Monitoring Colorado's Birds, 2008

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Rocky Mountain Bird Observatory
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In Cooperation With:
USDA Forest Service
Colorado Division of Wildlife
USDI Bureau of Land Management

ROCKY MOUNTAIN BIRD OBSERVATORY

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

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

***Core Values**: (Our goals for achieving our mission)*

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:

***Partnering** with state and federal natural resource agencies, private landowners, schools, and other nonprofits for conservation.*

***Studying** bird responses to habitat conditions, ecological processes, and management actions to provide scientific information that guides bird conservation efforts.*

***Monitoring** long-term trends in bird populations for our region.*

***Providing** active, experiential, education programs that create an awareness and appreciation for birds.*

***Sharing** the latest information in land management and bird conservation practices.*

***Developing** voluntary, working partnerships with landowners to engage them in conservation.*

***Working** across political and jurisdictional boundaries including, counties, states, regions, and national boundaries. Our conservation work emphasizes the Western United States, including the Great Plains, as well as Latin America.*

***Creating** informed publics and building consensus for bird conservation needs.*

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EXECUTIVE SUMMARY

Rocky Mountain Bird Observatory, in conjunction with its monitoring partners, the USDA Forest Service (USFS), Colorado Division of Wildlife (CDOW) and the USDI Bureau of Land Management (BLM), conducted landbird monitoring throughout Colorado (Monitoring Colorado's Birds; MCB) from 1998-2008. From 1998-2007, the sampling design was based on vegetation strata. In 2008 RMBO and its partners implemented a new sampling design based on spatially balanced random samples placed without regard to existing vegetation conditions. The primary stratification level of the new design is the Bird Conservation Region (BCR). Field methods remained the same across sampling designs: birds were surveyed at point count stations using distance and removal sampling methods.

The spatially balanced sampling design we implemented for landbird monitoring throughout Colorado in 2008 may serve as a model for other broad-scale, long-term monitoring programs. Benefits of our design include:

- Spatially-balanced designs are statistically more efficient than simple random samples.
- Strata based on fixed attributes allow for relating changes in bird populations to changes on the landscape through time.
- Each BCR within a state can be stratified differently, depending upon local needs and areas to which one wants to make inferences.
- All vegetation types are available for sampling.
- The design can incorporate weighting by factors that influence species' distributions.
- Aggregation of strata-wide estimates to BCR- or state-wide estimates is built into the design.
- Because each stratum has its own spatially-balanced, ordered sample, sampling effort can vary among strata and among years and still provide statistically valid estimates.
- Local population trends can be directly compared to regional trends.
- Incorporating spatial information in data analysis can increase precision.
- Coordination among partners can reduce the costs of monitoring per partner.

The 2007 MCB report (Beason et al. 2007) contained density estimates from 1998-2007. This report provides stratum-level and state-wide density estimates and state-wide population estimates for 69 landbird species with sufficient sample sizes to estimate a detection function using Distance sampling theory. The next steps in our data analysis, which are beyond the scope of this report, are:

1. Use data from previous years of MCB monitoring, along with the 2008 data, to estimate detection functions for species with fewer than 60 observations in 2008, and estimate 2008 densities for these species.
2. Estimate densities for 69 species using Removal modeling.
3. Estimate site occupancy for low-density species.
4. Post-stratify 2008 samples by vegetation cover types, calculate density estimates for species with robust sample sizes, and compare resulting estimates with estimates from the 1998-2007 MCB habitat-stratified samples.

ACKNOWLEDGEMENTS

Redesigning a broad-scale and long-term bird monitoring program involved many days of focused meetings and discussions among personnel from RMBO our partner agencies. Robert Skorkowsky of the USDA Forest Service, and Paul Lukacs and David Klute of the Colorado Division of Wildlife were key contributors to developing the BCR-based sampling design using spatially balanced sampling. Formulation of the design also benefited from discussions with Christina Vojta, Greg Hayward and Steve Hirtzel of the USFS, and Wes Anderson of the BLM. Nicoli Bencke and Cheron Ferland of the Routt National Forest and Paul Lukacs of CDOW completed the GIS and computer coding necessary to draw the new sample. Chris White and Rob Sparks of RMBO were instrumental in producing field maps and new data forms for field personnel. Chandman Sambuu updated the data base and online data entry to accommodate the new data forms.

Sincere thanks to the 2008 MCB field crew, led by Chris White: Tim Weber, Andrew Spencer, Lori Brummer, Jeff Birek, Matt Gracey, Brady Dunne, Rob Sparks, Craig Dodson, Jason Beason, Chris Nicholson, Jane McGarry, George Steele, and Mike Freiberg.

This report fulfills requirements in RMBO's contracts with the Colorado Division of Wildlife (PSC-1159-04 and PSC-1157-04), the USDA Forest Service (07-CS-11020603-049) and USDI Bureau of Land Management (1422 CAA020010 T01).

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INTRODUCTION

Birds can be excellent indicators of biological integrity and ecosystem health (Morrison 1986, Hutto 1998, O'Connell et al. 2000, Rich 2002, U.S. EPA 2002, Birdlife International 2003). Because they comprise a diverse group of niche specialists, occupy a broad range of habitats, are sensitive to both physical and chemical impacts on the environment, and often reflect the abundance and diversity of other organisms with which they coexist, birds can be useful barometers for environmental change and measuring the sustainability of human activities on ecosystems.

Population monitoring forms the backbone of avian conservation; without current monitoring data, conservation efforts may be misguided and inefficient. Population monitoring helps to achieve the intent of legislation such as the Migratory Bird Treaty Act (1918), National Environmental Policy Act (1969), Endangered Species Act (1973), the National Forest Management Act (1976) and various state laws (Sauer 1993, Manley et al. 1993).

Many avian species have been identified as priorities for conservation in State Wildlife Action Plans (Species of Greatest Conservation Need; e.g., Colorado Division of Wildlife 2006), National Forest Plans (Management Indicator Species and Sensitive Species), and the Partners in Flight North American Landbird Conservation Plan (Rich et al. 2004). Given the declines of many bird species that breed in North America (Rich et al. 2004), there is a critical need for monitoring programs that identify declining species and the causes of declines so that natural resource managers can prevent further losses and even increase bird populations.

Program History

Rocky Mountain Bird Observatory, in conjunction with its partners, the USDA Forest Service (USFS), Colorado Division of Wildlife (CDOW) and the USDI Bureau of Land Management (BLM), conducted landbird monitoring throughout Colorado (Monitoring Colorado's Birds; MCB) from 1998-2007. From 1998-2007, the sampling design was based on vegetation strata; however, we recognized several limitations to MCB's vegetation-stratified design. First, vegetation cover-types are not static. Vegetation may change on the landscape over time, due to plant succession, fire, drought, bark beetle infestation, land use changes, and other factors. Consequently, vegetation-based transects need to be re-located over time as the landscape changes. This did not allow us to relate changes in bird population density to changes in landscape conditions.

Second, due to fluctuating budgets and recent financial constraints, not every "habitat type" or vegetation cover type could be sampled; we needed a strategy that was adaptable to budget fluctuations. Third, in an effort to place sampling transects within homogeneous stands, small patches of distinct habitats and ecotones were excluded from sampling. Fourth, the original MCB design required that sampling locations were within 1.6 km of a road. These latter three factors made it difficult to combine data across strata to estimate state-wide or region-wide species' densities.

We were also motivated to re-evaluate the original MCB sampling design, in part, because of the goals and recommendations in the North American Bird Conservation Initiative's "Opportunities for Improving Avian Monitoring" (NABCI 2007). The goals are:

Goal 1: Fully integrate monitoring into bird management and conservation practices and ensure that monitoring is aligned with management and conservation priorities.

Goal 2: Coordinate monitoring programs among organizations and integrate them across spatial scales to solve conservation or management problems effectively.

Goal 3: Increase the value of monitoring information by improving statistical design.

Goal 4: Maintain bird population monitoring data in modern data management systems. Recognizing legal, institutional, proprietary, and other constraints, provide greater availability of raw data, associated metadata, and summary data for bird monitoring programs.

Along with our agency partners, we used the following questions to guide development of a new monitoring design:

Are the goals and objectives of the MCB program still current?

What are the strengths and limitations of various existing and alternative sampling designs?

Are there opportunities for integration of multiple monitoring programs to monitor at a more relevant biological scale and reduce the per-partner cost of monitoring?

Can a sampling design adapt to changes in budgets and partner participation?

Monitoring Objectives

Specific objectives of Monitoring Colorado's Birds are:
1.) to integrate existing bird monitoring efforts in the region to provide better information on distribution and abundance of all breeding birds, especially for high priority species;
2.) to provide basic habitat association data for most bird species to address habitat management issues;
3.) to provide long-term status and trend data for all regularly occurring breeding species in Colorado, with a target of detecting a minimum rate of population change of 3.0% per year within 30 years;
4.) to maintain a high-quality database that is accessible to all of our collaborators as well as to the public on the worldwide web, in the form of raw and summarized data and,
5.) to generate decision support tools that help guide conservation efforts and provide a better measure of conservation success.

METHODS

Sampling Design

Bird populations do not recognize administrative boundaries; therefore, we chose Bird Conservation Regions (BCRs) as the biologically meaningful spatial scale to which we want to make inferences about bird population densities and trends. BCRs are "ecologically distinct regions in North America with similar bird communities, habitats, and resource management issues" (http://www.nabci-us.org/bcrs.html). Colorado contains portions of

three BCRs: Northern Rockies (BCR 10), Southern Rockies/Colorado Plateau (BCR 16), and Shortgrass Prairie (BCR 18). Because BCR 10 constitutes < 3.5% of Colorado, we did not apply any stratification within the Colorado portion of BCR 10 in 2008. We stratified within the other two BCRs based on fixed attributes, without regard to existing vegetation conditions. In contrast to the historic, vegetation-stratified sampling, built into our new sampling design is the ability to combine data across strata (and across monitoring programs) in order to estimate bird population status and trends across large areas.

Within each stratum, we used generalized random-tesselation 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:

(1) 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 increase precision in density estimates;

(2) Sample units can be weighted according to any mappable variable of interest, to adjust the probability that sample units will be selected (Stevens and Olsen 2004). The sample weight can be accounted for in data analyses.

(3) 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). This will allow for adjustment of the sampling effort among years within each stratum, if necessary due to fluctuating budgets, while maintaining a random, spatially balanced sample.

We defined sampling units as 1-km^2 cells, and superimposed a uniform grid of cells over the entire state of Colorado, with a random starting point. All spatial data were compiled using ARCGIS 9.2 (ESRI).

Stratification and Cell Weighting

The GRTS design allows great flexibility in to stratification, as illustrated by the different approaches to stratification we took in BCRs 16 and 18 (Figures 1 & 2). Each state within a BCR and each BCR within a state can be stratified differently, depending upon local needs and areas to which one wants to make inferences.

In BCR 16 we created 13 strata based on Federal land ownership, with one stratum for each National Forest (8 strata), one stratum for each of three National Park Service Inventory and Monitoring Network of Parks, one stratum for BLM land, and one stratum for "All Other" land ownership designations, including private, state, and tribal lands (Figure 1).

We wanted to sample some cells containing higher order rivers and streams, which occur on a very small proportion of the landscape. Therefore, within each stratum in BCR 16 we weighted cells by Stralher stream order so that cells containing larger streams had a higher probability of being sampled (with stream orders 4-8 carrying equal weight). We obtained the hydrology spatial data layer from the CDOW website

We also wanted to have sufficient samples from high-elevation areas, which constitute a lower proportion of the landscape than low-elevations. We arbitrarily chose to assign a 4

times higher inclusion probability to cells between 3000-3999 m, and 5 times higher for cells ≥ 4000 m elevation.

In BCR 18 we created 9 strata, based on Federal land ownership, rivers, and latitude (Figure 2). We created one stratum in each of two National Grassslands, 1 stratum in Department of Defense lands, and 1 stratum each for two major rivers and their major tributaries. We stratified all remaining cells, regardless of land ownership, by dividing eastern Colorado into 4 latitudinal bands, defined by the state boundaries, the two river strata, and Interstate 70. We did not use any cell weighting in BCR 18.

Geospatial data were created by Routt National Forest personnel using ArcGIS 9.1 (ESRI, Redlands, CA). Paul Lukacs of the CDOW used SAS (SAS Institute Inc., Cary, NC) to compute cell weights and S-draw (WEST Inc., Cheyenne, WY) to select the sample. Note that CDOW has subsequently used the Reversed Randomized Quadrant-Recursive Raster (RRQRR) ArcGIS tool (Theobald and Norman 2006) and the SPSURVEY package (Kincaid 2008) in Program R (R Development Core Team 2008) to draw GRTS samples (Paul Lukacs, personal communication).

Sample Allocation

We allocated samples among strata in consideration of the interests of our partners (Table1). Note that all portions of the sampling frame (all strata) must be available for sampling. A minimum of two samples must occur within each stratum to be able to estimate stratum-level densities.

Sampling Methods

We retained many features of the previous MCB sampling techniques. Birds were surveyed from points using methods that allow for estimating detection probability through the principles of Distance sampling, Removal modeling, and Occupancy modeling. We retained 250 m spacing between sampling points. Whereas the original MCB design used 15 points in a linear array, the new sampling design uses a square of 16 points centered within the 1-km2 sampling cells.

Distance sampling theory estimates detection probability as a function of the distances between the observer and the birds detected (Buckland et al. 1993). The detection probability is used to adjust the count of birds to account for birds that were present but undetected.

Removal modeling is based on mark-recapture theory a declining number of birds detected during consecutive sampling intervals (Farnsworth et al. 2002). In this design, sampling intervals consist of 1-2 minutes segments of a complete sampling period. Removal modeling can also incorporate distance data.

Occupancy modeling is most commonly used to quantify the probability that an organism is present or absent within a defined spatial unit, and can even be used to estimate the density of an organism (Royle and Nichols 2003). We can use our data to estimate site occupancy of low-density birds for which we have too few detections to estimate population density. Occupancy modeling requires multiple surveys in time or space. Under our sampling framework, the sixteen grid points serve as spatial replicates within the 1-km^2 sampling cells. Although it was possible to apply occupancy modeling to the previous MCB sampling design, sampled areas and transects were not uniform in extent.

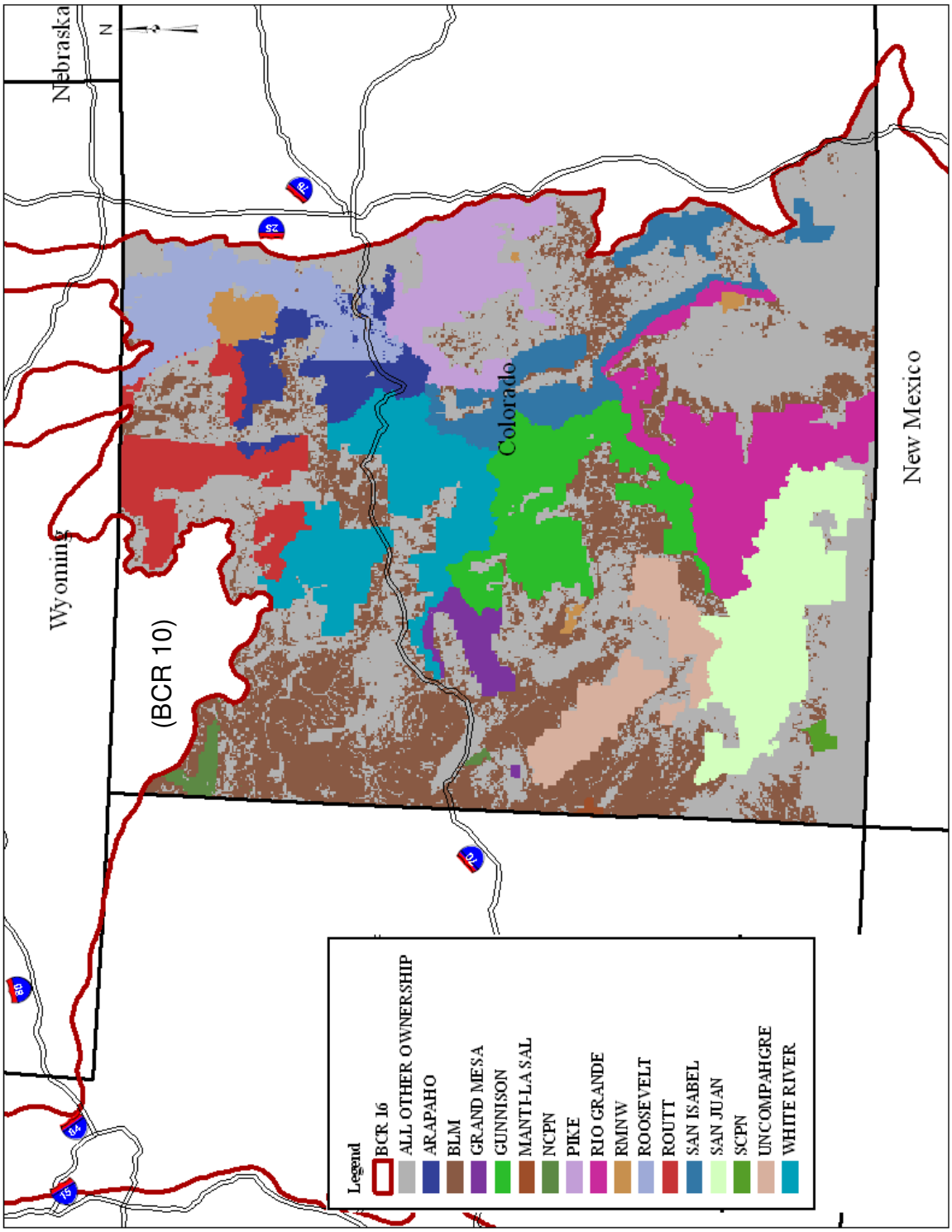

Figure 1. Stratification of the Colorado portion of the Southern Rockies/Colorado Plateau Bird Conservation Region (BCR 16). Note the unstratified portion of the Northern Rockies BCR (10) in northwestern Colorado.

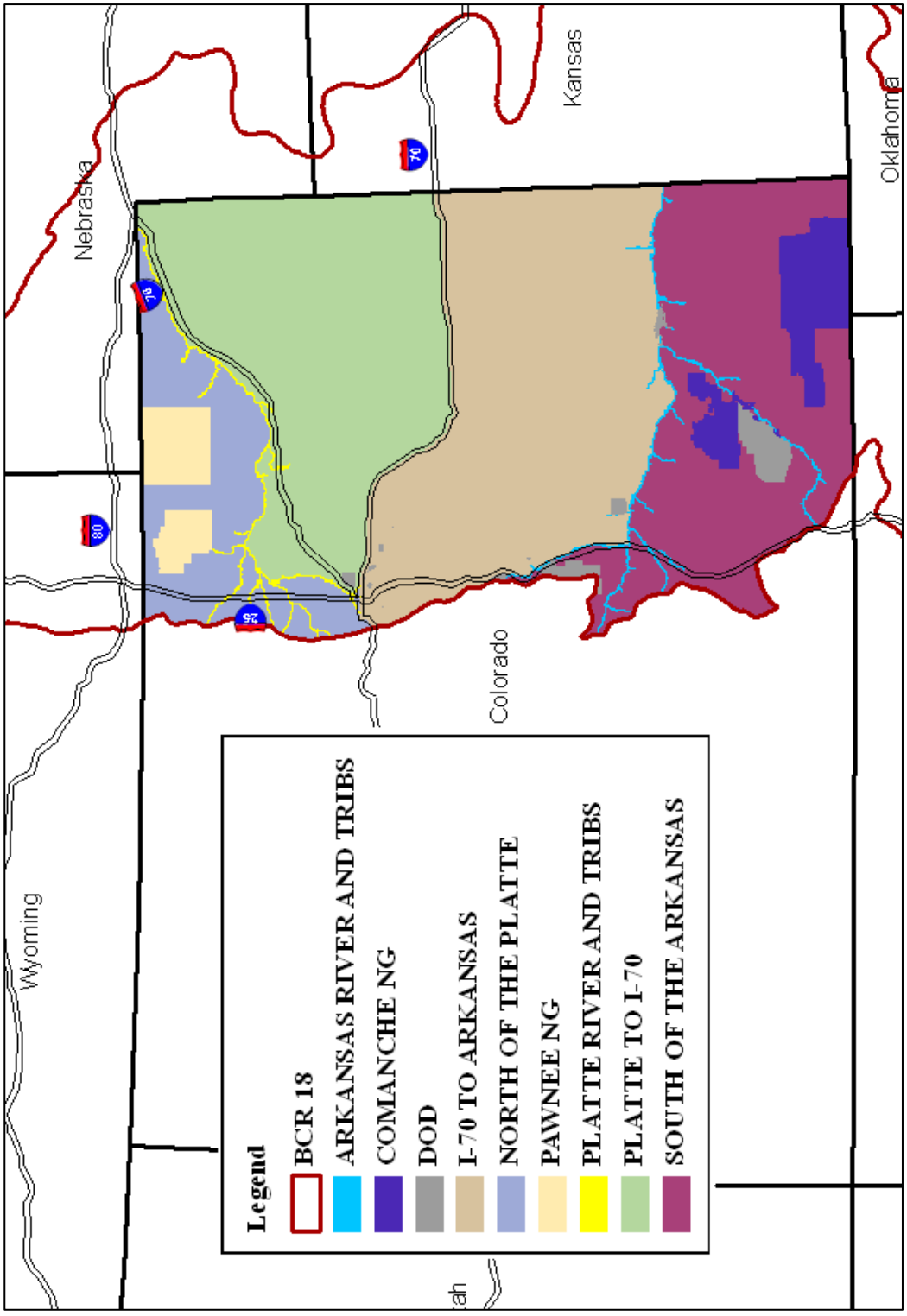

Figure 2. Stratification of the Colorado Portion of the Shortgrass Prairie Bird Conservation Region (18).

Table 1. Sample allocation among strata and stratum areas in Colorado, 2008.

BCR	Land Ownership or landscape feature Stratum	Area (km^2)	Target	Sampled	% Sampled
16	Bureau of Land Management				
	BLM	27,845	47	36	77
	National Forests				
	Arapaho-Roosevelt	9,645	10	8	80
	Grand Mesa-Gunnison-Uncompahgre	13,630	10	9	90
	Manti-La Sal	131	1	1	100
	Pike-San Isabel	10,950	10	10	100
	Rio Grande	8,348	10	9	90
	Routt	5,123	25	20	80
	San Juan	8,794	10	8	80
	White River	8,814	10	7	70
	National Park Inventory and Monitoring Networks				
	Northern Colorado Plateau	692	2	2	100
	Rocky Mountain	1,260	2	2	100
	Southern Colorado Plateau	214	2	2	100
	All Other Lands				
	All Other	51,517	45	31	69
	Total	146,963	184	145	79
18	Department of Defense				
	DOD	1,647	2	2	100
	National Grasslands				
	Comanche	4,836	8	8	100
	Pawnee	3,268	8	8	100
	River Systems and major tributaries				
	Arkansas	1,127	8	6	75
	North Platte	970	8	8	100
	All other lands				
	Platte River to northern CO border	11,455	8	8	100
	Between I-70 and Platte River	30,365	8	8	100
	Between Arkansas River and I-70	34,757	8	8	100
	Southern CO border to Arkansas River	24,985	8	8	100
	Total	113,410	66	64	97
10	All lands	9,251	1	0	0
Grand Total		269,624	251	209	83

The field methods used to survey birds in the MCB program in 2008 were nearly identical to the methods used in previous years (Hanni et al. 2009). Field technicians conducted five-minute point counts, divided into one-minute intervals, at each accessible survey point within the sample grids. For each bird detected, observers recorded the species, its sex, how it was detected (call, song, drumming, or visual), and distance from the observation point. Distances were measured using laser rangefinders. Observers conducted all transect surveys in the morning, between one-half hour before sunrise and 11 AM; most surveys were completed before 10 AM.

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). 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. The assumptions of Distance sampling theory are reasonably well met following the MCB protocol.

Field technicians each had excellent aural and visual bird-identification skills. Technicians completed a 5 day training program at the beginning of the season to ensure full understanding of the field protocols and to practice distance estimation.

Data Analysis

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

We used Program Distance 5.0 (Thomas et al. 2006) to estimate the detection probability and expected cluster size and their associated variances for each bird species. We fit the following functions to the distribution of distances for each species: Half normal key function with cosine series expansion, Uniform function with cosine series expansion, Hazard rate key function with cosine series expansion, and Hazard rate key function with simple polynomial series expansion (Buckland et al. 2001). We 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).

We used the SPSURVEY package (Kincaid 2008) in Program R (R Development Core Team 2008) to estimate density and its variance for each bird species. This was greatly facilitated by R code written for us by Paul Lukacs of the Colorado Division of Wildlife.

RESULTS

We completed 79% of 184 planned surveys in BCR 16, 97% of 66 planned surveys in BCR 18, and did not complete the one survey planned in BCR 10 (Table 1). The most common reason for surveys not being conducted was an inability to contact private landowners (Table 2). We think this can be resolved in future years by contacting more landowners prior to the field season.

Table 2. Reasons transects were not surveyed, including original and replacement transects.

Reason transects not surveyed	BCR 16	BCR 18	BCR 10
Inaccessible	14	0	0
Ran out of time	8	0	0
Denied access	5	5	3
Unable to contact landowner	26	10	0
Dogs following observer	1	0	0
Total	54	15	3

We detected > 22,000 individuals of 196 species across all strata (Appendices A and B). Using only the 2008 data, we were able to estimate stratum-level densities and state-wide densities and population sizes of 69 landbird species throughout Colorado (Tables 3-5).

Table 3. Estimated density (D; birds per km^2) and % Coefficient of Variation of estimated density for 69 landbird species in the Southern Rockies/Colorado Plateau Bird Conservation Region (16) within Colorado, 2008. Sample size (n) represents the number of independent detections used to estimate the detection function.

				National Park Service Inventory and Monitoring Networks											
				Northern Colorado Plateau						Southern Colorado Plateau			All Other Lands		
	BLM						Rocky Mountain								
Species	n	D	%CV	n	D	%CV	n	D	%CV	n	D	%CV	n	D	%CV
Killdeer	8	2.27	68	0	0.00		0	0.00		0	0.00		18	6.13	56
Mourning Dove	124	4.78	26	5	4.60	64	3	1.89	165	5	8.52	15	71	7.12	34
Broad-tailed Hummingbird	39	14.09	30	1	3.30	165	7	39.88	46	4	50.07	18	50	38.90	25
Hairy Woodpecker	5	1.06	51	3	7.69	167	0	0.00		0	0.00		3	2.99	85
Northern Flicker	28	1.28	35	0	0.00		3	1.59	160	1	2.07	36	29	2.59	28
Western Wood-Pewee	13	0.66	40	0	0.00		12	6.60	160	0	0.00		31	2.96	33
Dusky Flycatcher	37	4.77	29	0	0.00		0	0.00		6	9.84	165	12	2.41	48
Gray Flycatcher	89	7.93	26	20	63.00	18	0	0.00		0	0.00		4	0.18	88
Cordilleran Flycatcher	3	0.13	61	0	0.00		5	10.53	30	0	0.00		10	2.36	43
Ash-throated Flycatcher	74	5.39	21	8	6.34	90	0	0.00		3	5.65	11	14	0.66	56
Western Kingbird	14	1.42	59	0	0.00		0	0.00		0	0.00		18	3.43	47
Plumbeous Vireo	49	4.80	32	5	15.22	27	0	0.00		1	0.76	166	17	1.98	59
Warbling Vireo	17	1.31	43	0	0.00		0	0.00		0	0.00		55	9.79	41
Gray Jay	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	
Steller's Jay	7	0.31	59	0	0.00		6	3.45	161	0	0.00		4	0.44	33
Western Scrub-Jay	56	3.64	31	1	2.95	37	0	0.00		0	0.00		4	0.31	66
Pinyon Jay	42	0.91	39	4	3.64	38	0	0.00		0	0.00		8	0.23	58
Clark's Nutcracker	11	0.25	59	0	0.00		2	1.12	22	0	0.00		5	0.21	47
Black-billed Magpie	16	0.41	46	0	0.00		0	0.00		2	1.42	18	45	1.79	35
American Crow	10	0.23	53	3	0.58	167	5	1.18	162	0	0.00		23	1.00	44
Common Raven	14	0.69	43	0	0.00		1	0.77	162	6	13.39	27	13	0.85	55
Horned Lark	112	7.39	35	0	0.00		0	0.00		0	0.00		72	6.73	41
Violet-green Swallow	29	17.64	47	2	6.37	167	5	36.51	30	0	0.00		43	26.75	41
Cliff Swallow	56	35.53	66	0	0.00		0	0.00		2	26.61	38	31	15.17	35
Barn Swallow	3	2.17	84	0	0.00		0	0.00		0	0.00		16	16.82	55
Mountain Chickadee	11	1.16	47	0	0.00		3	14.50	28	0	0.00		16	5.36	28
Red-breasted Nuthatch	1	0.06	84	0	0.00		0	0.00		0	0.00		1	0.14	81
Rock Wren	91	4.50	24	7	7.85	15	0	0.00		1	2.04	36	14	1.03	53

				National Park Service Inventory and Monitoring Networks											
				Northern Colorado Plateau						Southern Colorado Plateau			All Other Lands		
	BLM						Rocky Mountain								
Species	n	D	%CV	n	D	%CV	n	D	%CV	n	D	%CV	n	D	%CV
Bewick's Wren	47	3.12	38	5	13.18	30	0	0.00		1	0.66	166	5	0.44	62
House Wren	5	0.41	69	2	2.32	165	4	5.61	160	0	0.00		51	11.87	33
Ruby-crowned Kinglet	4	0.34	65	0	0.00		1	0.52	160	0	0.00		11	2.15	69
Blue-gray Gnatcatcher	127	44.01	20	6	42.23	30	0	0.00		13	122.44	11	28	15.64	37
Mountain Bluebird	60	3.99	31	0	0.00		3	2.42	160	0	0.00		17	1.19	50
Townsend's Solitaire	3	0.17	78	0	0.00		2	3.20	19	0	0.00		5	1.34	71
Hermit Thrush	12	0.40	50	1	1.11	41	0	0.00		2	0.47	166	19	1.90	68
American Robin	65	5.16	28	1	1.71	166	6	8.95	37	3	24.31	38	92	28.83	27
Northern Mockingbird	5	0.29	71	0	0.00		0	0.00		0	0.00		0	0.00	
American Pipit	16	6.02	54	0	0.00		0	0.00		0	0.00		6	2.87	81
European Starling	0	0.00		0	0.00		0	0.00		0	0.00		42	7.02	59
Virginia's Warbler	84	14.00	31	0	0.00		0	0.00		6	20.68	42	20	6.34	58
Yellow Warbler	9	1.43	39	1	0.85	165	0	0.00		0	0.00		66	11.15	38
Yellow-rumped Warbler	3	0.55	72	0	0.00		11	33.24	36	0	0.00		19	4.84	44
Black-throated Gray Warbler	214	36.26	21	24	137.23	21	0	0.00		1	1.51	165	9	1.01	55
Western Tanager	35	2.23	35	1	0.70	165	2	1.54	160	2	3.56	11	18	2.53	33
Green-tailed Towhee	110	11.85	33	0	0.00		5	7.68	160	0	0.00		65	13.32	31
Spotted Towhee	142	15.55	34	0	0.00		0	0.00		16	33.27	44	62	11.46	30
Cassin's Sparrow	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	
Chipping Sparrow	136	12.82	21	4	4.04	165	1	1.22	160	6	17.34	12	17	2.38	35
Brewer's Sparrow	139	10.91	40	0	0.00		0	0.00		0	0.00		51	6.65	43
Vesper Sparrow	79	3.26	37	1	0.47	165	6	3.18	160	0	0.00		77	4.36	35
Lark Sparrow	35	3.71	28	1	0.95	165	0	0.00		0	0.00		38	8.89	62
Lark Bunting	1	0.07	69	0	0.00		0	0.00		0	0.00		0	0.00	
Savannah Sparrow	0	0.00		0	0.00		0	0.00		0	0.00		53	13.43	52
Grasshopper Sparrow	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	
Song Sparrow	2	0.53	66	0	0.00		2	2.81	163	3	16.06	48	25	6.12	57
Lincoln's Sparrow	0	0.00		0	0.00		1	1.03	160	0	0.00		2	0.95	83
White-crowned Sparrow	5	0.74	48	0	0.00		2	11.25	43	0	0.00		6	4.01	70
Dark-eyed Junco	3	0.32	75	0	0.00		5	3.23	161	0	0.00		19	4.21	52
McCown's Longspur	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	

				National Park Service Inventory and Monitoring Networks											
				Northern Colorado Plateau						Southern Colorado Plateau			All Other Lands		
	BLM						Rocky Mountain								
Species	n	D	%CV	n	D	%CV	n	D	%CV	n	D	%CV	n	D	%CV
Black-headed Grosbeak	79	6.48	38	0	0.00		0	0.00		3	2.72	165	32	5.11	32
Red-winged Blackbird	6	1.64	61	0	0.00		1	2.01	161	0	0.00		71	26.79	42
Western Meadowlark	78	2.06	28	3	0.91	165	0	0.00		1	1.43	35	204	9.50	26
Brewer's Blackbird	31	4.30	46	0	0.00		0	0.00		0	0.00		53	12.76	32
Common Grackle	0	0.00		0	0.00		0	0.00		0	0.00		5	2.14	116
Brown-headed Cowbird	24	4.87	31	0	0.00		0	0.00		0	0.00		35	10.43	27
House Finch	34	9.24	35	1	2.95	166	0	0.00		0	0.00		20	13.00	62
Red Crossbill	0	0.00		0	0.00		6	4.36	161	0	0.00		8	0.92	63
Pine Siskin	24	3.12	39	0	0.00		11	14.94	160	0	0.00		39	11.13	42
House Sparrow	0	0.00		0	0.00		0	0.00		0	0.00		2	1.86	67

Table 3, continued.

	National Forests																				
	Arapaho -Roosevelt			Grand Mesa-Gunnison-Uncompahgre			Pike-San Isabel			Rio Grande			Routt			San Juan			White River		
Species	n	D	%CV	n	D	%CV	n	D	%CV	n	D	%CV	n	D	%CV	n	D	%CV	n	D	%CV
Killdeer	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	
Mourning Dove	0	0.00		0	0.00		3	0.25	103	3	0.25	108	0	0.00		5	0.95	72	2	1.02	56
Broad-tailed Hummingbird	14	26.48	26	6	6.38	56	23	50.90	38	8	20.64	53	18	9.97	32	8	14.97	69	10	25.05	67
Hairy Woodpecker	2	0.81	101	0	0.00		0	0.00		0	0.00		34	25.29	38	2	0.44	104	11	27.19	57
Northern Flicker	4	0.79	52	4	0.82	49	9	1.83	41	2	0.82	80	10	0.78	55	10	1.13	53	7	2.19	35
Western Wood-Pewee	4	0.33	97	0	0.00		3	0.50	55	3	1.10	39	58	4.37	44	15	0.83	79	10	2.69	26
Dusky Flycatcher	2	1.36	74	0	0.00		2	3.61	78	3	4.59	76	23	5.43	48	7	0.99	83	9	13.33	31
Gray Flycatcher	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	
Cordilleran Flycatcher	1	0.25	92	6	2.14	62	10	11.51	71	10	7.57	38	6	0.84	47	2	2.07	78	4	0.98	99
Ash-throated Flycatcher	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	
Western Kingbird	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	
Plumbeous Vireo	0	0.00		0	0.00		3	0.63	97	0	0.00		0	0.00		10	0.66	101	0	0.00	
Warbling Vireo	5	0.79	97	5	2.86	80	12	7.13	40	13	8.15	40	82	8.77	31	15	2.55	50	33	13.80	33
Gray Jay	12	10.54	42	12	12.61	61	6	9.42	49	0	0.00		17	8.22	36	8	6.29	56	8	9.12	37
Steller's Jay	0	0.00		0	0.00		19	4.92	31	1	0.25	89	1	0.09	96	11	2.21	51	11	4.61	31

	National Forests																				
	Arapaho -Roosevelt			Grand Mesa-Gunnison-Uncompahgre			Pike-San Isabel			Rio Grande			Routt			San Juan			White River		
Species	n	D	%CV	n	D	%CV	n	D	%CV	n	D	%CV	n	D	%CV	n	D	%CV	n	D	%CV
Western Scrub-Jay	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	
Pinyon Jay	0	0.00		0	0.00		0	0.00		4	0.12	101	0	0.00		0	0.00		0	0.00	
Clark's Nutcracker	5	0.37	45	4	0.27	57	13	0.98	41	5	0.55	59	20	1.10	37	9	0.99	77	10	1.40	28
Black-billed Magpie	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	
American Crow	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		3	0.59	49
Common Raven	4	1.02	72	0	0.00		1	0.49	82	1	0.60	83	6	0.89	52	3	0.29	74	2	0.07	77
Horned Lark	4	1.14	64	0	0.00		0	0.00		11	9.10	79	0	0.00		8	6.44	81	5	1.45	90
Violet-green Swallow	0	0.00		1	2.32	89	0	0.00		2	5.22	81	9	4.91	55	6	6.86	76	3	1.70	102
Cliff Swallow	0	0.00		0	0.00		0	0.00		13	34.18	80	0	0.00		0	0.00		0	0.00	
Barn Swallow	0	0.00		0	0.00		0	0.00		1	4.80	89	0	0.00		0	0.00		0	0.00	
Mountain Chickadee	56	36.95	39	49	29.03	30	47	37.70	21	49	36.12	37	84	27.54	16	54	38.02	25	27	20.65	14
Red-breasted Nuthatch	5	1.49	82	4	0.56	93	3	0.81	73	6	1.77	72	22	2.28	29	9	2.56	56	8	3.44	39
Rock Wren	0	0.00		0	0.00		0	0.00		1	0.07	100	4	0.38	48	0	0.00		0	0.00	
Bewick's Wren	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	
House Wren	1	0.70	88	2	1.62	50	4	2.02	54	2	1.69	48	24	4.56	54	4	0.62	68	5	5.19	38
Ruby-crowned Kinglet	51	9.38	23	54	11.07	30	34	9.93	12	27	6.30	34	93	9.31	21	44	8.09	35	45	11.16	14
Blue-gray Gnatcatcher	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	
Mountain Bluebird	4	1.64	57	0	0.00		2	0.86	89	11	4.48	42	7	1.42	49	0	0.00		0	0.00	
Townsend's Solitaire	9	1.69	60	2	0.56	60	20	6.54	26	5	1.68	38	22	2.48	40	7	0.94	62	14	5.53	52
Hermit Thrush	50	5.95	43	47	4.56	36	37	5.27	37	40	5.36	33	125	7.48	28	44	5.59	32	35	5.15	34
American Robin	44	16.88	28	30	13.76	31	35	16.29	28	26	13.32	35	134	24.65	13	27	11.16	29	33	19.85	13
Northern Mockingbird	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	
American Pipit	22	8.70	49	49	26.88	84	6	3.17	89	0	0.00		12	1.59	88	23	17.16	81	26	6.97	91
European Starling	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	
Virginia's Warbler	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	
Yellow Warbler	0	0.00		0	0.00		1	0.86	78	0	0.00		1	0.14	87	0	0.00		3	0.48	98
Yellow-rumped Warbler	32	9.54	27	61	20.54	33	78	41.80	26	37	18.90	33	134	23.31	22	58	17.01	43	43	17.66	24
Black-throated Gray Warbler	0	0.00		0	0.00		1	0.42	96	0	0.00		0	0.00		0	0.00		0	0.00	
Western Tanager	5	1.27	68	3	0.55	73	1	0.50	78	2	0.83	84	36	3.79	27	23	3.97	51	30	12.58	21
Green-tailed Towhee	0	0.00		4	3.56	85	5	3.23	43	4	2.04	64	1	0.14	92	8	0.88	91	9	6.88	52
Spotted Towhee	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	

	National Forests																				
	Arapaho -Roosevelt			Grand Mesa-Gunnison-Uncompahgre			Pike-San Isabel			Rio Grande			Routt			San Juan			White River		
Species	n	D	%CV	n	D	%CV	n	D	%CV	n	D	%CV	n	D	%CV	n	D	%CV	n	D	%CV
Cassin's Sparrow	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	
Chipping Sparrow	3	0.48	97	7	3.59	69	6	2.20	35	4	1.74	57	32	4.54	34	19	4.58	53	14	13.13	38
Brewer's Sparrow	0	0.00		0	0.00		0	0.00		1	0.14	100	2	0.23	90	0	0.00		0	0.00	
Vesper Sparrow	0	0.00		0	0.00		0	0.00		2	0.14	100	7	0.37	49	0	0.00		0	0.00	
Lark Sparrow	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	
Lark Bunting	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	
Savannah Sparrow	18	17.44	67	0	0.00		3	2.53	89	16	19.56	80	5	0.86	90	0	0.00		0	0.00	
Grasshopper Sparrow	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	
Song Sparrow	0	0.00		0	0.00		0	0.00		1	1.10	82	2	0.44	88	0	0.00		0	0.00	
Lincoln's Sparrow	23	10.73	32	8	4.37	43	14	9.01	26	11	6.91	41	28	3.66	37	19	5.65	68	11	6.16	66
White-crowned Sparrow	43	25.39	57	32	25.07	51	11	8.37	80	25	15.96	70	35	6.11	37	16	17.07	56	48	23.86	53
Dark-eyed Junco	61	16.09	33	24	5.13	25	36	11.74	20	42	12.94	29	149	18.67	22	66	17.81	21	50	16.90	17
McCown's Longspur	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	
Black-headed Grosbeak	0	0.00		0	0.00		0	0.00		0	0.00		1	0.17	82	0	0.00		0	0.00	
Red-winged Blackbird	0	0.00		0	0.00		0	0.00		6	9.30	82	0	0.00		0	0.00		0	0.00	
Western Meadowlark	0	0.00		0	0.00		0	0.00		15	3.53	74	0	0.00		0	0.00		0	0.00	
Brewer's Blackbird	0	0.00		0	0.00		0	0.00		5	2.01	67	2	0.33	90	0	0.00		0	0.00	
Common Grackle	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	
Brown-headed Cowbird	0	0.00		0	0.00		0	0.00		1	1.45	79	0	0.00		3	0.40	100	0	0.00	
House Finch	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		1	2.67	84
Red Crossbill	16	5.52	36	20	4.38	56	14	6.62	63	8	2.64	58	11	1.84	41	22	7.05	43	12	4.62	52
Pine Siskin	70	27.80	24	26	10.30	34	25	18.32	22	45	25.95	42	85	20.11	18	64	46.28	32	42	26.93	40
House Sparrow	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	

Table 4. Estimated density (D; birds per km^2) and % Coefficient of Variation of estimated density for 69 landbird species in the Shortgrass Prairie Bird Conservation Region (18) within Colorado, 2008. Sample size (n) represents the number of independent detections used to estimate the detection function.

	Department of Defense			Comanche National Grassland			Pawnee National Grassland			Arkansas River			North Platte River		
Species	n	D	%CV	n	D	%CV	n	D	%CV	n	D	%CV	n	D	%CV
Killdeer	2	6.94	105	6	5.64	44	4	3.64	64	10	15.03	83	17	15.97	52
Mourning Dove	9	10.06	24	26	7.87	32	13	3.82	37	26	21.02	40	53	26.78	27
Broad-tailed Hummingbird	1	6.90	100	0	0.00		0	0.00		1	2.99	85	0	0.00	
Hairy Woodpecker	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	
Northern Flicker	0	0.00		0	0.00		0	0.00		2	0.80	58	20	4.97	34
Western Wood-Pewee	0	0.00		0	0.00		0	0.00		2	0.96	83	6	1.62	41
Dusky Flycatcher	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	
Gray Flycatcher	0	0.00		1	0.49	90	0	0.00		0	0.00		0	0.00	
Cordilleran Flycatcher	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	
Ash-throated Flycatcher	0	0.00		1	0.31	90	0	0.00		1	0.49	85	0	0.00	
Western Kingbird	4	6.55	25	11	4.88	28	1	0.43	88	10	7.10	35	20	8.87	66
Plumbeous Vireo	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	
Warbling Vireo	0	0.00		0	0.00		0	0.00		0	0.00		8	3.94	45
Gray Jay	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	
Steller's Jay	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	
Western Scrub-Jay	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	
Pinyon Jay	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	
Clark's Nutcracker	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	
Black-billed Magpie	0	0.00		0	0.00		0	0.00		4	0.90	78	3	0.42	85
American Crow	0	0.00		0	0.00		0	0.00		1	0.18	85	6	0.66	86
Common Raven	0	0.00		0	0.00		0	0.00		1	0.58	86	1	0.36	87
Horned Lark	10	18.52	100	101	50.67	18	359	174.65	8	16	12.84	57	3	1.51	81
Violet-green Swallow	0	0.00		0	0.00		0	0.00		1	3.32	92	2	3.41	96
Cliff Swallow	19	111.92	70	3	4.79	64	2	3.09	84	26	66.37	68	16	51.91	73
Barn Swallow	3	32.24	108	0	0.00		1	2.82	92	6	27.95	66	11	32.02	56
Mountain Chickadee	0	0.00		2	1.51	90	0	0.00		0	0.00		0	0.00	
Red-breasted Nuthatch	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	
Rock Wren	0	0.00		1	0.24	90	2	0.47	54	1	0.39	85	0	0.00	
Bewick's Wren	0	0.00		2	0.75	92	0	0.00		0	0.00		0	0.00	

	Department of Defense			Comanche National Grassland			Pawnee National Grassland			Arkansas River			North Platte River		
Species	n	D	%CV	n	D	%CV	n	D	%CV	n	D	%CV	n	D	%CV
House Wren	0	0.00		0	0.00		0	0.00		8	8.41	70	27	17.74	49
Ruby-crowned Kinglet	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	
Blue-gray Gnatcatcher	1	6.57	100	3	5.34	90	0	0.00		1	2.85	85	0	0.00	
Mountain Bluebird	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	
Townsend's Solitaire	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	
Hermit Thrush	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	
American Robin	4	13.28	67	2	1.80	91	0	0.00		19	36.07	45	130	154.26	26
Northern Mockingbird	18	11.26	20	7	1.19	34	0	0.00		10	2.71	49	0	0.00	
American Pipit	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	
European Starling	0	0.00		0	0.00		0	0.00		29	18.36	50	77	31.74	39
Virginia's Warbler	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	
Yellow Warbler	6	11.12	100	0	0.00		0	0.00		13	11.09	63	25	11.51	27
Yellow-rumped Warbler	4	6.58	30	0	0.00		0	0.00		0	0.00		2	0.89	64
Black-throated Gray Warbler	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	
Western Tanager	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	
Green-tailed Towhee	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	
Spotted Towhee	0	0.00		3	2.08	90	0	0.00		1	1.17	82	3	1.84	82
Cassin's Sparrow	6	6.33	100	54	15.44	24	13	3.60	81	12	5.49	67	0	0.00	
Chipping Sparrow	0	0.00		1	0.57	90	0	0.00		2	1.83	82	1	0.57	84
Brewer's Sparrow	1	1.82	100	9	4.43	35	14	6.68	47	1	0.79	82	0	0.00	
Vesper Sparrow	0	0.00		0	0.00		0	0.00		0	0.00		1	0.26	84
Lark Sparrow	5	8.23	32	6	3.22	38	0	0.00		11	9.46	69	1	0.54	82
Lark Bunting	0	0.00		104	21.66	16	71	14.34	33	19	6.33	71	0	0.00	
Savannah Sparrow	0	0.00		0	0.00		0	0.00		0	0.00		1	0.74	84
Grasshopper Sparrow	0	0.00		19	17.09	29	7	6.11	55	1	1.44	82	0	0.00	
Song Sparrow	0	0.00		0	0.00		0	0.00		8	10.27	69	15	10.52	50
Lincoln's Sparrow	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	
White-crowned Sparrow	1	2.43	101	0	0.00		0	0.00		0	0.00		1	0.66	85
Dark-eyed Junco	0	0.00		0	0.00		0	0.00		0	0.00		0	0.00	
McCown's Longspur	0	0.00		0	0.00		73	51.71	40	0	0.00		0	0.00	
Black-headed Grosbeak	0	0.00		1	0.51	90	0	0.00		0	0.00		1	0.51	82
Red-winged Blackbird	9	29.43	29	0	0.00		3	2.74	57	28	45.26	68	100	94.09	42

	Department of Defense			Comanche National Grassland			Pawnee National Grassland			Arkansas River			North Platte River		
Species	n	D	%CV	n	D	%CV	n	D	%CV	n	D	%CV	n	D	%CV
Western Meadowlark	28	17.68	100	114	19.49	19	91	15.09	16	49	13.40	34	50	8.55	47
Brewer's Blackbird	0	0.00		0	0.00		2	1.40	60	3	3.46	91	9	6.49	70
Common Grackle	1	6.91	101	0	0.00		0	0.00		19	56.93	65	108	202.26	24
Brown-headed Cowbird	4	13.00	66	8	7.04	33	0	0.00		4	5.63	62	39	35.16	26
House Finch	0	0.00		2	3.35	91	0	0.00		12	32.14	91	108	180.78	40
Red Crossbill	0	0.00		0	0.00		0	0.00		0	0.00		4	1.45	88
Pine Siskin	0	0.00		0	0.00		0	0.00		0	0.00		3	1.91	84
House Sparrow	0	0.00		0	0.00		2	0.00		12	48.00	91	0	0.00	

Table 4, continued.

	North of Platte River			I-70 to Platte River			Arkansas River to I-70			South of Arkansas River		
Species	n	D	%CV	n	D	%CV	n	D	%CV	n	D	%CV
Killdeer	10	9.80	64	4	5.31	62	34	27.63	63	9	7.96	57
Mourning Dove	36	11.37	49	22	9.40	33	34	8.90	32	35	9.97	30
Broad-tailed Hummingbird	0	0.00		0	0.00		0	0.00		0	0.00	
Hairy Woodpecker	0	0.00		0	0.00		0	0.00		0	0.00	
Northern Flicker	2	0.52	82	0	0.00		0	0.00		0	0.00	
Western Wood-Pewee	0	0.00		0	0.00		0	0.00		0	0.00	
Dusky Flycatcher	0	0.00		0	0.00		0	0.00		0	0.00	
Gray Flycatcher	0	0.00		0	0.00		0	0.00		0	0.00	
Cordilleran Flycatcher	0	0.00		0	0.00		0	0.00		0	0.00	
Ash-throated Flycatcher	0	0.00		0	0.00		0	0.00		0	0.00	
Western Kingbird	18	8.33	51	19	11.90	36	34	13.04	47	21	8.77	60
Plumbeous Vireo	0	0.00		0	0.00		0	0.00		0	0.00	
Warbling Vireo	0	0.00		0	0.00		0	0.00		0	0.00	
Gray Jay	0	0.00		0	0.00		0	0.00		0	0.00	
Steller's Jay	0	0.00		0	0.00		0	0.00		0	0.00	
Western Scrub-Jay	0	0.00		0	0.00		0	0.00		0	0.00	
Pinyon Jay	0	0.00		0	0.00		0	0.00		0	0.00	
Clark's Nutcracker	0	0.00		0	0.00		0	0.00		0	0.00	
Black-billed Magpie	2	0.29	85	1	0.20	83	1	0.12	92	0	0.00	
American Crow	3	0.35	85	0	0.00		0	0.00		0	0.00	

	North of Platte River			I-70 to Platte River			Arkansas River to I-70			South of Arkansas River		
Species	n	D	%CV	n	D	%CV	n	D	%CV	n	D	%CV
Common Raven	0	0.00		0	0.00		0	0.00		0	0.00	
Horned Lark	358	187.42	20	273	210.01	18	513	234.59	16	89	42.03	16
Violet-green Swallow	0	0.00		0	0.00		0	0.00		0	0.00	
Cliff Swallow	3	4.99	88	0	0.00		2	2.76	65	1	1.50	90
Barn Swallow	8	24.30	75	0	0.00		21	52.87	92	5	13.70	82
Mountain Chickadee	0	0.00		0	0.00		0	0.00		0	0.00	
Red-breasted Nuthatch	0	0.00		0	0.00		0	0.00		0	0.00	
Rock Wren	0	0.00		0	0.00		0	0.00		0	0.00	
Bewick's Wren	0	0.00		0	0.00		0	0.00		0	0.00	
House Wren	0	0.00		0	0.00		0	0.00		0	0.00	
Ruby-crowned Kinglet	0	0.00		0	0.00		0	0.00		0	0.00	
Blue-gray Gnatcatcher	0	0.00		0	0.00		0	0.00		0	0.00	
Mountain Bluebird	0	0.00		0	0.00		0	0.00		0	0.00	
Townsend's Solitaire	0	0.00		0	0.00		0	0.00		0	0.00	
Hermit Thrush	0	0.00		0	0.00		0	0.00		0	0.00	
American Robin	32	30.02	65	4	5.08	53	1	0.78	89	2	1.69	88
Northern Mockingbird	0	0.00		0	0.00		4	0.59	50	30	4.78	45
American Pipit	0	0.00		0	0.00		0	0.00		0	0.00	
European Starling	26	10.73	51	1	0.00		1	0.34	83	10	3.72	89
Virginia's Warbler	0	0.00		0	0.00		0	0.00		0	0.00	
Yellow Warbler	6	2.96	82	0	0.00		0	0.00		0	0.00	
Yellow-rumped Warbler	0	0.00		0	0.00		0	0.00		0	0.00	
Black-throated Gray Warbler	0	0.00		0	0.00		0	0.00		0	0.00	
Western Tanager	0	0.00		0	0.00		0	0.00		0	0.00	
Green-tailed Towhee	0	0.00		0	0.00		0	0.00		0	0.00	
Spotted Towhee	0	0.00		0	0.00		0	0.00		0	0.00	
Cassin's Sparrow	30	8.95	60	35	14.13	59	61	15.08	35	81	21.80	21
Chipping Sparrow	0	0.00		0	0.00		0	0.00		0	0.00	
Brewer's Sparrow	0	0.00		0	0.00		4	1.70	69	3	1.39	44
Vesper Sparrow	6	1.67	88	0	0.00		0	0.00		0	0.00	
Lark Sparrow	5	2.80	84	19	14.41	42	4	1.86	82	17	8.60	49
Lark Bunting	14	3.04	44	41	12.05	67	17	3.06	60	90	17.64	27
Savannah Sparrow	0	0.00		0	0.00		0	0.00		0	0.00	

	North of Platte River			I-70 to Platte River			Arkansas River to I-70			South of Arkansas River		
Species	n	D	%CV	n	D	%CV	n	D	%CV	n	D	%CV
Grasshopper Sparrow	0	0.00		59	74.91	42	12	9.33	50	27	22.86	46
Song Sparrow	0	0.00		0	0.00		0	0.00		0	0.00	
Lincoln's Sparrow	0	0.00		0	0.00		0	0.00		0	0.00	
White-crowned Sparrow	0	0.00		0	0.00		0	0.00		0	0.00	
Dark-eyed Junco	0	0.00		0	0.00		0	0.00		0	0.00	
McCown's Longspur	82	62.50	85	0	0.00		0	0.00		0	0.00	
Black-headed Grosbeak	0	0.00		0	0.00		0	0.00		0	0.00	
Red-winged Blackbird	3	2.95	86	4	5.31	53	13	10.58	77	0	0.00	
Western Meadowlark	116	20.70	20	144	34.76	15	254	37.56	14	211	34.29	93
Brewer's Blackbird	2	1.50	85	2	2.04	85	0	0.00		0	0.00	
Common Grackle	44	85.98	65	7	18.51	53	3	4.86	61	2	3.53	89
Brown-headed Cowbird	1	0.92	83	1	1.24	87	3	2.28	61	1	0.83	88
House Finch	26	45.41	82	0	0.00		0	0.00		0	0.00	
Red Crossbill	0	0.00		0	0.00		0	0.00		0	0.00	
Pine Siskin	0	0.00		0	0.00		0	0.00		0	0.00	
House Sparrow	55	142.02	76	85	7.06	83	0	0.00		0	0.00	

Table 5. Estimated densities and population sizes (N) of 69 landbird species throughout Colorado[1], 2008

Species	Density	N	SE(N)	%CV	90% Confidence Limits (N)	
Killdeer	3.60	937,194	228,706	24	584,927	1,501,610
Mourning Dove	4.69	1,221,375	131,077	11	990,282	1,506,396
Broad-tailed Hummingbird	10.52	2,737,037	348,536	13	2,134,625	3,509,455
Hairy Woodpecker	2.22	577,077	198,161	34	299,946	1,110,261
Northern Flicker	0.75	195,491	32,389	17	141,595	269,901
Western Wood-Pewee	0.77	199,341	96,215	48	81,294	488,807
Dusky Flycatcher	1.57	408,364	155,906	38	198,179	841,466
Gray Flycatcher	2.43	631,188	101,149	16	461,969	862,391
Cordilleran Flycatcher	1.30	338,358	84,837	25	208,542	548,983
Ash-throated Flycatcher	0.64	166,012	51,659	31	91,487	301,245
Western Kingbird	2.53	658,604	108,291	16	478,184	907,096
Plumbeous Vireo	0.81	212,078	41,810	20	144,637	310,965
Warbling Vireo	2.00	520,742	75,514	15	392,488	690,905
Gray Jay	1.90	495,415	101,690	21	332,695	737,721
Steller's Jay	0.55	143,435	53,154	37	71,008	289,737
Western Scrub-Jay	0.23	60,802	13,981	23	38,967	94,871
Pinyon Jay	0.17	43,260	12,744	29	24,577	76,146
Clark's Nutcracker	0.25	63,886	10,114	16	46,934	86,961
Black-billed Magpie	0.19	48,926	9,689	20	33,311	71,861
American Crow	0.16	42,052	20,301	48	17,147	103,131
Common Raven	0.68	176,264	35,465	20	119,287	260,456
Horned Lark	32.67	8,501,050	630,897	7	7,351,688	9,830,103
Violet-green Swallow	3.90	1,013,766	197,078	19	695,011	1,478,713
Cliff Swallow	12.15	3,162,831	925,382	29	1,803,528	5,546,629
Barn Swallow	7.10	1,848,210	613,003	33	981,202	3,481,322
Mountain Chickadee	8.42	2,190,699	225,610	10	1,791,227	2,679,259
Red-breasted Nuthatch	0.44	115,586	24,996	22	76,020	175,746
Rock Wren	0.57	149,606	16,571	11	120,491	185,757
Bewick's Wren	0.61	159,923	38,064	24	100,947	253,355
House Wren	2.13	553,182	134,483	24	345,855	884,795
Ruby-crowned Kinglet	2.31	601,510	55,416	9	502,328	720,274
Blue-gray Gnatcatcher	8.10	2,107,232	203,074	10	1,745,300	2,544,220
Mountain Bluebird	0.54	140,953	41,759	30	79,832	248,869
Townsend's Solitaire	0.82	212,623	34,435	16	155,111	291,459
Hermit Thrush	1.46	381,144	47,653	13	298,591	486,520
American Robin	14.49	3,771,092	453,447	12	2,981,820	4,769,280
Northern Mockingbird	0.70	183,469	30,528	17	132,707	253,648
American Pipit	2.48	646,586	247,010	38	313,655	1,332,907
European Starling	2.44	633,865	150,928	24	400,039	1,004,363
Virginia's Warbler	1.39	361,627	92,327	26	220,982	591,785
Yellow Warbler	1.75	454,734	127,310	28	265,416	779,090
Yellow-rumped Warbler	6.60	1,717,475	188,994	11	1,385,168	2,129,504
Black-throated Gray Warbler	5.98	1,555,015	261,779	17	1,120,564	2,157,907
Western Tanager	1.15	300,098	41,610	14	228,981	393,303
Green-tailed Towhee	1.68	436,881	127,868	29	249,074	766,299
Spotted Towhee	2.21	576,160	142,313	25	357,598	928,305
Cassin's Sparrow	3.08	800,539	131,919	16	580,832	1,103,352

Species	Density	N	SE(N)	%CV	90% Confidence Limits (N)	
Chipping Sparrow	2.41	626,137	90,394	14	472,513	829,707
Brewer's Sparrow	1.18	306,034	59,153	19	210,255	445,444
Vesper Sparrow	0.46	120,906	50,346	42	55,216	264,746
Lark Sparrow	2.12	552,347	107,456	19	378,571	805,891
Lark Bunting	2.65	689,195	107,252	16	508,942	933,288
Savannah Sparrow	1.85	480,863	183,649	38	233,308	991,092
Grasshopper Sparrow	4.46	1,161,130	300,508	26	704,922	1,912,585
Song Sparrow	1.62	421,664	114,755	27	249,709	712,029
Lincoln's Sparrow	1.64	427,178	71,423	17	308,509	591,493
White-crowned Sparrow	4.77	1,242,168	254,344	20	834,975	1,847,938
Dark-eyed Junco	3.63	943,513	96,073	10	773,208	1,151,329
McCown's Longspur	3.87	1,006,663	505,224	50	397,586	2,548,808
Black-headed Grosbeak	0.53	136,750	47,707	35	70,381	265,706
Red-winged Blackbird	7.79	2,028,044	474,738	23	1,289,646	3,189,219
Western Meadowlark	7.41	1,929,635	339,146	18	1,370,897	2,716,099
Brewer's Blackbird	1.16	302,201	67,738	22	195,808	466,402
Common Grackle	12.91	3,359,189	733,572	22	2,200,434	5,128,147
Brown-headed Cowbird	2.82	733,929	122,175	17	530,789	1,014,813
House Finch	9.81	2,551,935	774,674	30	1,426,081	4,566,621
Red Crossbill	1.33	347,272	86,482	25	214,719	561,656
Pine Siskin	7.00	1,822,695	297,815	16	1,326,009	2,505,425
House Sparrow	6.74	1,753,381	1,032,060	59	602,014	5,106,765

[1] Excluding the portion of Colorado in BCR 10 (9251 km^2) and the Manti-La Sal National Forest (131 km^2).

DISCUSSION AND RECOMMENDATIONS

The spatially balanced sampling design we implemented for landbird monitoring throughout Colorado in 2008 may serve as a model for other broad-scale, long-term monitoring programs. Benefits of our design include:

- Spatially-balanced designs are statistically more efficient than simple random samples.
- Strata based on fixed attributes allow for relating changes in bird populations to changes on the landscape through time.
- Each BCR within a state can be stratified differently, depending upon local needs and areas to which one wants to make inferences.
- All vegetation types are available for sampling.
- The GRTS design can incorporate weighting by factors that influence species' distributions.
- Aggregation of strata-wide estimates to BCR- or state-wide estimates is built into the design.
- Because each stratum has its own spatially-balanced, ordered sample, sampling effort can vary among strata and among years and still provide statistically valid estimates.
- Local population trends can be directly compared to regional trends.
- Incorporating spatial information in data analysis can increase precision.
- Coordination among partners can reduce the costs of monitoring per partner.

We considered 2008 to be a pilot year for implementing this study design. We are currently evaluating whether the elevation and stream-order weighting we applied in BCR 16 provided an optimal sample distribution. It may be that the weight we applied to high elevation sites resulted in under-sampling at low- and mid-elevation locations within some strata, as evidenced by smaller-than-anticipated sample sizes for Pygmy Nuthatches and Grace's Warblers. Along with our monitoring partners, we are implementing this spatially-balanced, BCR-stratified design in other states. Within National Forests or National Parks with large wilderness areas, we are considering sub-stratifying based on wilderness/non-wilderness. We would then allocate fewer samples to wilderness areas to increase efficiency.

This report provides state-wide density and population estimates for 69 landbird species with sufficient sample sizes to estimate a detection function using Distance sampling theory. The next steps in our data analysis, which are beyond the scope of this report, are:

1. Use data from previous years of MCB monitoring, along with the 2008 data, to estimate detection functions for species with fewer than 60 observations in 2008, and estimate 2008 densities for these species.
2. Estimate densities using Removal modeling.
3. Estimate site occupancy for low-density species.
4. Post-stratify 2008 samples by vegetation cover types, calculate density estimates for species with robust sample sizes, and compare resulting estimates with estimates from the 1998-2007 MCB habitat-stratified samples.

Another area for future research is to better understand for each species what fraction of individuals detected are females. For example, if detections of "species x" are 100% singing males, the total population of males and females could be adjusted to approximately 2 times the current estimate. For "species y", it may be that detections are frequently clusters of 2 birds representing a mated pair. In this case, the estimate would not be adjusted. This

issue is currently being examined by the Partners in Flight science committee (Arvind Panjabi, personal communication). An alternative approach to this question would be to calculate density estimates from a subset of the data known to represent male birds. This would work best for species that are sexually dimorphic.

We intend to incorporate vegetation sampling into the MCB study design after we have settled issues of cell weighting. Each sample grid could be surveyed by a two-person crew, sampling, for example, 1/3 of grids every three years. This will allow us to examine finer-scale avian-habitat associations than are possible with vegetation data collected by the bird survey personnel through simple ocular estimation.

In addition to vegetation sampling, we could sample owls and other taxa at the same grids used to sample diurnal birds. We will collaborate on a pilot study on the White River National Forest in 2009, surveying for forest owls at the MCB sample grids.

LITERATURE CITED

Beason, J., R. Sparks, J. Blakesley, C. White, A. Panjabi, and D. Hanni. 2007. Monitoring Colorado's birds: 2007 field season report. Tech. Rep. M-MCB07-01. Rocky Mountain Bird Observatory, Brighton, CO, 307 pp.

Birdlife International. 2003. Biodiversity Indicator for Europe: Population Trends of Wild Birds. http://www.birdlife.org/action/science/indicators/pdfs/eur _biodiversity_ indicators

Buckland, S. T., D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borchers, and L. Thomas. 2001. Introduction to Distance Sampling. Oxford University Press, London, UK.

Colorado Division of Wildlife. 2006. Colorado's Comprehensive Wildlife Conservation Strategy. Unpublished report, Denver, CO, 328 pp.

Farnsworth, G. L., K. H. Pollock, J. D. Nichols, T. R. Simons, J. E. Hines, and J. R. Sauer. 2002. A removal model for estimating detection probabilities from point-count surveys. Auk 119:414-425.

Hanni, D. J., C. M. White, J. A. Blakesley, G. J. Levandoski, and J. J. Birek. 2009. Field protocol for spatially-balanced sampling of landbird populations. Unpublished report. Rocky Mountain Bird Observatory, Brighton, CO. 28 pp. http://www.rmbo.org/public/monitoring/.

Hutto, R. L. 1998. Using landbirds as an indicator species group. Pp. 75-92 in J. M. Marzluff and R. Sallabanks (eds.), Avian conservation: Research and Management. Island Press, Washington, DC.

Kincaid, T. 2008. User Guide for spsurvey, version 2.0; Probability Survey Design and Analysis Functions.

Manley, P. N., W. M. Block, F. R. Thompson, G. S. Butcher, C. Paige, L. H. Suring, D. S. Winn, D. Roth, C. J. Ralph, E. Morris, C. H. Flather, and K. Byford. 1993. Guidelines for Monitoring Populations of Neotropical Migratory Birds on National Forest System Lands. USDA Forest Service, Washington. 35 pp.

Morrison, M. 1986. Bird populations as indicators of environmental change. Current Ornithology 3:429-451.

O'Connell, T. J., L. E. Jackson, and R. P. Brooks. 2000. Bird guilds as indictors of ecological condition in the central Appalachians. Ecological Applications 10:1706-1721.

R Development Core Team. 2008. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org.

Rich, T. D. 2002. Using breeding land birds in the assessment of western riparian systems. Wildlife Society Bulletin 30(4):1128-1139.

Rich, T. D., C. J. Beardmore, H. Berlanga, P. J. Blancher, M. S. W. Bradstreet, G. S. Butcher, D. W. Demarest, E. H. Dunn, W. C. Hunter, E. E. Iñigo-Elias, J. A. Kennedy, A. M. Martell, A. O. Panjabi, D. N. Pashley, K. V. Rosenberg, C. M. Rustay, J. S. Wendt, T. C. Will. 2004. Partners in Flight North American Landbird Conservation Plan. Cornell Lab of Ornithology. Ithaca, NY.

Royle, J. A. and Nichols, J. D. 2003. Estimating abundance from repeated presence absence data or point counts. Ecology 84:777-790.

Sauer, J. R. 1993. Monitoring Goals and Programs of the U.S. Fish and Wildlife Service. In Finch, D.M. and P.W. Stangel (eds.) Status and Management of Neotropical Migratory Birds; 1992 Set. 21-25; Estes Park, Co. Gen. Tech. Rep. RM-229. Fort Collins, CO. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 422 pp.

Stevens, D. L., and A. R. Olsen. 2004. Spatially balanced sampling of natural resources. Journal of the American Statistical Association 99:262-278.

NABCI (U.S. North American Bird Conservation Initiative Monitoring Subcommittee). 2007. Opportunities for Improving Avian Monitoring. U.S. North American Bird Conservation Initiative Report. 50 pp. Division of Migratory Bird Management, U.S. Fish and Wildlife Service, Arlington, VA; http://www.nabci-us.org/.

Theobald, D. M. and J. B. Norman. 2006. Spatially-balanced sampling using the Reversed Randomized Quadrant-Recursive Raster algorithm: A User's Guide for the RRQRR ArcGIS v9.1 tool. URL: http://www.nrel.colostate.edu/projects/starmap.

Thomas, L., J. L. Laake, S. Strindberg, F. C. C. Marques, S. T. Buckland, D. L. Borchers, D. R. Anderson, K. P. Burnham, S. L. Hedley, J. H. Pollard, J. R. B. Bishop, and T. A. Marques. 2006. Distance 5.0. Release 2. Research Unit for Wildlife Population Assessment, University of St. Andrews, UK.

U.S. Environmental Protection Agency. 2002. Methods for evaluating wetland condition: biological assessment methods for birds. Office of Water, U.S. Environmental Protection Agency, Washington, D.C. EPA-822-R-02-023.

APPENDIX A

Number of birds detected, by stratum, in the Southern Rockies/Colorado Plateau Bird Conservation Region (16) within Colorado, 2008.

	Stratum												
		National Forests								NPS I & M Networks			
Species	BLM	Arapaho-Roosevelt	Grand Mesa-Gunnison-Uncompahgre	Manti-La Sal	Pike-San Isabel	Rio Grande	Routt	San Juan	White River	Northern Colorado Plateau	Rocky Mountain	Southern Colorado Plateau	All Other Lands
Pied-billed Grebe	2												
Clark's Grebe	1												
American White Pelican													4
Double-crested Cormorant													
Great Blue Heron													1
Great Egret													1
Green Heron													
Black-crowned Night-heron													1
White-faced Ibis													5
Turkey Vulture	3												
Canada Goose	4					2							7
Gadwall						1							2
Mallard	3					2			1				10
Northern Shoveler													
Northern Pintail													1
American Green-winged Teal													2
Canvasback													
Redhead													2
Lesser Scaup	1												
Common Merganser													1
Ruddy Duck													
Osprey													1
Mississippi Kite													
Bald Eagle	1												
Northern Harrier	3												
Sharp-shinned Hawk													1
Cooper's Hawk								2	2	1			1

	Stratum												
		National Forests								NPS I & M Networks			
Species	BLM	Arapaho-Roosevelt	Grand Mesa-Gunnison-Uncompahgre	Manti-La Sal	Pike-San Isabel	Rio Grande	Routt	San Juan	White River	Northern Colorado Plateau	Rocky Mountain	Southern Colorado Plateau	All Other Lands
Northern Goshawk			1				2						
Swainson's Hawk						2							
Red-tailed Hawk	7						2		1				8
Ferruginous Hawk													
Golden Eagle	2											1	
American Kestrel	4												13
Peregrine Falcon													
Common Peafowl													1
Chukar	4												
Ring-necked Pheasant													2
Dusky Grouse	1	2						1					
Wild Turkey													
Northern Bobwhite													
Scaled Quail													
Virginia Rail													
American Coot	1												2
Sandhill Crane	1												3
Killdeer	10												22
Mountain Plover													
Spotted Sandpiper	6					1							1
Long-billed Curlew													
Wilson's Snipe													13
Wilson's Phalarope													
California Gull											4		2
Rock Pigeon	2												2
Band-tailed Pigeon					1								
Eurasian Collared-Dove													2
Mourning Dove	144		1	10	3	5		5	4	6	8	7	80
Great Horned Owl													1
Burrowing Owl													

Species	Stratum												
	BLM	National Forests								NPS I & M Networks			All Other Lands
		Arapaho-Roosevelt	Grand Mesa-Gunnison-Uncompahgre	Manti-La Sal	Pike-San Isabel	Rio Grande	Routt	San Juan	White River	Northern Colorado Plateau	Rocky Mountain	Southern Colorado Plateau	
Common Nighthawk	1		1										5
Common Poorwill													2
Chimney Swift													
White-throated Swift	27							3		8		1	3
Black-chinned Hummingbird	18			1								1	14
Broad-tailed Hummingbird	39	16	7		24	8	21	11	15	1	10	5	50
Rufous Hummingbird			1				1						
Belted Kingfisher													
Lewis's Woodpecker													
Red-headed Woodpecker													
Red-naped Sapsucker	1				1	1	9	5	13		2		
Williamson's Sapsucker		1	1						5				
Downy Woodpecker							4						2
Hairy Woodpecker	10	3		1			37	3	14	3			4
American Three-toed Woodpecker			5				7	3	5				
Northern Flicker	28	5	6	3	10	4	10	11	7		3	1	29
Northern Flicker (Red-shafted)							3				1		3
Northern Flicker (Yellow-shafted)													
Olive-sided Flycatcher	1	3					5	1	4				1
Western Wood-Pewee	13	4		1	3	5	63	16	12		15		34
Willow Flycatcher													2
Least Flycatcher	1												
Hammond's Flycatcher	1	1			6	4	5	3	2				9
Dusky Flycatcher	42	2	1		2	3	25	9	13			6	16
Gray Flycatcher	104			6						21		1	5
Cordilleran Flycatcher	3	1	6		12	10	9	2	5		7		12
Say's Phoebe	11									1			8
Ash-throated Flycatcher	80			5						8		3	15
Cassin's Kingbird	2												
Western Kingbird	14												19

	Stratum												
		National Forests								NPS I & M Networks			
Species	BLM	Arapaho-Roosevelt	Grand Mesa-Gunnison-Uncompahgre	Manti-La Sal	Pike-San Isabel	Rio Grande	Routt	San Juan	White River	Northern Colorado Plateau	Rocky Mountain	Southern Colorado Plateau	All Other Lands
Eastern Kingbird													
Loggerhead Shrike													2
Gray Vireo	25			5						3			
Plumbeous Vireo	55			1	4			10		5		1	19
Warbling Vireo	19	7	6		13	14	94	17	45				63
Gray Jay		14	12		6		18	8	8				
Steller's Jay	7				19	1	1	13	14		9		7
Blue Jay													
Western Scrub-Jay	59			2						1			4
Pinyon Jay	46			3		5				4		1	8
Clark's Nutcracker	13	5	5		18	7	21	11	11		2		6
Black-billed Magpie	18					1						3	52
American Crow	12								3	3	5		24
Chihuahuan Raven	1		1										1
Common Raven	35	9	2	4	3	2	8	6	2	1	4	7	28
Horned Lark	119	7			1	11		8	9				95
Purple Martin	1												
Tree Swallow	5				1	4	7	1					7
Violet-green Swallow	36		1	2	2	3	9	7	3	2	7		48
Northern Rough-winged Swallow	2												10
Bank Swallow	1												
Cliff Swallow	60					16						3	36
Barn Swallow	3					1							20
Black-capped Chickadee	5						2						8
Mountain Chickadee	12	57	53	2	54	52	86	63	36		8		18
Juniper Titmouse	29			2						1			4
Bushtit	25			6									15
Red-breasted Nuthatch	1	6	6		4	6	22	11	9				1
White-breasted Nuthatch	15			1	3	1		17	1		4		7
Pygmy Nuthatch								15	2		8		2

Species	Stratum												
	BLM	National Forests								NPS I & M Networks			All Other Lands
		Arapaho-Roosevelt	Grand Mesa-Gunnison-Uncompahgre	Manti-La Sal	Pike-San Isabel	Rio Grande	Routt	San Juan	White River	Northern Colorado Plateau	Rocky Mountain	Southern Colorado Plateau	
Brown Creeper			1		2	1	2	5	4				
Rock Wren	112			4		1	5			9		2	17
Canyon Wren	21				3								2
Bewick's Wren	54			9						5		1	6
House Wren	6	1	2		4	2	29	8	9	2	5		56
Marsh Wren													
American Dipper					1								
Golden-crowned Kinglet		1			2		3	2	5				
Ruby-crowned Kinglet	4	61	57		36	27	101	48	56		1		12
Blue-gray Gnatcatcher	151			12						6		15	37
Western Bluebird	1							4			3		4
Mountain Bluebird	66	4		3	2	11	7				3		19
Townsend's Solitaire	3	13	3		23	6	26	8	19		2	1	7
Swainson's Thrush					1		8		1				
Hermit Thrush	13	58	55		44	42	129	50	44	1		2	19
American Robin	72	53	36	1	42	31	151	36	44	4	11	3	121
Gray Catbird	1												5
Northern Mockingbird	5												
Sage Thrasher	30												14
Brown Thrasher													
American Pipit	17	25	53		6		18	24	29				6
Cedar Waxwing		2					1						
European Starling													53
Northern Parula			1										
Orange-crowned Warbler	10						4	1	5			1	13
Virginia's Warbler	91											6	25
Yellow Warbler	13				1		1		3	1			79
Yellow-rumped Warbler	1	1	2				1	28	22				2
Yellow-rumped Warbler (Audubon's)	2	32	62		80	37	155	41	32		12		19
Yellow-rumped Warbler (Myrtle)													

	Stratum												
		National Forests								NPS I & M Networks			
Species	BLM	Arapaho-Roosevelt	Grand Mesa-Gunnison-Uncompahgre	Manti-La Sal	Pike-San Isabel	Rio Grande	Routt	San Juan	White River	Northern Colorado Plateau	Rocky Mountain	Southern Colorado Plateau	All Other Lands
Black-throated Gray Warbler	249			13	1					26		1	11
Grace's Warbler						1							
MacGillivray's Warbler	5				1	1	7	4	7				5
Common Yellowthroat													
Wilson's Warbler	3	2	2		8		10		1				2
Yellow-breasted Chat													
Hepatic Tanager													
Western Tanager	39	5	3	1	4	2	40	29	37	1	3	3	20
Green-tailed Towhee	131		4	2	5	5	1	10	10		6		77
Spotted Towhee	164			8								17	71
Cassin's Sparrow													
Rufous-crowned Sparrow													
Chipping Sparrow	151	3	8	3	7	4	39	25	20	4	1	6	22
Brewer's Sparrow	160			2		1	2			1			57
Vesper Sparrow	84			1		2	9			1	7		87
Lark Sparrow	40			3						1			41
Black-throated Sparrow	4												
Sage Sparrow	52												4
Lark Bunting	1												
Savannah Sparrow		18			3	17	5						57
Grasshopper Sparrow													
Fox Sparrow		2	2										
Song Sparrow	4					1	2				2	3	26
Lincoln's Sparrow		26	9		17	11	36	23	11		1		2
White-crowned Sparrow	5		33			26	9	17			3		
White-crowned Sparrow (Mountain)		56	3		13		38		53				7
Dark-eyed Junco	2	52	20		7	36	114	85	70				16
Dark-eyed Junco (Gray-headed)	3	17	6		38	6	52				6		4
McCown's Longspur													
Black-headed Grosbeak	86			2			1					7	40

	Stratum												
		National Forests								NPS I & M Networks			
Species	BLM	Arapaho-Roosevelt	Grand Mesa-Gunnison-Uncompahgre	Manti-La Sal	Pike-San Isabel	Rio Grande	Routt	San Juan	White River	Northern Colorado Plateau	Rocky Mountain	Southern Colorado Plateau	All Other Lands
Blue Grosbeak	1												1
Lazuli Bunting	18						1					7	13
Indigo Bunting													
Bobolink													2
Red-winged Blackbird	12					10					1		83
Western Meadowlark	99					16				6		1	228
Yellow-headed Blackbird	1												1
Brewer's Blackbird	33			2		5	2						55
Common Grackle													6
Great-tailed Grackle													
Brown-headed Cowbird	32			2		1		3					37
Orchard Oriole													
Baltimore Oriole													
Bullock's Oriole	3												13
Brown-capped Rosy-finch	8	5	2						2		1		7
Pine Grosbeak		13	9		7		9	1	3				
Cassin's Finch	5	2	3				10	1	7	2	1		1
House Finch	48			8					1	2			32
Red Crossbill		16	23		17	8	13	22	13		10		8
White-winged Crossbill			3										
Pine Siskin	24	80	27		30	45	100	67	51		12		42
Lesser Goldfinch	8						1	1					9
American Goldfinch	2						1			1			16
Evening Grosbeak	1	1	3			1	1	1	1				
House Sparrow													2
Points surveyed[1]	442	115	100	16	103	96	238	92	93	19	18	19	264

[1]The sampling unit was a grid of 16 points; however, because not all points were completed within each grid, the number of points are provided here.

APPENDIX B

Number of birds detected, by stratum, in the Shortgrass Prairie Bird Conservation Region (18) within Colorado, 2008.

	Stratum								
Species	DOD	Comanche National Grassland	Pawnee National Grassland	Arkansas River	North Platte River	North of Platte River	I-70 to Platte River	Arkansas River to I-70	South of Arkansas River
Pied-billed Grebe									
Clark's Grebe									
American White Pelican					2				
Double-crested Cormorant	1			1	1		1		
Great Blue Heron				2	4	1		1	
Great Egret					1				
Green Heron					1				
Black-crowned Night-heron					1				
White-faced Ibis				1					
Turkey Vulture				1	2				1
Canada Goose					6				
Gadwall									
Mallard	3			5	5	5			
Northern Shoveler	1								
Northern Pintail				1					
American Green-winged Teal									
Canvasback	1								
Redhead									
Lesser Scaup	1								
Common Merganser									
Ruddy Duck	4								
Osprey				1					
Mississippi Kite				1					
Bald Eagle									
Northern Harrier	3	5		1				1	
Sharp-shinned Hawk					1				
Cooper's Hawk									

	Stratum								
Species	DOD	Comanche National Grassland	Pawnee National Grassland	Arkansas River	North Platte River	North of Platte River	I-70 to Platte River	Arkansas River to I-70	South of Arkansas River
Northern Goshawk									
Swainson's Hawk	2	6	2	3	2	3	6	4	
Red-tailed Hawk					8			4	3
Ferruginous Hawk			3						
Golden Eagle									
American Kestrel	1	1		3	12	2	1	1	2
Peregrine Falcon				1					
Common Peafowl									
Chukar									
Ring-necked Pheasant	1				11	4	7	1	
Dusky Grouse									
Wild Turkey					2				
Northern Bobwhite					3				
Scaled Quail	3								1
Virginia Rail					2				
American Coot	1								
Sandhill Crane									
Killdeer	2	11	7	10	18	18	8	36	11
Mountain Plover			3				2	3	2
Spotted Sandpiper					2				
Long-billed Curlew		2							
Wilson's Snipe					1				
Wilson's Phalarope	1								
California Gull						1	2		
Rock Pigeon	3		1	12	7	7	1		
Band-tailed Pigeon									1
Eurasian Collared-Dove					7	8	2		
Mourning Dove	9	39	13	29	55	44	39	46	50
Great Horned Owl									
Burrowing Owl			3					1	

	Stratum							
Species	DOD	Comanche National Grassland	Pawnee National Grassland	Arkansas River	North Platte River	North of Platte River	I-70 to Platte River	Arkansas River to I-70	South of Arkansas River
Common Nighthawk		4	4			2	1	2	1
Common Poorwill									
Chimney Swift				1					
White-throated Swift									
Black-chinned Hummingbird		3							
Broad-tailed Hummingbird	1			1					
Rufous Hummingbird									
Belted Kingfisher				1	2				
Lewis's Woodpecker				2					
Red-headed Woodpecker	1			1	2			1	
Red-naped Sapsucker									
Williamson's Sapsucker									
Downy Woodpecker				2	3				
Hairy Woodpecker									
American Three-toed Woodpecker									
Northern Flicker				2	9				
Northern Flicker (Red-shafted)					8	3			
Northern Flicker (Yellow-shafted)					3				
Olive-sided Flycatcher									
Western Wood-Pewee				2	7			1	
Willow Flycatcher									
Least Flycatcher									
Hammond's Flycatcher									
Dusky Flycatcher									
Gray Flycatcher		1							
Cordilleran Flycatcher									
Say's Phoebe	1	3	3	1	1	1		2	6
Ash-throated Flycatcher		2		1					
Cassin's Kingbird		1						3	
Western Kingbird	4	15	1	13	20	18	22	38	24

	Stratum								
Species	DOD	Comanche National Grassland	Pawnee National Grassland	Arkansas River	North Platte River	North of Platte River	I-70 to Platte River	Arkansas River to I-70	South of Arkansas River
Eastern Kingbird	3	2		2	17	2		2	1
Loggerhead Shrike	1	3							
Gray Vireo									
Plumbeous Vireo									
Warbling Vireo					10				
Gray Jay									
Steller's Jay									
Blue Jay				2	13			1	
Western Scrub-Jay									
Pinyon Jay									
Clark's Nutcracker									
Black-billed Magpie				4	3	3	1	2	
American Crow				1	6	3			
Chihuahuan Raven		3							7
Common Raven				1	1				
Horned Lark	10	238	375	44	3	372	301	541	163
Purple Martin									
Tree Swallow									
Violet-green Swallow				1	2				
Northern Rough-winged Swallow				3	3				
Bank Swallow				2	24				
Cliff Swallow	21	9	2	29	20	3	1	2	2
Barn Swallow	8		1	6	12	10		22	5
Black-capped Chickadee				2	9	2			
Mountain Chickadee		3							
Juniper Titmouse									
Bushtit		6		1					
Red-breasted Nuthatch									
White-breasted Nuthatch				1	4				
Pygmy Nuthatch									

	Stratum							
Species	DOD	Comanche National Grassland	Pawnee National Grassland	Arkansas River	North Platte River	North of Platte River	I-70 to Platte River	Arkansas River to I-70	South of Arkansas River
Brown Creeper				1					
Rock Wren		1	3	2					
Canyon Wren									
Bewick's Wren		4							
House Wren				10	29				
Marsh Wren					1				
American Dipper									
Golden-crowned Kinglet									
Ruby-crowned Kinglet									
Blue-gray Gnatcatcher	2	5		2					
Western Bluebird									
Mountain Bluebird		1							
Townsend's Solitaire									
Swainson's Thrush					1				
Hermit Thrush									
American Robin	4	3		20	136	33	7	1	3
Gray Catbird	1			1					
Northern Mockingbird	19	8		10			1	5	30
Sage Thrasher									
Brown Thrasher	1				1				
American Pipit									
Cedar Waxwing					1	2		1	
European Starling			2	36	89	31	4	4	14
Northern Parula									
Orange-crowned Warbler									
Virginia's Warbler									
Yellow Warbler	6			19	31	6		2	
Yellow-rumped Warbler									
Yellow-rumped Warbler (Audubon's)	4				2				
Yellow-rumped Warbler (Myrtle)	1								

	Stratum							
Species	DOD	Comanche National Grassland	Pawnee National Grassland	Arkansas River	North Platte River	North of Platte River	I-70 to Platte River	Arkansas River to I-70	South of Arkansas River
Black-throated Gray Warbler									
Grace's Warbler									
MacGillivray's Warbler	1				1				
Common Yellowthroat	4				7				
Wilson's Warbler									
Yellow-breasted Chat	7			1					
Hepatic Tanager		1							
Western Tanager									
Green-tailed Towhee									
Spotted Towhee		5		5	3				
Cassin's Sparrow	6	98	16	25		33	36	68	107
Rufous-crowned Sparrow		1							
Chipping Sparrow		2		4	1				
Brewer's Sparrow	1	15	15	1				4	8
Vesper Sparrow				1	1	7			
Lark Sparrow	6	11	1	12	1	6	22	4	23
Black-throated Sparrow									
Sage Sparrow									
Lark Bunting		150	73	36		16	41	17	111
Savannah Sparrow					1				
Grasshopper Sparrow		36	7	3			60	12	38
Fox Sparrow									
Song Sparrow				11	16				
Lincoln's Sparrow									
White-crowned Sparrow	1				1				
White-crowned Sparrow (Mountain)									
Dark-eyed Junco									
Dark-eyed Junco (Gray-headed)									
McCown's Longspur			78			94			
Black-headed Grosbeak		1			2				

	Stratum								
Species	DOD	Comanche National Grassland	Pawnee National Grassland	Arkansas River	North Platte River	North of Platte River	I-70 to Platte River	Arkansas River to I-70	South of Arkansas River
Blue Grosbeak	1					1			2
Lazuli Bunting		1							
Indigo Bunting	1								
Bobolink									
Red-winged Blackbird	15		3	33	117	4	8	19	
Western Meadowlark	28	162	96	71	52	141	164	288	245
Yellow-headed Blackbird	3			2			1		
Brewer's Blackbird			2	3	9	2	3		
Common Grackle	1			19	126	64	14	3	3
Great-tailed Grackle	1			1		1			
Brown-headed Cowbird	4	12		6	42	1	1	5	2
Orchard Oriole	1				5				
Baltimore Oriole					3				
Bullock's Oriole	4			1	12	5	1	1	4
Brown-capped Rosy-finch									
Pine Grosbeak									
Cassin's Finch									
House Finch		4		12	110	28	1		
Red Crossbill					4				
White-winged Crossbill									
Pine Siskin					3				
Lesser Goldfinch				2					
American Goldfinch			1		18				
Evening Grosbeak									
House Sparrow				13	95	64	6		2
Points surveyed[1]	26	96	99	60	96	92	68	111	102

[1]The sampling unit was a grid of 16 points; however, because not all points were completed within each grid, the number of points are provided here.