Monitoring Bird Populations in Wind Cave National Park

January 2010

Rocky Mountain Bird Observatory

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:

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.*

Suggested Citation:
J. A. Blakesley, D. C. Pavlacky Jr., and D. J. Hanni. 2010. Monitoring Bird Populations in Wind Cave National Park. Tech. Rep. M-WICA09-01. Rocky Mountain Bird Observatory, Brighton, CO, 9 pp.

Cover Photo:
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Contact Information:
Jennifer Blakesley jennifer.blakesley@rmbo.org
RMBO
PO Box 1232
Brighton, CO 80603
303-659-4348

EXECUTIVE SUMMARY

Rocky Mountain Bird Observatory, in cooperation with the National Park Service, designed and implemented a program to monitor birds in Wind Cave National Park in 2008 and 2009. The study design consisted of a spatially balanced sample of 20 sampling units, each consisting of a grid of 9 points from which we surveyed birds. We used Distance sampling to estimate density of avian species with moderate to large sample sizes. For less abundant species we estimated the proportion of sample grids occupied. Estimates of density and occupancy incorporated estimates of detection probability.

We surveyed each point three times during the avian breeding season each year and obtained sufficient numbers of detections to estimate density of 22 species and occupancy rate of an additional 10 species. We were able to estimate densities of five species designated by Partners in Flight as stewardship species or species of concern in the Badlands and Prairies Bird Conservation Region.

Monitoring birds can be an important component of effective ecosystem management. We recommend that the National Park Service continue to monitor birds at Wind Cave National Park following the sampling design implemented by Rocky Mountain Bird Observatory.

ACKNOWLEDGEMENTS

This project was funded by the National Park Service through an agreement with the Rocky Mountain Bird Observatory (RMBO). This report constitutes the fulfillment of the requirements in our contract with the National Park Service (Task Agreement # J60670800018).

We sincerely thank Marcia Wilson of the National Park Service for funding and supporting the project. We are grateful to Emily Jerman for conducting surveys in 2008 and 2009, sometimes under difficult conditions.

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INTRODUCTION

Wind Cave National Park was originally established in 1903 to protect its namesake cave. Over time, the Park was enlarged to conserve 11,451 hectares of mixed-grass prairie and lodgepole pine (*Pinus contorta*) forest adjacent to the cave. To effectively protect and preserve these ecosystems, the National Park Service is charged with managing the Park's natural resources, from bison (*Bison bison*) to birds and from plant communities to the unique features of Wind Cave.

Bird populations are excellent indicators of ecosystem health (Morrison 1986; Hutto 1998; NABCI 2009). Because birds are conspicuous and relatively easy to identify, and because bird communities often reflect the abundance and distribution of other organisms with which they coexist, monitoring birds can be an important component of effective ecosystem management.

METHODS

Rocky Mountain Bird Observatory surveyed birds in Wind Cave National Park, during the breeding seasons of 2008 and 2009. We developed a spatially balanced sampling design within the Park prior to the 2008 field season (Stevens and Olson 2004). Sampling units were 750 x 750 meter grids; each grid contained 9 sampling points, with 250 meter spacing between points. Grids were not excluded if the grid center fell within Park boundaries; however, we excluded sampling points that fell outside of park boundaries. We selected 20 grids for sampling, with three surveys conducted at each sampling point each year.

We surveyed birds using methods that allow for estimating detection probability through the principles of Distance sampling and Occupancy estimation. We used Distance sampling to estimate density of avian species with moderate to large sample sizes. For less abundant species we estimated the proportion of sample grids occupied.

Distance sampling theory estimates detection probability as a function of the distances between the observer and the birds detected (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. The assumptions of Distance sampling theory are reasonably well met following our sampling protocol (Hanni et al. 2009).

Occupancy estimation is commonly used to quantify the proportion of sample units occupied by an organism (MacKenzie et al. 2002). Occupancy estimation theory uses a detection probability to adjust the proportion of sites occupied to account for species that were present but undetected (MacKenzie et al. 2002). We used our data to estimate the site occupancy of low-density species for which we had too few detections to estimate population density. Occupancy estimation requires multiple surveys to the sample unit in time or space (MacKenzie and Royle 2005). Under our sampling framework, we estimated the detection probabilities (p) using three repeat visits in time. The nine grid points served as spatial replicates for estimating the proportion of points occupied within the 1-km^2 sampling cells. The assumptions of occupancy estimation are 1) the probabilities of detection and occupancy are constant across the sample units, 2) each point is closed to changes in occupancy over the sampling season, 3) the detection of species at each point are independent and 4) the target species are never falsely detected (MacKenzie et al. 2006).

One field technician conducted seven-minute point counts at each accessible survey point within the sample grids. For each bird detected, the technician recorded the species, its sex, how it was detected (call, song, drumming, or visual), and distance from the sampling point. Distances were measured using a laser rangefinder. The technician conducted all surveys in the morning, between one-half hour before sunrise and 11 AM, from 24 May to 9 July 2008 and from 24 May to 11 July 2009. The technician completed a 5 day training program at the beginning of the 2008 season to ensure full understanding of the field protocol and to practice distance estimation.

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 6.0 (Thomas et al. In press) to estimate the detection probability, expected cluster size and 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). The required sample size for estimating a detection function is at least 60-80 independent detections. It is possible, using program DISTANCE, to construct a common detection function across years, and obtain separate density estimates for each year. We modeled detection functions of each species across years and separately for each year. 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.

We used the multi-scale occupancy model (Nichols et al. 2008) in program MARK (White and Burnham 1999) to estimate 1) the proportion of 1-km^2 sampling units occupied by a species [Psi], 2) the proportion of points occupied by a species given presence within the1-km^2 sampling units [Theta] and 3) the probability of detecting a species given presence [p]. Our application of the multi-scale model is analogous to a within-season robust design (Pollock 1982) where the points are the primary samples for estimating Theta and the repeat visits to the each point are the secondary samples for estimating p (Nichols et al. 2008). We considered both Theta and p to be nuisance variables that were important for generating unbiased estimates of Psi. Theta can be considered an availability parameter or the probability that a species was present and available for sampling at the points (Nichols et al. 2008). We used a constrained parameterization and held Theta and p constant. We truncated the data, using only detections within 125 m of the sample points (half of the distance between sampling points).

RESULTS

We detected 4,547 birds of 87 species in 2008 and 4,086 individuals of 82 species in 2009 (99 species across both years; Appendix A). Using data from both years, we were able to estimate densities of 22 species (Table 1). Using data from only 2009, we were able to estimate the proportion of sampling grids occupied by 10 additional species for which we had at least 10 detections (Table 2).

DISCUSSION AND RECOMMENDATIONS

The "State of the Birds, United States of America 2009" reported that populations of many avian species declined during the past 40 years, with grassland birds experiencing particularly steep and steady declines (NABCI 2009). Within the

Badlands and Prairies Bird Conservation Region, in which Wind Cave National Park is situated, 18 bird species were designated as stewardship species or species of concern or by Partners in Flight (Rich et al. 2004). Among these species, we detected five on > 20 occasions across the two survey years. We were able to estimate densities of all five species: Black-billed Magpie (*Pica hudsonia*), Mountain Bluebird (*Sialia currucoides*), Vesper Sparrow (*Pooecetes gramineus*), Grasshopper Sparrow (*Ammodramus savannarum*) and Western Meadowlark (*Sturnella neglecta*).

Table 1. Sample sizes (*n*), estimated densities ($\hat{D}$; number of birds/km^2), 90% Upper and Lower Confidence Limits (LCL & UCL), and percent coefficient of variation (%CV) for 22 avian species in Wind Cave National Park, 2008 and 2009. Sample size represents the number of independent detections used to estimate the detection function.

Species	Year	*n*	$\hat{D}$	SE($\hat{D}$)	LCL	UCL	%CV
Mourning Dove	2008	57	14.08	3.81	9.10	21.80	27
	2009	41	10.17	2.93	6.38	16.18	29
Northern Flicker	2008	29	2.54	0.62	1.70	3.78	25
	2009	33	2.67	0.68	1.77	4.03	25
Black-billed Magpie	2008	52	1.61	0.42	1.06	2.45	26
	2009	10	0.09	0.03	0.05	0.15	34
American Crow	2008	51	9.27	3.09	5.43	15.82	33
	2009	16	2.92	1.10	1.61	5.31	38
Horned Lark	2008	66	13.18	6.50	6.11	28.39	49
	2009	27	2.75	1.49	1.19	6.33	54
Black-capped Chickadee	2008	51	26.55	7.64	16.70	42.23	29
	2009	31	16.20	4.69	10.16	25.83	29
Red-breasted Nuthatch	2008	58	12.11	4.30	6.87	21.33	35
	2009	50	10.48	3.80	5.88	18.67	36
Rock Wren	2008	53	5.44	1.87	3.13	9.43	34
	2009	23	2.50	0.98	1.35	4.66	39
House Wren	2008	27	1.01	0.32	0.62	1.68	31
	2009	49	1.85	0.44	1.24	2.72	24
Mountain Bluebird	2008	93	21.87	5.46	14.60	32.77	25
	2009	83	19.59	5.05	12.90	29.73	26
American Robin	2008	58	76.27	28.04	42.46	136.99	37
	2009	44	58.09	21.92	31.87	105.87	38
Yellow-rumped Warbler	2008	30	2.30	0.75	1.37	3.88	33
	2009	32	2.46	0.79	1.48	4.10	32
Ovenbird	2008	27	1.39	0.80	0.57	3.33	58
	2009	37	1.91	0.85	0.95	3.83	44
Western Tanager	2008	49	17.18	5.23	10.52	28.03	30
	2009	92	12.17	4.55	6.70	22.07	37
Spotted Towhee	2008	82	72.53	19.96	46.50	113.12	28
	2009	79	70.15	22.70	41.74	117.88	32
Chipping Sparrow	2008	158	180.06	33.63	132.78	244.18	19
	2009	158	180.77	30.63	137.07	238.42	17
Vesper Sparrow	2008	91	13.93	3.86	8.90	21.80	28
	2009	34	5.23	1.48	3.30	8.26	28
Grasshopper Sparrow	2008	87	44.57	10.35	30.57	64.97	23
	2009	98	110.50	29.98	71.28	171.30	27
Dark-eyed Junco	2008	41	24.20	6.43	15.76	37.20	27
	2009	22	13.04	6.09	6.28	27.09	47
Western Meadowlark	2008	210	84.84	14.91	63.68	113.03	18
	2009	179	72.60	12.34	55.00	95.83	17
Brown-headed Cowbird	2008	58	70.11	13.07	51.73	95.03	19
	2009	45	54.61	10.83	39.53	75.43	20
American Goldfinch	2008	90	38.64	9.22	26.23	56.89	24
	2009	16	6.90	3.97	2.86	16.62	58

Table 2. Number of transects with detections (n Tran), estimated occupancy rate (Psi), 95% Upper and Lower Confidence Limits (LCL & UCL), and percent coefficient of variation (%CV) for 10 avian species in Wind Cave National Park, 2009.

Species	n Tran	Psi	SE	LCL	UCL	%CV
Dusky Flycatcher	4	0.21	0.10	0.08	0.45	45
Eastern Kingbird	5	0.27	0.10	0.11	0.51	39
Plumbeous Vireo	9	0.47	0.12	0.26	0.69	25
Barn Swallow	4	0.22	0.10	0.08	0.48	46
White-breasted Nuthatch	10	0.71	0.21	0.26	0.94	29
Yellow Warbler	8	0.60	0.34	0.08	0.96	57
Yellow-breasted Chat	4	0.22	0.10	0.08	0.47	46
Lark Sparrow	7	0.44	0.14	0.20	0.71	33
Lazuli Bunting	5	0.32	0.14	0.12	0.61	43
Red Crossbill	9	0.51	0.13	0.27	0.75	26

Our survey effort yielded reasonably precise density estimates for 22 species, as indicated by low coefficients of variation (< 50%). Simulations using 10 years of data from a similar avian monitoring program (J. Blakesley, unpublished) indicated that it would be possible to detect an average 3% decline in the population of a species within 25 years with 80% power and CV ≤ 40%. A similar trend could be detected within 30 years with CV ≤ 50%. It is important to note that the ability to detect population trends for any species is a function of not only the sampling effort but also the abundance and annual variation in abundance of that particular species. Some grassland bird species shift their breeding ranges from year to year based on environmental conditions. These species may require more precise density estimates to monitor population trends within 25-30 years.

We recommend that the National Park Service continue to monitor birds at Wind Cave National Park following the sampling design developed and implemented by Rocky Mountain Bird Observatory. Monitoring bird populations is important for evaluating the long-term impacts of natural disturbance and succession on ecosystem functioning (Brawn et al. 2001). Temporal trends in bird abundance may be especially important for the management of landscape mosaics with both forest and grassland components. In this respect, birds from grassland and forest habitats are useful indicators of environmental change (Morrison 1986).

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APPENDIX A.

Number of birds detected, by species, in Wind Cave National Park in 2008 and 2009

Species	2008	2009	Species	2008	2009
American Crow	183	100	Gray Catbird	2	1
American Goldfinch	168	29	Gray Jay	14	9
American Kestrel	20	28	Great Horned Owl	3	0
American Redstart	1	5	Hairy Woodpecker	8	14
American Robin	251	177	Hermit Thrush	1	0
Barn Swallow		56	Horned Lark	90	50
Black-billed Magpie	87	37	House Finch	2	0
Black-capped Chickadee	152	79	House Wren	27	51
Black-headed Grosbeak		19	Indigo Bunting	2	0
Blue Jay	1	2	Killdeer	32	16
Brewer's Blackbird	149	57	Lark Bunting	10	9
Brown Creeper	2	4	Lark Sparrow	28	29
Brown Thrasher	5	16	Lazuli Bunting	5	16
Brown-headed Cowbird	234	223	Least Flycatcher	4	3
Bullock's Oriole	4	2	Lewis's Woodpecker	1	0
Burrowing Owl	0	7	Loggerhead Shrike	1	0
Canada Goose	0	25	Long-billed Curlew	1	1
Canyon Wren	3	1	Merlin	4	0
Cedar Waxwing	19	4	Mountain Bluebird	124	118
Chipping Sparrow	388	350	Mourning Dove	132	150
Cliff Swallow	24	13	Northern Flicker	42	58
Common Nighthawk	15	39	Northern Goshawk	1	0
Common Poorwill	1	1	Northern Rough-winged Swallow	6	0
Common Yellowthroat	4	3	Ovenbird	40	47
Cooper's Hawk	1	3	Pine Siskin	2	0
Cordilleran Flycatcher	0	2	Plumbeous Vireo	1	52
Dark-eyed Junco	81	64	Prairie Falcon	1	3
Dickcissel	0	1	Pygmy Nuthatch	0	3
Downy Woodpecker	7	1	Red Crossbill	0	75
Dusky Flycatcher	6	18	Red-breasted Nuthatch	76	90
Eastern Bluebird	0	2	Red-headed Woodpecker	5	16
Eastern Kingbird	32	30	Red-naped Sapsucker	2	1
Eastern Meadowlark	0	3	Red-tailed Hawk	19	10
Eastern Phoebe	0	1	Red-winged Blackbird	17	0
European Starling	23	31	Ring-necked Pheasant	1	0
Field Sparrow	40	30	Rock Wren	74	126
Golden Eagle	1	6	Ruby-crowned Kinglet	2	1
Golden-crowned Kinglet	1	0	Say's Phoebe	5	2
Grasshopper Sparrow	199	218	Sharp-tailed Grouse	8	0

Species	2008	2009
Song Sparrow	4	0
Spotted Towhee	289	285
Squirrel, Red	2	3
Swainson's Thrush	1	0
Townsend's Solitaire	7	8
Turkey Vulture	25	22
Unknown Bird	53	10
Unknown Blackbird	0	10
Unknown Duck	0	2
Unknown Falcon	1	1
Unknown Flycatcher	11	5
Unknown Owl	6	0
Unknown Raptor	4	1
Unknown Sparrow	29	13
Unknown Swallow	64	11
Unknown Woodpecker	21	7

Species	2008	2009
Upland Sandpiper	44	42
Vesper Sparrow	200	132
Violet-green Swallow	64	30
Warbling Vireo	4	5
Western Kingbird	1	0
Western Meadowlark	588	481
Western Tanager	69	141
Western Wood-Pewee	52	51
White-breasted Nuthatch	26	35
White-crowned Sparrow	6	2
White-throated Swift	0	12
Wild Turkey	30	41
Yellow Warbler	9	29
Yellow-breasted Chat	12	23
Yellow-rumped Warbler	32	49