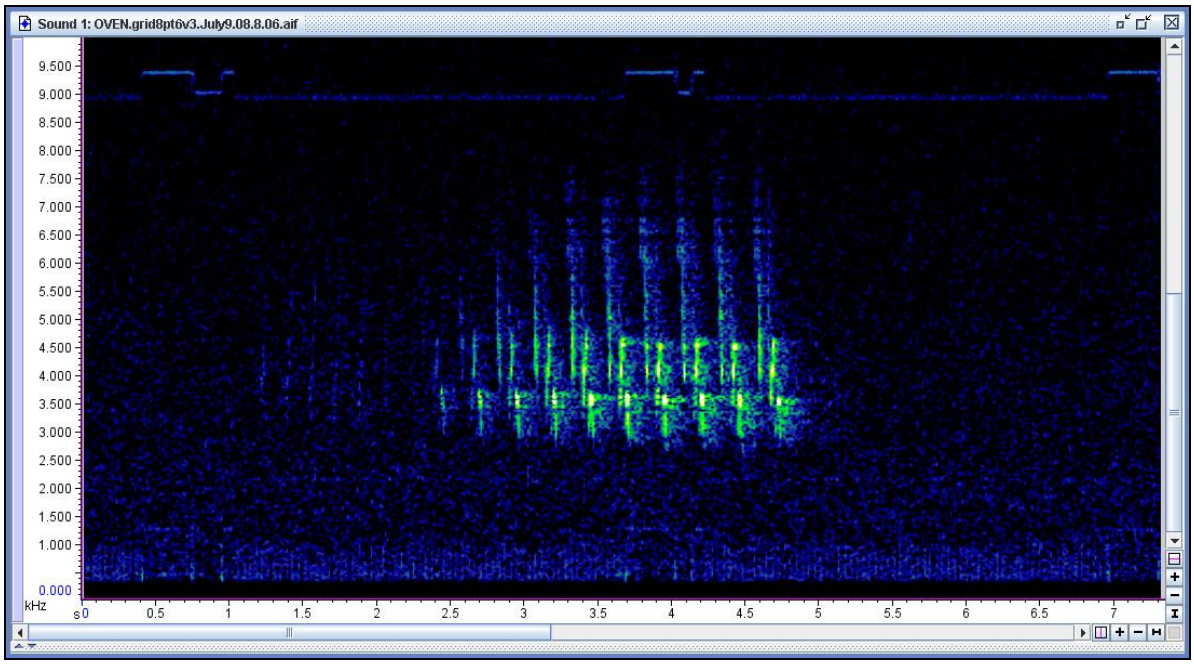
Monitoring Bird Populations in Wind Cave National Park using Point Counts and Autonomous Recording Units



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Rocky Mountain Bird Observatory
PO Box 1232
Brighton, CO 80601-1232
303.659.4348
www.rmbo.org

Tech. Report # M-ANALYSES-NPS-08-1

In Cooperation With:

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.*

Suggested Citation:

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Cover image:

Sonogram of a singing Ovenbird recorded in Wind Cave National Park in 2008. Sonogram produced by Cornell University's Raven Pro software program.

Contact Information:

Jason Beason jason.beason@rmbo.org
Jennifer Blakesley jennifer.blakesley@rmbo.org

Executive Summary

Rocky Mountain Bird Observatory conducted bird surveys in Wind Cave National Park in the Northern Great Plains Network of the National Park Service. We conducted surveys in May-July 2008 at points established using a spatially balanced sampling design. A single observer collected data on multiple visits to each point. At a subset of points, the National Park Service set up Autonomous Recording Units (ARU) to collect data on the same days that the observer surveyed the points.

After all data were collected, one RMBO biologist listened to the ARU audio recordings and noted all birds songs and calls recorded during the seven-minute point counts, to compare species counts from the field observer with counts from the ARU. In addition, he noted species recorded thirteen minutes before and after the point count to determine if having an observer present at the point caused the birds to behave differently. While ARUs generally produced high quality recordings, 11% of the 120 recordings were not used because of mechanical problems with the ARUs, distortion on the recordings due to high wind, and other factors.

We recorded 60 bird species through point counts and 50 species through analysis of recordings during point counts. Some species were only detected by one method, resulting in 83 species detected by both methods during the seven minute point counts. Adding 13 minutes before and after the point counts resulted in 69 total species being detected from the recordings.

Some species appeared to produce fewer songs per minute in the minutes immediately preceding and the first few minutes during the point count. Most of these species returned to their pre-count frequency of song production before the end of the point count. This effect could confound modeling of detection probability through Removal Sampling, but should have little influence on density estimates from Distance Sampling.

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 (Cooperative Agreement # H1200-004-0002).

We sincerely thank Marcia Wilson of the National Park Service for funding and supporting the project. We also thank Jeff Birek, Greg Levandoski, Arvind Panjabi, Rob Sparks, and Chris White of RMBO for assisting with identification of recorded bird sounds. We are grateful to Emily Jerman for conducting surveys, sometimes under difficult conditions. Rob Sparks and David Hanni of RMBO assisted in the design and implementation of the project and reviewed this report.

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Introduction

Autonomous Recording Units (ARUs) are used to record animal and other sounds in natural settings for scientific studies. The units consist of a microphone; an amplifier, frequency filter, and programmable computer; software that schedules, records, and stores the data; a disk drive to store up to 80 gigabytes of data. ARUs are weatherproof and can be placed at a site for weeks or even months, powered by D-cells or 12-volt batteries.

Several research projects have utilized ARUs in the field with positive results. One study showed that the units can be beneficial when targeting species of interest when accompanied with call playback (Amones 2008). The Cornell Lab of Ornithology is using ARUs to conduct their search for the Ivory-billed Woodpecker (Cornell Lab of Ornithology 2009). ARUs have also proven to be useful for conducting nocturnal surveys by reducing the need for hiking in difficult terrain in the dark. One such study targeted Boreal Owls in Colorado, demonstrating that weatherproof recording devices could be utilized successfully to eliminate the need to have observers conducting surveys at night in subzero temperatures (Tyler Hicks, pers. comm.).

For more than a decade, Rocky Mountain Bird Observatory (RMBO) has conducted avian point counts using Distance Sampling to estimate avian species densities. The Northern Great Plains Network (NGPN) of the National Park Service approached RMBO to collaborate on an effort to compare data collected during point counts with data collected by ARUs. Objectives of this pilot project were to

- Evaluate the advantages and disadvantages of using ARUs in place of or in addition to conducting point counts
- Determine whether on-the-ground observers influence the singing rates of birds
- Determine optimal times of day for conducting surveys
- Determine optimal days of the year for conducting surveys

Methods

Study Area

This study was conducted throughout Wind Cave National Park, South Dakota. Rocky Mountain Bird Observatory developed a spatially balanced sampling design (e.g., Blakesley and Hanni 2009) within the Park. Sampling units were 750 x 750 meter grids; each grid contained 9 sampling points, with 250 meter spacing between points. We selected 20 grids for sampling, with 3 visits to each grid, and two grids sampled each work day of the field season.

Field Methods

We surveyed birds from points using methods that allow for estimating detection probability through the principles of Distance sampling and Removal modeling. 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.

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.

The field technician conducted seven-minute point counts, divided into one-minute intervals, 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 observation point. Distances were measured using laser rangefinders. The technician conducted all transect surveys in the morning, between one-half hour before sunrise and 11 AM, from 25 May to 9 July, 2008. The technician 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.

The NGPN leased ten ARUs from Cornell Laboratory of Ornithology to supplement on-the-ground field surveys. NGPN personnel placed the units at two randomly-selected points within the grids to be sampled by RMBO's field technician each day. When sampling at a point with an ARU, the technician spoke "start" and "end" to facilitate audio analysis of the ARU recordings.

Analytical Methods

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 did not conduct removal modeling on the 2008 data set due to limited funding.

We analyzed 33 minutes of ARU recordings corresponding to the 13 minutes preceding the point count, the seven minute count, and the 13 minutes following the point count. An RMBO Biologist ("audio analyst") listened to and viewed the recordings using Raven Pro software which produces sonograms as well as audio broadcast. The sonograms aided song identification in some instances once the analyst learned how to identify distinct visual patterns of some species' songs. The audio analyst noted the number of each bird species heard during each 1-minute interval. Sometimes the analyst could distinguish two or more birds of the same species singing at the same time.

The analyst tabulated data by two criteria. First, he estimated the minimum number of birds of each species producing songs throughout the 13 minutes preceding the point count, during the point count, and throughout the 13 minutes following the point count. If, for example, only one Chipping Sparrow was heard singing at a time in minutes 1, 3, and 4 of the point count, the number of Chipping Sparrows in that interval was recorded as 1. Second, he counted the number of songs of each species in each minute of the count. Using the example above, the data for each minute of the 7-minute count would appear as 1, 0, 1, 1, 0, 0, 0. The first method can be considered the minimum number of birds at a point and we used these counts for comparison with the point count data. In contrast, the second method applies to singing rates rather than a number of individuals and we used these counts to examine effects of observer presence on the birds' singing behavior.

Using only the ARU data, we visually compared the number of per minute detections of each species before, during, and after the seven-minute point counts, excluding species with fewer than 4 detections per minute summed over all point counts. If the presence of the field technician had a negative effect on singing rates, we would expect to see a decrease in the number of detections per minute in the period preceding the point count, followed by an increase in detections per minute in the period following the point count.

Results

Density

Although Buckland et al. (2001) recommend a minimum sample size of 60 for fitting a detection function to point count data, we estimated densities of 18 species having sample sizes as low as n = 31 (Table 1). In future analyses, 2008 data can be combined with data from other years to generate more robust detection functions, resulting in more reliable density estimates species with small sample sizes.

Table 1. Estimated densities ($\hat{D}$; number of birds/km^2), 90% Upper and Lower Confidence Limits (LCL & UCL), sample sizes (*n*), and percent coefficient of variation (%CV) for 18 avian species in Wind Cave National Park, 2008.

Species	$\hat{D}$	LCL	UCL	n	%CV
Mourning Dove	18	11	30	61	29
Black-billed Magpie	2	1	3	47	29
American Crow	11	6	20	51	35
Horned Lark	13	6	32	66	55
Black-capped Chickadee	29	16	56	31	40
Red-breasted Nuthatch	13	6	25	54	42
Rock Wren	3	2	6	53	35
Mountain Bluebird	28	16	49	74	35
American Robin	81	42	159	65	41
Western Tanager	16	9	28	38	35
Spotted Towhee	109	69	171	91	28
Chipping Sparrow	169	113	250	166	24
Vesper Sparrow	14	8	24	97	33
Grasshopper Sparrow	40	25	64	109	29
Dark-eyed Junco	23	11	49	34	46
Western Meadowlark	64	45	91	312	21
Brown-headed Cowbird	92	56	153	58	31
American Goldfinch	31	22	43	114	21

Comparison of Point Count and ARU Data

We attempted to record 120 point-count sessions (two points per grid x 20 grids x 3 visits per grid). The ARUs generally provided high quality recordings; however, at times the units recorded excessive background noise which made identifying bird sounds difficult or impossible. Several of the recordings were inaudible because of mechanical noise from the ARUs. In the end, 82% (98 of 120) recorded point counts were of sufficient quality to be analyzed.

During the 33-minute sampling periods, 84 bird species were recorded by the field technician and/or the ARU/audio analyst. During point counts, the field technician recorded 60 species whereas the ARU audio files from the same time period recorded 50 species (Table 2). In the 13 minutes preceding and 13 minutes following the point count, the ARUs recorded an additional 19 species.

The field technician recorded 21 species during point counts that the audio analyst did not hear on the ARU recordings from the same time periods (Table 2). Ten of these species (each with only 1-3 detections) were detected by non-aural cues. Of the additional 11 species, ten were represented by only 1-4 detections. The final species, Brewer's Sparrow, was likely a misidentification of Field Sparrows; we reclassified these detections for evaluation of the presence of the observer on birds' singing rates.

Twelve species were recorded by the ARU before or after the point count, but not during the seven-minute point count by either the ARU or the field technician (Long-billed Curlew, Pinyon Jay, Pygmy Nuthatch, Swainson's Thrush, Northern Mockingbird, Cedar Waxwing, American Redstart, Song Sparrow, Black-headed Grosbeak, Blue Grosbeak, Common Grackle, and Pine Siskin). However, these species were each represented by only 1-3 individuals.

Eleven species were recorded by the ARU during the point count but not recorded by the field technician. Eight of the species were each represented by only 1-2 individuals (Cooper's Hawk, Black-backed Woodpecker, Cordilleran Flycatcher, Steller's Jay, Violet-green Swallow, Eastern Bluebird, Brown Thrasher, and Rose-breasted Grosbeak). Three species (Plumbeous Vireo, Field Sparrow, and Red Crossbill) were each represented by 7-10 individuals and were likely not recorded by the technician due to misidentification (Field Sparrows were likely recorded as Brewer's Sparrows).

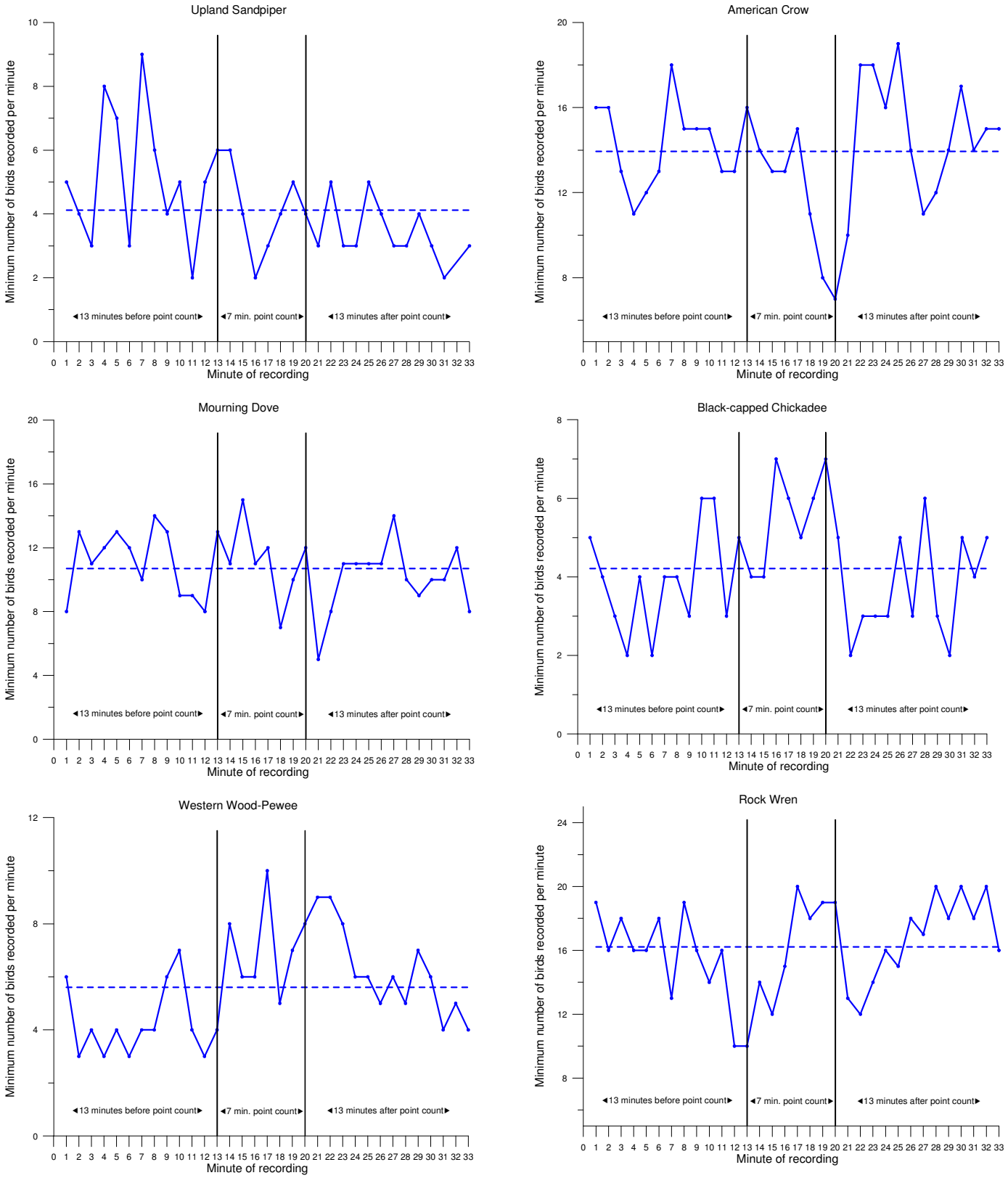
Seventeen species had an average rate of at least 4 songs per minute, summing across all 98 surveys. For some species (e.g., Western Wood-pewee, Rock Wren), the number detections recorded during each minute of the audio analyses showed a decrease in the number of detections in the final minutes before and early minutes during the point count for some species; however, on average, song rates for these species returned to pre-count levels within a few minutes (Appendix A; Figure 1). For other species, the song rate appeared to remain stable throughout the 33 minutes we evaluated (e.g., Mourning Dove, Western Tanager; Appendix A; Figure 1). Average song frequency during the 7-minute point count was similar to average song frequency during the first and last 7 minutes of the analysis (representing the time during which the observer was not present nor near the survey point) for 15 species. Singing rates were slightly higher during the point count for Black-capped Chickadees and Western Wood-pewees and slightly lower during the point count for Field Sparrows.

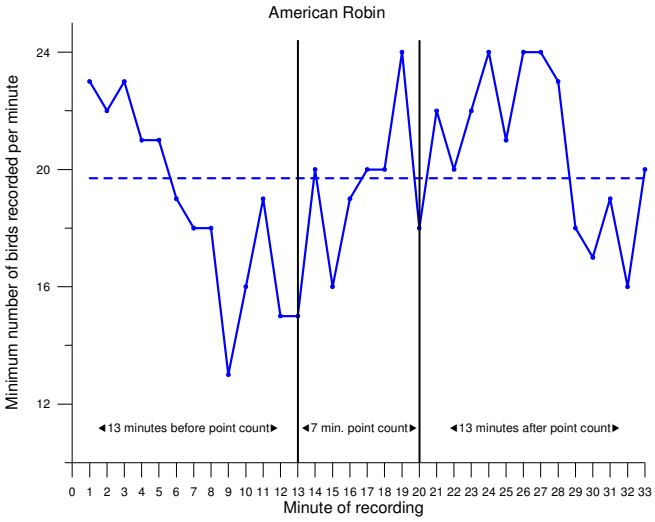
Table 2. Comparison of audio analysis and point count detections (n = 98 point counts) including 13-minute intervals before and after point counts and number of visual detections during the point counts.

	Audio Analysis:			Point Counts:	
Species	13 min. before point count	7 min. point count	13 min. after point count	7 min. point count	visual (non-aural) detections
Ring-necked Pheasant	0	0	0	1	1
Wild Turkey	11	5	11	5	1
Turkey Vulture	0	0	0	1	1
Cooper's Hawk	1	1	0	0	0
Northern Goshawk	0	0	0	1	0
Red-tailed Hawk	0	0	0	1	0
Golden Eagle	0	0	0	1	1
American Kestrel	0	0	1	4	3
Killdeer	0	1	2	4	0
Upland Sandpiper	19	12	14	9	1
Long-billed Curlew	1	0	0	0	0
Mourning Dove	32	25	31	25	4
Common Nighthawk	4	0	2	1	1
Red-headed Woodpecker	3	2	2	1	1
Red-naped Sapsucker	2	0	0	1	0
Downy Woodpecker	2	1	1	2	2
Hairy Woodpecker	6	2	5	2	1
Black-backed Woodpecker	1	1	1	0	0
Northern Flicker	7	2	7	12	5
Western Wood-Pewee	11	14	12	15	0
Dusky Flycatcher	5	1	3	2	1
Cordilleran Flycatcher	3	1	1	0	0
Say's Phoebe	0	0	0	1	0
Western Kingbird	0	0	0	1	1
Eastern Kingbird	2	3	4	5	4
Plumbeous Vireo	8	8	9	0	0
Warbling Vireo	4	2	4	2	1
Gray Jay	0	0	0	1	1
Steller's Jay	0	1	1	0	0
Pinyon Jay	3	0	0	0	0
Black-billed Magpie	9	1	6	14	3
American Crow	52	33	54	39	9
Horned Lark	6	3	5	15	1
Violet-green Swallow	3	1	3	0	0
Black-capped Chickadee	22	14	19	35	7
Mountain Chickadee	0	0	0	1	0
Red-breasted Nuthatch	9	5	7	16	0
White-breasted Nuthatch	2	7	4	13	1
Pygmy Nuthatch	0	0	1	0	0
Rock Wren	37	29	37	22	4
Canyon Wren	1	0	1	1	1

	Audio Analysis:			Point Counts:	
Species	13 min. before point count	7 min. point count	13 min. after point count	7 min. point count	visual (non-aural) detections
House Wren	8	6	5	7	1
Golden-crowned Kinglet	0	0	0	2	0
Ruby-crowned Kinglet	0	0	0	2	0
Eastern Bluebird	1	1	3	0	0
Mountain Bluebird	12	7	10	29	11
Townsend's Solitaire	0	2	4	2	2
Swainson's Thrush	0	0	1	0	0
American Robin	49	35	35	50	7
Northern Mockingbird	1	0	1	0	0
Brown Thrasher	0	1	1	0	0
European Starling	0	0	0	1	1
Cedar Waxwing	1	0	0	0	0
Yellow Warbler	7	3	5	1	1
Yellow-rumped Warbler	11	8	13	6	2
Black-and-white Warbler	0	0	0	2	0
American Redstart	1	0	1	0	0
Ovenbird	11	9	11	8	1
Yellow-breasted Chat	7	6	5	3	2
Western Tanager	22	8	20	20	4
Spotted Towhee	53	41	46	56	8
Chipping Sparrow	33	24	31	91	24
Brewer's Sparrow	0	0	0	14	0
Field Sparrow	13	10	11	0	0
Vesper Sparrow	39	30	38	45	1
Lark Sparrow	6	3	2	11	1
Lark Bunting	1	0	0	1	0
Grasshopper Sparrow	33	27	32	44	1
Song Sparrow	0	0	1	0	0
White-crowned Sparrow	0	0	0	4	1
Dark-eyed Junco	11	8	11	18	1
Rose-breasted Grosbeak	1	2	0	0	0
Black-headed Grosbeak	1	0	1	0	0
Blue Grosbeak	0	0	1	0	0
Lazuli Bunting	3	2	4	1	0
Indigo Bunting	1	1	4	1	0
Western Meadowlark	148	137	142	130	28
Brewer's Blackbird	2	0	1	3	3
Common Grackle	2	0	0	0	0
Brown-headed Cowbird	34	18	29	33	10
Red Crossbill	5	7	12	0	0
Pine Siskin	0	0	2	0	0
American Goldfinch	3	3	3	25	6
Number of species	**58**	**50**	**60**	**60**	-

Figure 1. The minimum number of birds recorded per minute by Autonomous Recording Units, summed across 98 surveys. Dashed lines represent the averages throughout the 33 minutes.




American Robin
Minimum number of birds recorded per minute
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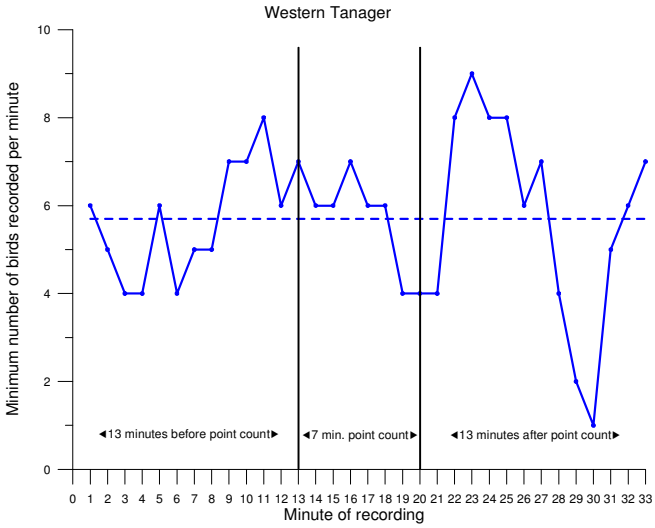
Minute of recording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Minimum number of birds recorded per minute
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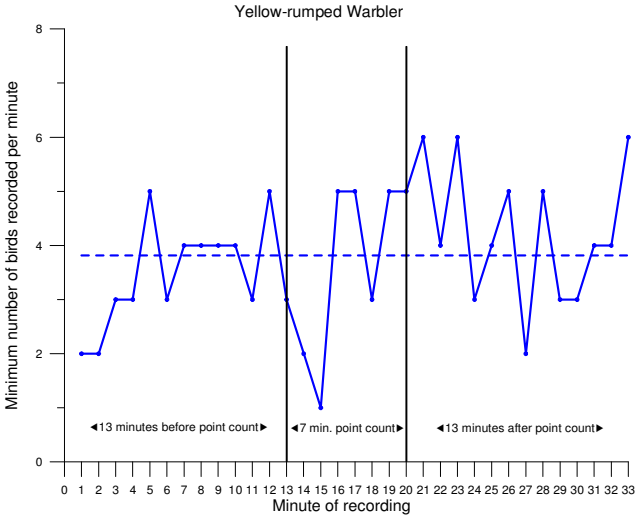
◄13 minutes after point count►
Minute of recording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Minimum number of birds recorded per minute
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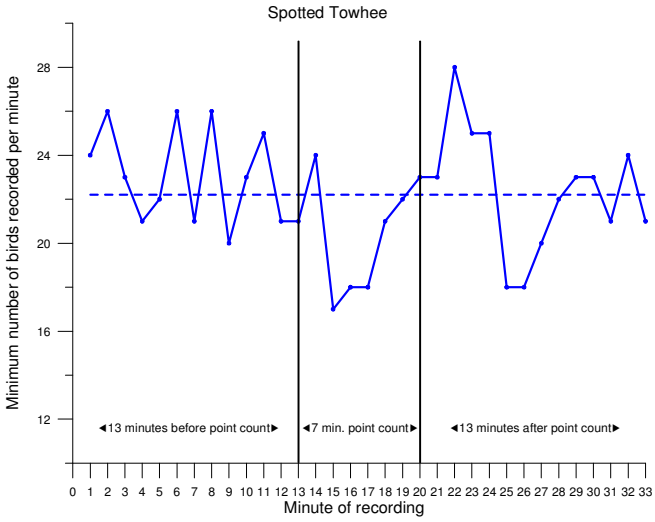
Minute of recording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Minimum number of birds recorded per minute
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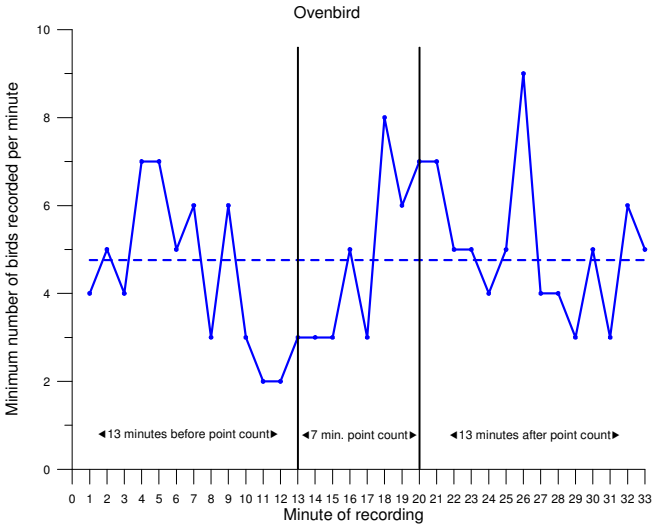
Minute of recording


Ovenbird
Minimum number of birds recorded per minute
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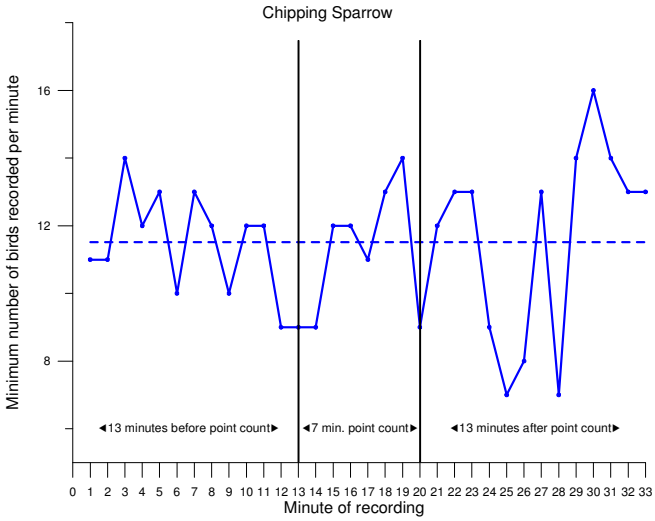
◄7 min. point count►
◄13 minutes after point count►
Minute of recording


Chipping Sparrow
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◄13 minutes after point count►
Minute of recording


Field Sparrow
Minimum number of birds recorded per minute
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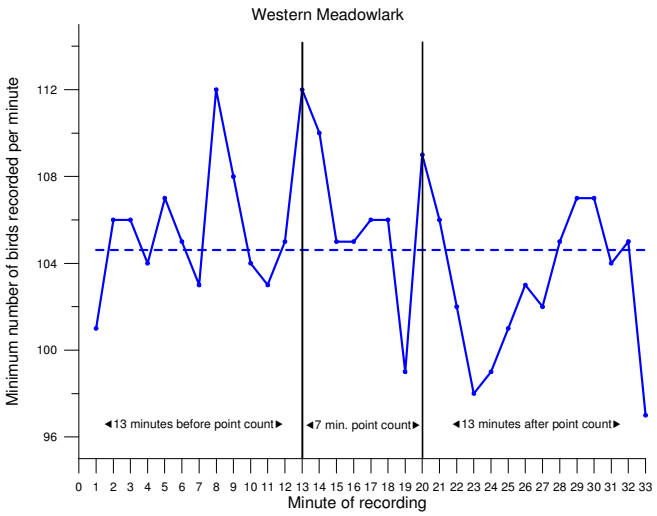
◄13 minutes after point count►
Minute of recording


Western Meadowlark
Minimum number of birds recorded per minute
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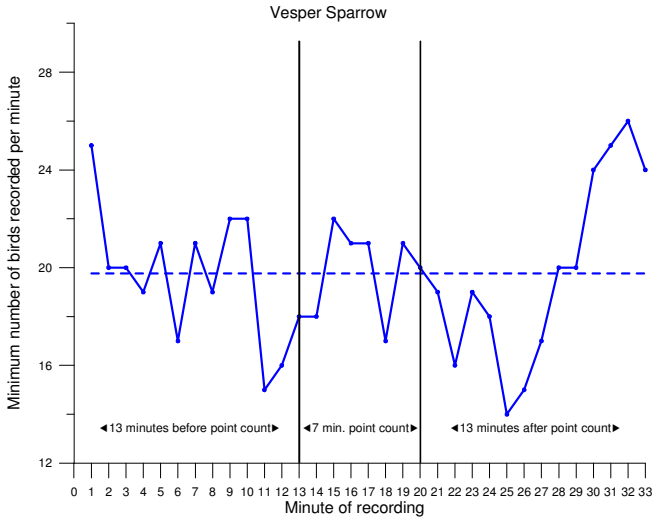
Minute of recording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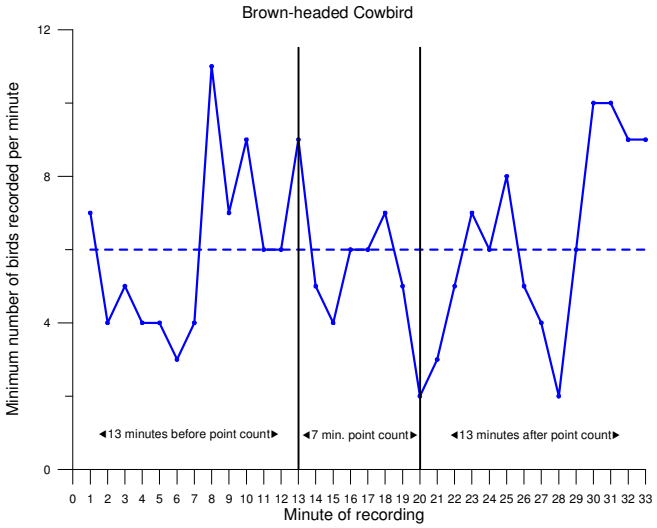
Minute of recording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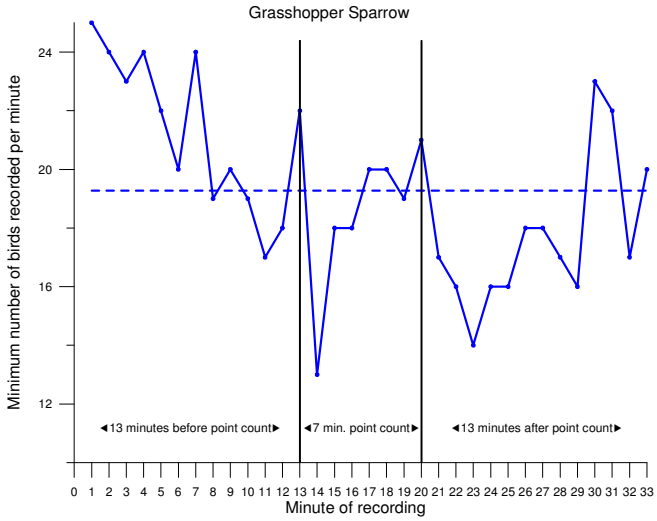
Minute of recording


Grasshopper Sparrow
Minimum number of birds recorded per minute
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◄7 min. point count►
◄13 minutes after point count►
Minute of recording

Discussion and Recommendations

The survey effort implemented in 2008 allowed us to estimate densities of 18 bird species, although sample sizes were lower than recommended for Distance analysis for 8 species. Following the 2009 field season, we will be able to combine the 2008 and 2009 data to obtain more robust detection functions for all species.

Using Autonomous Recording Units allowed us to assess the apparent influence of a field observer on the singing rates of birds before, during, and after point count surveys. Although some species appeared to decrease their song frequency as the observer arrived at the survey point, all species resumed singing during the 7-minute point count at or near non-survey singing rates. Note, however, that singing frequency would not affect density estimates, as long as an individual bird sang and was detected at least once during the survey period. The ARUs provided an unanticipated benefit of allowing us to recognize species identification errors recorded by the field technician. In addition, they allowed for post-survey identification of bird species that were less common at Wind Caves National Park during the field season (e.g., Red Crossbills).

Using a single ARU without a field observer is not practical for obtaining density estimates for breeding birds because there is no way to distinguish between two or more birds of the same species recorded singing at different times during the survey period unless an observer is present in the field. Celis-Murillo et al. (2009) used a 4-microphone "soundscape recording system" (SRS) to record bird vocalizations. When played back in a room with four speakers, the resulting recording allowed a listener to distinguish the direction from which a bird was singing during the recording. This alleviated the problem of distinguishing among singing individuals of the same species. However, in order to estimate detection probability, a necessary step for estimating density, it would be necessary to calibrate the SRS for each species in each habitat. Such calibration was conducted by Hobson et al. (2002) using a different microphone configuration than that used by Celis-Murillo et al. (2009). Arrays of ARUs were used to triangulate on calls of African elephants (Payne et al. 2003); arrays of ARUs could be similarly used to locate individual singing birds, but would not be practical for estimating densities over large areas.

Celis-Murillo et al. (2009) found that data obtained from recordings were more suitable for removal modeling than data collected by the field observer. This was probably due to the field observer needing several minutes to catch up with recording all of the individual birds singing during a survey, whereas the recording analyst could more accurately assign each bird to the appropriate time interval in which it sang. It would be fruitful to analyze the 2008 Wind Cave National Park data under the removal sampling framework with additional funding.

Finally, although an ARU will not record individual birds that are not producing aural cues during a survey (singing, calling, drumming), ARUs alone may be good tools for estimation of species richness (Haselmayer and Quinn 2000). ARUs can also be safer and more economical than using field observers for recording nocturnal species (Tyler Hicks, pers. comm.).

Due to limited funding, we were unable to analyze the recordings to determine the optimal times of day and days of the year for conducting breeding bird surveys at Wind Caves National Park. The ARU recordings from 2008 may be analyzed for these objectives with additional funding.

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Appendix A. Total number of detections for each species recorded during audio analyses by minute before, during and after the point count.

	Minutes Before Point Count													Minutes During Point Count							Minutes After Point Count												
	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	1	2	3	4	5	6	7	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13
Wild Turkey	5	4	5	5	5	4	2	2	3	2	2	1	1	2	1	3	2	1	2	2	4	3	2	4	5	2	3	4	2	0	1	1	2
Cooper's Hawk	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
American Kestrel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
Killdeer	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0	1	0	0
Upland Sandpiper	5	4	3	8	7	3	9	6	4	5	2	5	6	6	4	2	3	4	5	4	3	5	3	3	5	4	3	3	4	3	2	0	3
Long-billed Curlew	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mourning Dove	8	13	11	12	13	12	10	14	13	9	9	8	13	11	15	11	12	7	10	12	5	8	11	11	11	11	14	10	9	10	10	12	8
Common Nighthawk	0	0	0	1	0	0	0	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	2	0	1	1	0
Red-headed Woodpecker	1	1	2	2	1	2	1	1	1	3	2	1	1	2	1	1	0	1	1	1	0	1	0	1	1	1	1	1	1	1	1	0	1
Red-naped Sapsucker	1	1	1	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Downy Woodpecker	0	0	0	0	1	1	1	0	1	1	0	0	0	1	1	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Hairy Woodpecker	0	0	0	2	1	0	0	0	2	1	2	1	0	1	0	0	1	1	1	1	1	2	1	0	1	1	0	0	0	0	1	0	0
Black-backed Woodpecker	0	0	0	0	1	1	1	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Northern Flicker	2	3	2	1	2	2	1	1	1	0	0	0	1	1	1	0	0	1	0	0	1	0	0	0	2	3	3	3	4	0	2	1	0
Western Wood-Pewee	6	3	4	3	4	3	4	4	6	7	4	3	4	8	6	6	10	5	7	8	9	9	8	6	6	5	6	5	7	6	4	5	4
Dusky Flycatcher	2	1	2	2	2	2	2	1	1	2	2	1	1	1	1	1	1	1	1	1	1	1	1	2	2	0	2	1	1	1	1	1	0
Cordilleran Flycatcher	1	1	1	0	0	0	0	0	0	0	1	1	0	1	1	0	1	1	1	0	0	1	1	1	1	0	1	1	0	1	1	1	1
Eastern Kingbird	1	0	0	1	1	0	0	1	1	1	0	0	0	0	1	2	1	1	1	3	2	2	1	1	0	1	1	1	2	2	0	1	2
Plumbeous Vireo	2	3	5	4	2	2	3	4	4	4	6	6	5	4	5	5	5	5	7	7	3	7	4	6	4	4	1	3	3	3	3	2	3
Warbling Vireo	0	0	2	2	1	1	0	1	2	1	1	1	2	1	1	1	1	2	1	2	2	2	2	0	1	1	1	1	1	0	0	0	0
Steller's Jay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Pinyon Jay	0	0	2	3	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Black-billed Magpie	4	4	5	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	1	1	0	0	1	2	0	0	1	0	0	1	2	0

	Minutes Before Point Count													Minutes During Point Count							Minutes After Point Count												
	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	1	2	3	4	5	6	7	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13
American Crow	16	16	13	11	12	13	18	15	15	15	13	13	16	14	13	13	15	11	8	7	10	18	18	16	19	14	11	12	14	17	14	15	15
Horned Lark	1	0	1	1	2	1	1	0	3	0	0	0	0	0	0	0	0	1	2	2	1	1	2	3	1	0	1	0	1	0	1	0	0
Violet-green Swallow	0	0	1	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	2	1
Black-capped Chickadee	5	4	3	2	4	2	4	4	3	6	6	3	5	4	4	7	6	5	6	7	5	2	3	3	3	5	3	6	3	2	5	4	5
Red-breasted Nuthatch	2	3	2	2	3	2	2	1	3	2	2	1	1	2	3	2	1	0	0	2	1	0	1	2	1	1	0	1	2	1	1	1	0
White-breasted Nuthatch	0	0	0	0	0	0	0	0	1	1	0	1	1	2	2	0	3	2	1	3	0	0	1	2	2	0	0	0	0	0	0	2	1
Pygmy Nuthatch	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	1	0
Rock Wren	19	16	18	16	16	18	13	19	16	14	16	10	10	14	12	15	20	18	19	19	13	12	14	16	15	18	17	20	18	20	18	20	16
Canyon Wren	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
House Wren	4	4	4	5	4	4	4	5	5	4	3	4	5	4	5	5	5	4	4	1	2	2	2	2	4	3	2	2	2	3	3	2	3
Eastern Bluebird	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	2	0	0	1	1	1	1	0	0	0	0	1
Mountain Bluebird	4	3	2	5	2	3	3	1	0	2	3	2	3	0	1	2	1	2	2	3	3	3	3	5	3	2	2	3	0	2	3	3	1
Townsend's Solitaire	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	1	1	1	1	0	2	2	3	3	2	1	1	0	1
Swainson's Thrush	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
American Robin	23	22	23	21	21	19	18	18	13	16	19	15	15	20	16	19	20	20	24	18	22	20	22	24	21	24	24	23	18	17	19	16	20
Northern Mockingbird	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	1	1	1	0	1	0	0	0	0	1	1
Brown Thrasher	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Cedar Waxwing	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Yellow Warbler	1	1	2	1	1	1	2	1	2	1	1	3	1	0	2	3	2	2	1	1	1	1	1	3	0	2	2	0	2	0	0	0	0
Yellow-rumped Warbler	2	2	3	3	5	3	4	4	4	4	3	5	3	2	1	5	5	3	5	5	6	4	6	3	4	5	2	5	3	3	4	4	6
American Redstart	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Ovenbird	4	5	4	7	7	5	6	3	6	3	2	2	3	3	3	5	3	8	6	7	7	5	5	4	5	9	4	4	3	5	3	6	5
Yellow-breasted Chat	4	3	2	2	4	7	4	6	5	4	2	3	2	2	2	2	4	2	4	4	3	2	1	3	3	5	1	3	2	4	3	3	1
Western Tanager	6	5	4	4	6	4	5	5	7	7	8	6	7	6	6	7	6	6	4	4	4	8	9	8	8	6	7	4	2	1	5	6	7

	Minutes Before Point Count													Minutes During Point Count							Minutes After Point Count												
	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	1	2	3	4	5	6	7	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13
Spotted Towhee	24	26	23	21	22	26	21	26	20	23	25	21	21	24	17	18	18	21	22	23	23	28	25	25	18	18	20	22	23	23	21	24	21
Chipping Sparrow	11	11	14	12	13	10	13	12	10	12	12	9	9	9	12	12	11	13	14	9	12	13	13	9	7	8	13	7	14	16	14	13	13
Field Sparrow	7	5	6	8	8	6	5	6	4	5	6	5	4	5	6	3	5	6	3	6	5	5	5	5	7	6	6	6	6	6	6	6	7
Vesper Sparrow	25	20	20	19	21	17	21	19	22	22	15	16	18	18	22	21	21	17	21	20	19	16	19	18	14	15	17	20	20	24	25	26	24
Lark Sparrow	0	0	1	1	1	1	1	1	1	3	3	3	1	0	0	2	1	1	0	1	1	0	0	0	0	0	0	1	1	0	1	0	0
Lark Bunting	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grasshopper Sparrow	25	24	23	24	22	20	24	19	20	19	17	18	22	13	18	18	20	20	19	21	17	16	14	16	16	18	18	17	16	23	22	17	20
Song Sparrow	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Dark-eyed Junco	4	2	4	1	1	2	1	1	2	2	2	1	1	2	4	3	1	2	2	2	1	2	0	1	2	4	5	3	4	3	1	2	1
Rose-breasted Grosbeak	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Black-headed Grosbeak	1	1	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0
Blue Grosbeak	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Lazuli Bunting	2	1	2	0	0	0	0	0	0	0	0	2	2	1	1	1	2	2	2	1	2	2	2	2	3	2	1	1	1	1	2	2	1
Indigo Bunting	1	1	1	1	1	1	1	1	1	0	0	0	1	1	1	1	0	1	0	0	0	0	1	1	1	1	1	2	2	2	1	0	1
Western Meadowlark	101	106	106	104	107	105	103	112	108	104	103	105	112	110	105	105	106	106	99	109	106	102	98	99	101	103	102	105	107	107	104	105	97
Brewer's Blackbird	0	0	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Common Grackle	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Brown-headed Cowbird	7	4	5	4	4	3	4	11	7	9	6	6	9	5	4	6	6	7	5	2	3	5	7	6	8	5	4	2	6	10	10	9	9
Red Crossbill	2	0	2	1	1	0	0	0	0	0	0	0	0	4	5	0	1	0	0	1	1	0	0	1	0	2	1	2	3	6	3	0	0
Pine Siskin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	2	0	1
American Goldfinch	1	0	0	0	1	2	1	1	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	1	0