create an awareness and appreciation for birds.*
- ***Fostering** good stewardship on private and public lands through voluntary, cooperative partnerships that create win-win situations for wildlife and people.*
- ***Partnering** with state and federal natural resource agencies, private citizens, schools, universities and other non-governmental organizations to build synergy and consensus for bird conservation.*
- ***Sharing** the latest information on bird populations, land management and conservation practices to create informed publics.*
- ***Delivering** bird conservation at biologically relevant scales by working across political and jurisdictional boundaries in western North America.*

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EXECUTIVE SUMMARY

Rocky Mountain Bird Observatory (RMBO), in conjunction with the Colorado State Land Board, conducted landbird monitoring throughout the Lowry Range parcel located near Denver, CO in 2012. This project used a spatially balanced sampling design and a survey protocol implemented in portions of 12 states as part of a program entitled "Integrated Monitoring in Bird Conservation Regions" (IMBCR). The IMBCR design allows inferences to 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 the Lowry Range can be compared to nearby regional estimates to determine whether avian populations within the Lowry Range are similar to regional populations. We used regional population estimates for the Colorado portion of BCR 18 (shortgrass prairie) as the region for comparison in this report.

In 2012, RMBO completed 16 planned surveys, resulting in 243 point counts conducted. Surveys on the Lowry Range were conducted between 23 May and 2 June. Field technicians observed 2,623 individuals of 54 bird species during the 16 surveys. Using the RIMBCR package for Progarm R designed by Paul Lukacs, we estimated densities of 111 species occurring in the Colorado portion of BCR18 and/or on the Lowry Range, including 24 priority species as designated by Partner's In Flight. The data yielded robust density estimates (CV < 50%) for 28 species. Results presented in this interim report were derived using detection data collected in 2012. The annual report, which will produced in the near future, will reflect density estimates produced using multiple years of data to increase the number of species for which density estimates can be reported. Additionally, RMBO will include occupancy and species richness estimates for both the Lowry Range and the Colorado portion of BCR18 in the annual report.

The IMBCR study design allows the estimation of density, population size and occupancy rates for individual strata or biologically meaningful combinations of strata. Interactive maps showing survey and detection locations, species counts, and density, population and occupancy estimates will be made available in the annual report and on RMBO's Avian Data Center at http://rmbo.org/v3/avian/ExploretheData.aspx. Instructions for using the Avian Data Center are included in Appendix A of this report and are available on the Avian Data Center itself.

Data were collectively analyzed across the entire IMBCR sampling frame. Increasing the spatial extent of the analysis enabled us to quantify geographic variation in detection probabilities and will increase the precision of occupancy estimates produced in the future. This approach allowed us to estimate common detection probabilities for species that would have otherwise had an insufficient number of detections at more local scales. Additionally, by utilizing a larger data set we obtained more accurate estimates of detection probability.

This spatially-balanced sampling design serves as a model for other long-term monitoring efforts because of its ability to address conservation and management needs of a wide range of stakeholders, landowners and government entities at local and regional scales. The IMBCR design represents one method for achieving effective collaboration in North American bird monitoring and could be applied to other Colorado State Land Board parcels and, with sampling on other Colorado State Land Board parcels, could be used to produce estimates for the entirety of Colorado State Land Board parcels.

ACKNOWLEDGEMENTS

Stratification and allocation of survey effort were determined in collaboration with the Colorado State Land Board (COSLB). Many individuals helped make the 2012 field season a success. We thank Mindy Gottsegen of the COSLB for obtaining funds to conduct this research. We acknowledge RMBO's IT personnel who managed and updated the RMBO database and produced a new data entry system. Rob Sparks of RMBO implemented the GRTS sample selection. Brittany Woiderski produced the sample allocation map for this report. We thank Paul Lukacs of the University of Montana who created the RIMBCR statistical package for Program R which was used to produce the multi-scale occupancy and density estimates. We also thank field technicians Chuck Aid and Nick Meyer for collecting the point count data in 2012. Finally, this report benefited from review by RMBO staff.

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INTRODUCTION

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

The apparent large-scale declines of avian populations and the loss, fragmentation and degradation of native habitats highlight the need for extensive and rigorous landbird monitoring programs (Rich et al. 2004, US North American Bird Conservation Initiative Committee 2009). As natural areas are developed, it is imperative for land managers to better understand the impacts subsequent landscape changes have on wildlife communities.

Before monitoring can be used by land managers to guide conservation efforts, sound program designs and analytic methods are necessary to produce unbiased population estimates (Sauer and Knutson 2008). At the most fundamental level, reliable knowledge about the status of avian populations requires accounting for spatial variation and incomplete detection of the target species (Pollock et al. 2002, Rosenstock et al. 2002, Thompson 2002). Addressing spatial variation entails 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 (Pollock et al. 2002, Thompson 2002).

In order to provide local land managers with unbiased and reliable information on avian communities within the Colorado State Land Board's Lowry Range, Rocky Mountain Bird Observatory (RMBO) utilized a probabilistic sampling design based on the "Integrated Monitoring in Bird Conservation Regions (IMBCR)" (White et al. 2012) design for this study. Important properties of the IMBCR design that relate to this study are:

- All vegetation types are available for sampling.
- Strata are based on fixed attributes; this will allow us to relate changes in bird populations to changes on the landscape through time.
- Local population estimates and trends can be directly compared to regional scales.
- Coordination among partners can reduce the costs of monitoring per partner.

Using the IMBCR design, RMBO'S monitoring objectives are to:

1. Provide a design framework to spatially integrate existing bird monitoring efforts in the region to provide better information on distribution and abundance of breeding landbirds, especially for high priority species;
2. Provide basic habitat association data for bird species to address habitat management issues;
3. Provide robust occupancy estimates that account for incomplete detection and are comparable at different geographic extents;
4. Maintain a high-quality database that is accessible to all of our collaborators as well as to the public over the internet, in the form of raw and summarized data.

By using the IMBCR design for avian monitoring on the Lowry Range, RMBO was able to use detections from approximately 1,200 samples throughout the inter-mountain west. This provided RMBO with additional detections for avian species which provided the statistical power to estimate densities of more species than would have otherwise been possible. Additionally, data collected under the IMBCR design was used to produce regional estimates for bird densities within the Colorado portion of BCR18 to provide a geographically appropriate regional comparison.

METHODS

Study Area

The study area was defined as the area contained by the State Land Board's Lowry Range boundary. The Lowry Range is located about 20 miles southeast of Metro Denver. It spans approximately 26,000 acres (approximately 105 km^2) and is composed of a mixture of shortgrass prairie, Piedmont tallgrass prairie, and riparian habitats. Because the Lowry Range lies within Bird Conservation Region 18 (shortgrass prairie) we have presented results for the Colorado portion of Bird Conservation Region 18 produced through the Integrated Monitoring in Bird Conservation Regions (IMBCR) program in 2012 for use as a regional comparison.

Sampling Design

Sampling Units

We defined sampling units as 1-km^2 cells, each containing 16 evenly-spaced sample points, 250 meters apart (Figure 1). The grid used to define the 1-km^2 cells was established for the IMBCR program by superimposing a uniform grid of cells over the entire state of Colorado, with a random starting point.

Sample Selection

Following the IMBCR design, we used generalized random-tessellation stratification (GRTS), a spatially balanced sampling algorithm, to select sample units (Stevens and Olsen 2004a) from with the study area Spatial data and sample cells were compiled and selected using ARCGIS 9.2 (ESRI 1999).

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 2004b).

- Incorporating information about spatial autocorrelation in the data can increase precision of density estimates;

- All sample cells in the sampling frame are ordered, such that any set of consecutively numbered units is a spatially-balanced sample (Stevens and Olsen 2004b). In the case of fluctuating budgets, we can adjust the sampling effort among years within each stratum while still preserving a random, spatially-balanced sampling design.

Based on available funding, RMBO conducted point counts at 16 and 81 individually selected sample cells on the Lowry Range and the Colorado portion of BCR18; respectively. This resulted in a total of 243 and 961 point counts on the Lowry Range and within the Colorado portion of BCR18. Figure 2 below illustrates the location of the sample cells and point count stations visited within the Lowry Range during the 2012 field season.

Figure 1. Image of an IMBCR 1-km2 sample cell containing 16 survey points arranged in a 4 X 4 matrix.

Sampling Methods

Surveyors with excellent aural and visual bird-identification skills conducted field work between May 23rd and June 2nd in 2012. Prior to conducting surveys, surveyors completed an intensive seven-day training program to ensure technicians had a complete understanding of field protocols and sufficient knowledge of bird identification. Surveyors attempted to collect data at all points within a sample cell each morning; however, not all 16 points were surveyed within every sample cell. Inclement weather, safety concerns because points were near a mining site, and decreased bird activity were the most common reasons for all 16 points not being surveyed during the sampling of Lowry Range sample cells.

We conducted point counts using a Distance sampling framework (Buckland et al. 2001) following protocol established by IMBCR partners (Hanni et al. 2011). Surveyors conducted avian counts in the morning, beginning ½-hour before sunrise and concluding no later than 10:30 AM. For every bird detected during the six-minute period, observers recorded the species, sex; horizontal distance from the observer; minute and type of detection (e.g., call, song, visual). Surveyors measured distances to each bird using laser rangefinders. When it was not possible to measure the distance to a bird, observers estimated the distance by measuring to some nearby object. Surveyors recorded birds flying over but not using the immediate surrounding landscape. While surveyors traveled between points within a sample 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 are used for the development of a species inventory for the Lowry Range and distribution mapping purposes only.

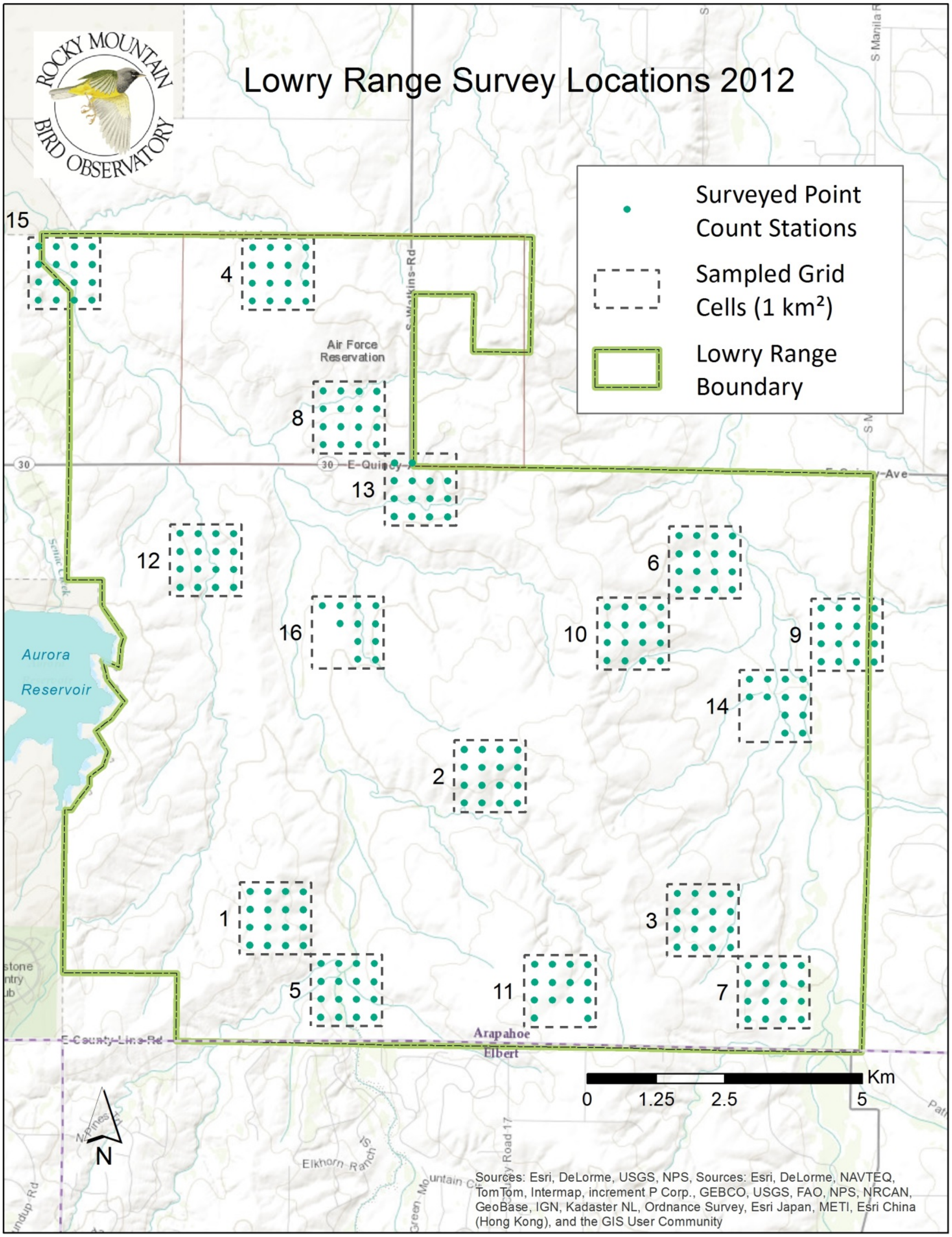

Figure 2. Sample cells and individual point count stations surveyed within the Lowry Range during the 2012 field season.

Surveyors 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. Surveyors 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, surveyors recorded time, ambient temperature, cloud cover, precipitation and wind speed. Surveyors navigated to each point using hand-held Global Positioning System (GPS) units. Before beginning each six-minute count, surveyors recorded vegetation data (within a 50 meter radius). Vegetation data included the dominant habitat type; structural stage and the relative abundance; percent cover and mean height of trees and shrubs by species; as well as grass height and ground cover types. Surveyors 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 RMBO's Field Protocol for Spatially Balanced Sampling of Landbird Populations on our Avian Data Center website: http://rmbo.org/v3/Portals/5/Protocols/2012%20Field_protocol_for_spacially_balanced_sampling_final.pdf.

Data Analysis

Distance Analysis

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

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 the data separately for each species. We attempted to estimate densities of all species detected within the Lowry Range and any of the strata comprising the Colorado portion of BCR18. 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, and birds detected between points from analyses.

We estimated bird densities using the new RIMBCR package in Program R (R Development Core Team 2013) developed by Paul Lukacs of the University of Montana. RIMBCR streamlined data analysis procedures we had previously completed in multiple steps. RIMBCR calls the raw data from the IMBCR SQL server database maintained by RMBO and returns final estimates to the database in tabular format. For each species, RIMBCR fit global detection functions. RIMBCR used Akaike's Information Criterion (AIC) corrected for small sample size (AIC_c) and model selection theory to select the most parsimonious detection function for each species (Burnham and Anderson 2002). RIMBCR incorporated the SPSURVEY package

(Kincaid 2008) in Program R to estimate density for each species. The SPSURVEY package uses spatial information from the survey locations to improve estimates of the variance of density. We computed density estimates for each stratum as well as for the aggregation of strata within the Colorado portion of BCR18. The Colorado portion of BCR18 estimates were calculated using an area-weighted mean.

RESULTS

We detected 2,623 individual birds during 243 point count surveys (10.79 individuals/point count) within the Lowry Range compared to 10,503 individual birds detected during 961 point count surveys (10.93 individuals/point count) conducted within the Colorado portion of BCR18. One or more individuals of 54 avian species were detected on the Lowry Range compared to 108 species which were detected within the Colorado portion of BCR18. Using the RIMBCR package RMBO was able to estimate densities of 111 species for the Lowry Range and/or the Colorado portion of BCR18 (Table 1). Of the 111 species for which density estimates were produced, 28 species are considered "priority species" by Partner's In Flight for BCR18. Robust estimates, with a percent coefficient of variance less than 50%, were produced for 18 and 28 species on the Lowry Range and Colorado portion of BCR18; respectively.

Table 1. Estimated densities of breeding bird species on the Lowry Range and the Colorado portion of BCR18, 2012. n = the number of independent detections; D = estimated densities per km^2 ; % CV = percent coefficient of variation of estimates; S = the number of sample units used in analyses. BCR18 priority species, as designated by Partner's In Flight, are bolded.

	Lowry Range (S=16)			Colorado-BCR18 (S=81)		
Species	**n**	**D**	**% CV**	**n**	**D**	**% CV**
American Avocet	0	0	0	41	0.06	71.69
American Coot	0	0	0	1	0.00	128.70
American Crow	0	0	0	17	0.05	67.19
American Goldfinch	1	0.22	101.58	54	0.25	40.42
American Kestrel	11	0.50	33.71	7	0.02	76.79
American Robin	14	2.19	36.33	215	3.19	39.74
American White Pelican	0	0	0	6	0.02	313.81
Ash-throated Flycatcher	0	0	0	9	0.06	61.96
Bank Swallow	25	7.95	104.78	10	0.07	110.92
Barn Swallow	12	4.60	66.77	111	10.54	53.54
Belted Kingfisher	0	0	0	1	0.00	107.32
Bewick's Wren	0	0	0	5	0.08	106.12
Black-billed Magpie	4	0.13	77.47	37	0.02	66.01
Black-capped Chickadee	0	0	0	25	0.25	65.12
Black-chinned Hummingbird	0	0	0	4	0.23	96.27
Black-headed Grosbeak	0	0	0	21	0.13	74.50
Blue Grosbeak	4	0.25	50.19	17	0.06	33.43
Blue Jay	6	0.70	106.73	34	0.13	67.55
Blue-gray Gnatcatcher	0	0	0	3	0.06	79.95
Blue-winged Teal	0	0	0	7	0.01	103.37
Bobolink	0	0	0	2	0.00	100.56

	Lowry Range (S=16)			Colorado-BCR18 (S=81)		
Species	**n**	**D**	**% CV**	**n**	**D**	**% CV**
Brewer's Blackbird	9	2.30	64.30	14	1.84	59.09
Brewer's Sparrow	0	0	0	22	0.81	61.29
Brown Thrasher	0	0	0	8	0.02	73.16
Brown-headed Cowbird	12	1.74	39.70	83	1.38	24.66
Bullock's Oriole	18	3.76	40.12	23	0.67	51.43
Burrowing Owl	1	0.02	107.17	5	0.03	65.90
Canada Goose	0	0	0	188	0.24	48.19
Canyon Towhee	0	0	0	6	0.01	66.08
Canyon Wren	0	0	0	2	0.00	100.80
Cassin's Kingbird	0	0	0	1	0.00	99.76
Cassin's Sparrow	4	0.30	77.55	301	4.31	29.99
Cedar Waxwing	0	0	0	13	0.08	92.03
Chihuahuan Raven	0	0	0	1	0.01	166.54
Chimney Swift	0	0	0	1	0.02	121.10
Chipping Sparrow	1	0.29	99.71	4	0.02	80.65
Cliff Swallow	21	10.02	91.35	442	6.68	37.20
Common Grackle	0	0	0	269	4.22	33.04
Common Nighthawk	9	0.72	42.78	10	0.05	37.34
Common Raven	0	0	0	13	0.03	65.17
Common Yellowthroat	0	0	0	46	0.29	99.81
Cooper's Hawk	0	0	0	1	0.01	107.69
Cordilleran Flycatcher	0	0	0	1	0.00	99.31
Dark-eyed Junco	0	0	0	1	0.09	103.43
Double-crested Cormorant	0	0	0	17	0.04	125.68
Downy Woodpecker	0	0	0	10	0.07	32.55
Eastern Bluebird	0	0	0	3	0.05	171.70
Eastern Kingbird	9	1.41	36.57	34	0.30	59.47
Eurasian Collared-Dove	0	0	0	73	0.35	35.66
European Starling	111	26.28	53.28	211	3.46	36.56
Grasshopper Sparrow	62	19.51	23.03	91	11.23	29.85
Gray Catbird	2	1.08	105.34	0	0	0
Great Blue Heron	0	0	0	7	0.01	104.20
Great Horned Owl	0	0	0	5	0.05	109.00
Greater Prairie-Chicken	0	0	0	5	0.07	591.98
Greater Roadrunner	0	0	0	1	0.00	107.47
Great-tailed Grackle	0	0	0	15	0.06	100.36
Green-tailed Towhee	0	0	0	2	0.01	99.19
Hairy Woodpecker	0	0	0	4	0.02	71.24
Horned Lark	374	69.97	16.60	1475	98.08	10.81
House Finch	0	0	0	126	2.44	66.88
House Sparrow	0	0	0	190	9.70	61.92
House Wren	12	2.81	46.81	88	1.15	54.75

	Lowry Range (S=16)			Colorado-BCR18 (S=81)		
Species	**n**	**D**	**% CV**	**n**	**D**	**% CV**
Indigo Bunting	1	0.20	103.90	12	0.12	102.51
Juniper Titmouse	0	0	0	3	0.02	78.83
Killdeer	7	0.91	53.94	68	1.51	50.74
Ladder-backed Woodpecker	0	0	0	1	0.00	101.52
Lark Bunting	342	68.10	47.90	1872	70.07	19.87
Lark Sparrow	13	1.99	36.96	135	3.82	26.09
Lazuli Bunting	0	0	0	3	0.02	53.81
Loggerhead Shrike	1	0.08	101.74	1	0.04	99.77
Long-billed Curlew	0	0	0	2	0.05	100.89
Mallard	10	0.52	57.60	76	0.28	46.25
Marsh Wren	0	0	0	2	0.03	103.46
McCown's Longspur	0	0	0	44	0.47	57.98
Mountain Plover	1	0.07	110.53	0	0	0
Mourning Dove	123	6.05	22.24	460	5.14	14.80
Northern Flicker	7	0.47	50.66	38	0.14	39.72
Northern Mockingbird	2	0.09	99.91	103	0.69	27.52
Northern Rough-winged Swallow	0	0	0	42	1.68	83.78
Orchard Oriole	2	0.54	70.98	0	0	0
Pine Siskin	0	0	0	8	0.06	70.85
Prairie Falcon	1	0.05	112.99	1	0.00	108.67
Red-tailed Hawk	8	0.26	43.90	21	0.08	65.48
Red-winged Blackbird	75	9.60	36.16	505	5.61	34.09
Ring-necked Pheasant	0	0	0	85	0.33	47.96
Rock Pigeon	3	0.29	104.46	79	0.32	56.61
Rock Wren	3	0.18	72.26	11	0.02	66.47
Rufous-crowned Sparrow	0	0	0	1	0.01	100.24
Savannah Sparrow	0	0	0	3	0.01	103.65
Say's Phoebe	0	0	0	19	0.18	43.79
Scaled Quail	0	0	0	3	0.02	79.10
Song Sparrow	0	0	0	44	0.17	40.21
Spotted Sandpiper	0	0	0	6	0.07	115.11
Spotted Towhee	0	0	0	15	0.14	62.57
Swainson's Hawk	5	0.28	77.00	11	0.14	70.99
Tree Swallow	1	0.37	100.87	18	0.14	73.42
Turkey Vulture	0	0	0	6	0.01	66.63
Upland Sandpiper	0	0	0	2	0.02	73.89
Vesper Sparrow	73	6.73	19.89	25	0.90	56.85
Violet-green Swallow	0	0	0	47	0.33	77.17
Warbling Vireo	0	0	0	1	0.00	93.34
Western Kingbird	105	17.02	32.25	165	7.04	36.01
Western Meadowlark	574	28.82	5.59	1578	23.54	9.38

	Lowry Range (S=16)			Colorado-BCR18 (S=81)		
Species	**n**	**D**	**% CV**	**n**	**D**	**% CV**
Western Wood-Pewee	0	0	0	12	0.03	68.04
White-breasted Nuthatch	1	0.16	101.64	4	0.01	49.15
Wild Turkey	0	0	0	3	0.02	110.47
Wilson's Snipe	4	0.11	71.27	2	0.00	103.91
Wood Duck	0	0	0	2	0.01	107.89
Yellow Warbler	21	3.37	43.18	72	0.93	45.48
Yellow-breasted Chat	0	0	0	17	0.08	85.08

Of the 111 species for which density estimates were produced, the Lowry Range exhibited higher densities of 35 species while the Colorado portion of BCR18 exhibited higher densities of 76 species. Densities of 11 PIF BCR18 priority species were higher within the Lowry Range than in the Colorado portion of BCR18 while the reverse was true for 13 species.

DISCUSSION

The Integrated Monitoring in Bird Conservation Regions Program (IMBCR) annually collects breeding bird information in all or portions of 13 states. Each year, occupancy and density estimates are calculated at a variety of spatial scales. This information can be used in the following ways to inform avian conservation:

1) **Bird Population estimates can be compared in space and time.** For example, estimates for the Lowry Range can be compared to state and regional estimates to determine whether 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 populations can be targeted for protection and strata with low populations can be prioritized for conservation action; a threshold could be set to trigger a management action when populations reach a predetermined level;
3) **Population estimates of treatment areas can be compared to regional estimates to evaluate effectiveness of management actions.** For example, if sagebrush areas are being treated to improve habitat for Greater Sage-grouse (GRSG) and estimates for sagebrush-obligate birds increase in these areas in relation to regional estimates where treatment is not occurring, the results would suggest that the GRSG management actions are also beneficial to other sagebrush-obligate bird species;
4) **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;
5) **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.

Lowry managers should be aware that we anticipate the density estimates presented in the 2012 annual report to differ somewhat from the results presented in this interim report. This is because density estimates presented here were produced using detection data from 2012 alone. For the annual report RMBO will produce density estimates using data collected under the IMBCR design since 2008. This will affect the density estimates in two ways 1) we anticipate the production of density estimates for additional species will be possible with supplementary detection data; 2) the detection curve for each species will be improved slightly with the inclusion of additional data which will, in turn, adjust the resulting density estimates. We therefore have produced this interim report to serve as an example of the information that can be obtained through the IMBCR design and to show how managers may use regional estimates (i.e., the Colorado portion of BCR18) to make comparisons to site specific estimates (i.e., the Lowry Range).

RMBO and its partners are currently in the process of further automating both the density and occupancy analyses which will ultimately improve efficiency and consistency of future analyses. Through the efforts to produce the estimates presented here, substantial improvements to the automation process have been initiated. We anticipate the automated RIMBCR package to be completed in the near future and resulting estimates to follow shortly thereafter. Once completed, the RIMBCR package will allow for the production of both density and occupancy estimates using the IMBCR data. Species richness analyses, produced using occupancy estimates, can then follow.

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