A Comparison of Four Methodologies Used to Monitor Shortgrass Prairie Birds in Eastern Colorado

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EXECUTIVE SUMMARY

In 2001, Rocky Mountain Bird Observatory, in cooperation with the Colorado Division of Wildlife, assessed field techniques to determine the most effective technique/s for monitoring shortgrass prairie birds in eastern Colorado. We evaluated four techniques that were randomly allocated across the shortgrass prairie of eastern Colorado: 1) Road-based point counts, conducted at the section level (1mi x 1mi, as delineated by the Public Land Survey System) from roads (n = 1237 sections); 2) Interior line transects, conducted at the section level away from roads (n = 48 sections); 3) *Monitoring Colorado's Birds* (*MCB*) point transects, conducted irrespective of sections and roads (n = 22 point transects); and 4) 30-mile driving line transects, conducted along roads, through all habitat types in Colorado (n = 87 line transects). Program DISTANCE was used to estimate densities of birds using each of the four techniques.

Our results suggest that the four techniques vary in the number of species, habitats, and land ownerships sampled: 1) The road-based point count technique had the largest sampling effort, and obtained density estimates for 33 species in the shortgrass prairie of eastern Colorado; 2) Interior line transects obtained density estimates for 10 species conducted on sections that were publicly owned or private lands where we were given permission from landowners in the shortgrass prairie of eastern Colorado; 3) *MCB* point transects obtained density estimates for 10 species on public lands and private lands where access was granted; and 4) 30-mile driving line transects obtained density estimates for 9 species on all habitat types in eastern Colorado.

Road-based point counts yielded density estimates for many shortgrass prairie bird species and represented private and public land ownership proportionately, which can be used in future analyses, within eastern Colorado. This technique required more effort, during the data collection period, but resulted in more accurate density estimates that can be used to determine trends and distributions of shortgrass prairie birds across eastern Colorado.

There are several ways to improve future bird monitoring on the shortgrass prairie of eastern Colorado. First, the section survey, road-based point count, technique should be expanded to other habitats (e.g., land in the Conservation Reserve Program (CRP), shrublands, and cropland). Second, a program to monitor species that occur aggregated on prairie-dog colonies, playas and monitor raptor nests, should be implemented; and,. Finally, a correction factor that can adjust for the road bias in individual species should be calculated. These efforts will lead to the most comprehensive monitoring protocol in the shortgrass prairie.

INTRODUCTION

Grassland birds have experienced steeper, more consistent, and geographically more widespread declines than any other guild of North American species, including neotropical migrants (Sampson and Knopf 1996). According to Partners In Flight, 11% of shortgrass prairie bird species are declining, and an additional 66% lack sufficient data to address current population trends (Partners in Flight Species Assessment Database, 2001). Several species found in the prairie are endemic (found nowhere else) or are closely associated with the Great Plains grasslands (Mengel 1970). One reason for these declines is loss of native prairie on both the breeding and wintering grounds to urban sprawl and conversion of prairie to cropland.

Another problem is that few data exist that tie common management practices on grasslands to communities of grassland birds. Scientifically sound data that addresses this problem would allow public land managers and private landowners to better manage grasslands with shortgrass prairie bird communities in mind. To date, resource managers have relied on data derived from the Breeding Bird Survey (BBS), currently the best and most extensive bird-monitoring program, to monitor bird populations (Robbins et al. 1989, Sauer 1993). Land managers in the shortgrass prairie make management decisions that range in scale and BBS data do not reliably predict population trends at small geographic scales (Sauer 2000) and do not incorporate vegetation characteristics in their protocol. Thus, making the BBS data insufficient to guide local and regional management decisions. Several authors have suggested the implementation of regional habitat-based bird monitoring programs to complement data generated by BBS (Butcher 1992, Butcher et al. 1993, Sauer 2000, Sauer and Cooper 2000).

This study is a pilot project created to develop a consistent all bird monitoring plan throughout an ecoregion, the shortgrass prairie. Partnering with different organizations that embrace similar goals will allow us all to work together to conduct consistent all bird monitoring across this ecosystem. The Colorado Division of Wildlife (CDOW) and Rocky Mountain Bird Observatory (RMBO) are working together to address previous problems in shortgrass prairie bird monitoring.

The 2002 CDOW strategic plan identifies desired achievements that are shared by both CDOW and RMBO.

- Identify areas of high priority prairie bird habitat.
- Identify and prioritize prairie bird habitat inventory needs.
- Develop best management practices for the shortgrass prairie to assist landowners in enhancing or restoring the habitat to support prairie birds.
- Develop a long-term monitoring system for a variety of species in the shortgrass prairie to ensure populations remain healthy and to detect possible population declines.

These commonalities led to an interest from both parties to compare four monitoring techniques in eastern Colorado to determine the most efficient technique/s to monitor shortgrass prairie birds.

In 1998, RMBO, in cooperation with the CDOW, United States Forest Service (USFS), and Bureau of Land Management (BLM), initiated a habitat-based monitoring program, *Monitoring Colorado's Birds* (*MCB*), that is conducted in 13 habitats in Colorado, including shortgrass prairie. This program has proven effective. However, a large percentage of shortgrass prairie bird species occur in low densities and *MCB* has proven incapable of obtaining robust sample size for most of these species that are of conservation concern (e.g., Long-billed Curlew and Burrowing Owl). Thus, we tested three new techniques to monitor prairie bird distributions and trends in the shortgrass prairie.

The four techniques that were compared here were, road-based point counts, interior line transects, *Monitoring Colorado's Birds* point transects, and 30-Mile driving transects. The purpose of this study was to compare the four techniques to determine the most efficient methodology for monitoring shortgrass prairie bird distribution and trends.

METHODS

Study area:

Three of the techniques (road-based point counts, interior line transects, and the *MCB* point transects) were conducted in the shortgrass prairie located in 26 counties in eastern Colorado (Figure 1). The shortgrass prairie ecoregion within eastern Colorado receives between 300 mm and 500 mm of precipitation per year, and is characterized by two dominant grass species, buffalo grass (*Buchloe dactyloides*) and blue grama (*Bouteloua gracilis*) (Lauenroth and Milchunas 1992). The size of this study area is approximately 3,600,000 hectares of shortgrass prairie.

The 30-mile driving line transect technique contrasted the other three techniques, in that this technique includes all habitats in the 26 counties located in eastern Colorado (Figure 1). The study area was calculated, using a GIS vegetation layer, to be approximately 11,700,000 hectares, which includes all habitat types in this region.

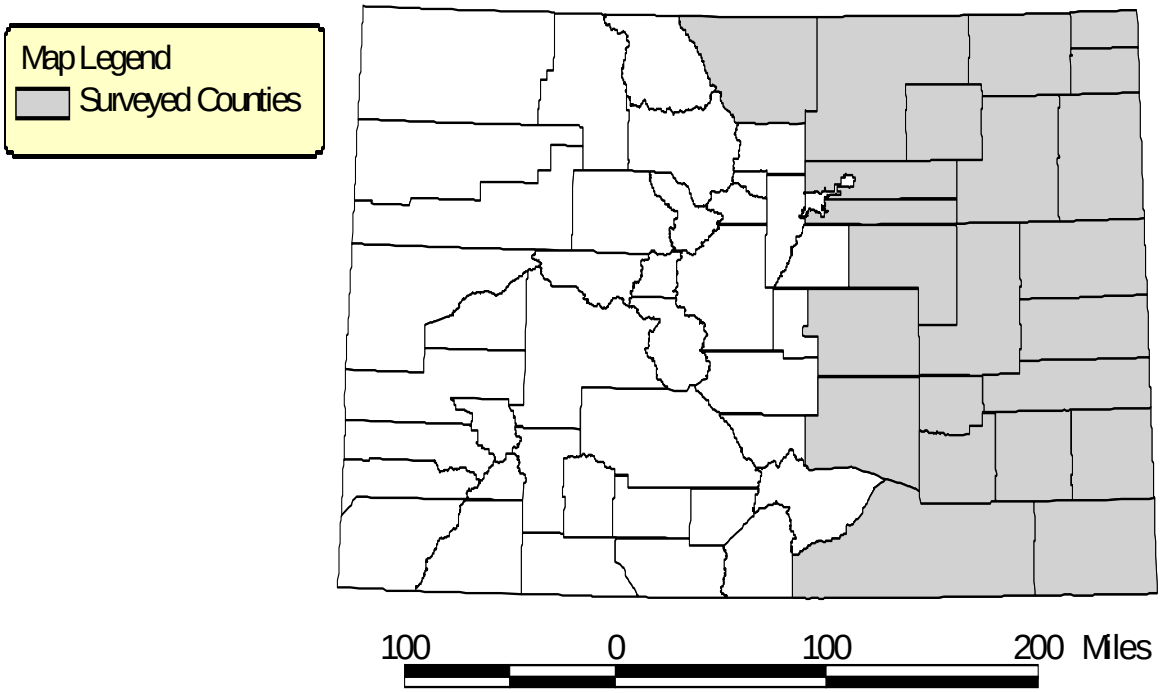


Figure 1. Random sections were selected in these counties from the shortgrass prairie in this region as determined by GAP 2000.

Section Selection:

Two of the sampling techniques (road-based point counts and interior line transects) use the section (1mi. x 1mi.), not the point count, as the sampling unit. This unit was selected based on it being the common unit of land management in Colorado, the layout of roads in Colorado, and for the ease of location. Sections of shortgrass prairie were identified using ArcView. In ArcView, we combined different GIS layers to identify 35,145 sections of shortgrass prairie that contained between 600 and 700 acres of shortgrass prairie. The maximum shrub component of a section to be considered as shortgrass was 25%, based on a GIS vegetation layer. From these sections, 2,000 sections were randomly selected to survey. If the section was not accessible from at least one road the sample was relocated to the closest section of shortgrass prairie in a randomly selected direction that met the criteria.

The randomly selected sections were surveyed during the 2001 field season. Sections were surveyed from 14 May through 5 July 2001, to include the main period of breeding activity exhibited by grassland birds. The start date was determined by the widespread arrival and courtship displays of a late-breeding species, the Lark Bunting (*Calamospiza melanocorys*). Surveys were terminated when birds started congregating in post-breeding flocks and the frequency of courtship displays were noticeably reduced. We began surveys in the southern latitudes and ended in the north so as to follow the seasonality of breeding activities as they progressed from south to north.

Road-based point counts:

Five minute,180˚-point counts were conducted from the road looking into the focal section. The number of points conducted (1-4) and the distance between the point count stations, spaced at least 0.322 km apart, were established randomly along section perimeters. Between one and four point counts were conducted to determine the number of point counts that proved to be most efficient. We conducted surveys from sunrise to 11:00 when bird activity, and thus detectability, was highest. Observers recorded habitat and weather conditions; surveys were postponed during heavy rains, dense fog and/or winds exceeding 18 miles/hour. We recorded all birds seen and/or heard within the focal section during the five-minute period and determined the distance to each bird at the point of first detection (measured using a Bushnell Yardage Pro 500 Rangefinder). Finally, we recorded the location of each point count using a Garmin *etrex* global positioning system (GPS) unit.

Interior line transects:

Line transects were conducted in the interior (at least 161 m from a fence) of sections that had previously been surveyed using the point count methodology. The observer randomly established the initial line transect 805 m along the edge of the section starting from the corner, and 161 m in and perpendicular from the edge or fence-line of the section that the observer just navigated from. Using a compass or GPS unit, the observer calculated the bearing 45° from the edge or fence-line of the section that the observer traveled. The observer walked along this bearing 1130 m toward the center of another fence-line of the section and turned 90 degrees into the section. At the next section edge, another 90 degree turn towards the inside of the section will be made, creating a three

segment (1.13km, 1130m), U-shaped transect (3.39km, 3390m) within the section. A gap, where no birds were recorded (161 m), at the end of each of the segments, was established to avoid double counting. While walking the line transect all bird species seen and/or heard were recorded. The observer also recorded perpendicular distances using a Bushnell Yardage Pro 500 laser rangefinder to measure the distance to the points where the birds where initially detected by sight.

Monitoring Colorado Bird's (MCB) point transects (Leukering 2000):
MCB conducted point transects consisting of 15 five-minute point counts spaced at 250-m intervals along a randomly selected line. We considered the intervals between points as legs of a line transect. At the individual points, we recorded the radial distance to each bird detected. Along the transect legs, we recorded species whose population densities are relatively low (thus, poorly-recorded on point counts) and estimated the perpendicular distance to each. We also recorded perpendicular distances for individuals of these target species detected on points in order to be able to pool birds on points with birds on transect legs. Individual birds initially detected on points will not be recorded between points.

30 mile driving line transects:
30-mile driving line transects were conducted in eastern Colorado. The 30-mile long routes were selected using a systematic distribution of the starting points and random direction of travel. Transects continued in the random direction until the end of a road was reached or the transect was on course to intersect another transect. During the driving survey the observer kept their speed below 20 mph. We felt that at this speed the observer could view both sides of the road searching for all low density species that were the size of a Loggerhead Shrike (*Lanius ludovicianus*) or larger. Once an individual was encountered, the observer would record the perpendicular distance to the point where the bird was first detected using a Bushnell Yardage Pro 500 laser rangefinder. At this time basic habitat information around the bird, at the point of detection was recorded. During the transect, information was recorded on the locations and dimensions of prairie dog colonies and playas were also recorded

Data Analyses:

Program DISTANCE (Thomas 1998-99) was used to analyze the point count and line transect data from all four techniques using data collected during the 2001 field season. Each of the four techniques were analyzed separately. The notation, concepts and analysis methods of DISTANCE were developed by Buckland et. al. (1993). We used program DISTANCE to estimate density (D) on species that had a minimum of 25 observations or had a CV of less than 50% indicating robust data. During analyses, DISTANCE assigns a unique detection function thus, avoiding some potential problems associated with traditional analysis of point counts (e.g., varying detectability among habitats, species, and different years). Analysis using program DISTANCE assumes that 1) all birds at distance 0 are detected; 2) distances of the birds close to the points or line are measured accurately; and, 3) birds do not move in response to the observer's presence.

One difference in the analysis between the techniques in DISTANCE was that in the section survey road-based point counts the sampling effort was set to 0.5; birds were recorded only in the focal section instead of within the entire 360º.

The index of abundance used in the distribution maps was calculated from data collected using the road-based point count technique. The index of abundance, represented by graded symbols, was defined as the total number of a species detected on the section divided by the number of point counts conducted on that section. The index of abundance was created to adjust for the amount of effort on each of the sections between one and four point counts.

RESULTS

Road-based point counts- We conducted 2929 point counts on 1237 sections (Figure2). The portion in Las Animas county, in the south west portion of the shortgrass prairie, was not sampled due to time restrictions and loss of field technicians. The technique yielded detections of 18370 individual birds of 82 different species.

1237 section were surveyed with, one point each on 361 sections, two points each on 316 sections, three points each on 304 sections, and four points each on 256 sections. An average of 3.33 species was detected with one point count, 4.48 with two, 5.07 with three, and 5.36 with four. Utilizing two point counts per section detected significantly more species ($p<0.05$, $\alpha=.05$) than one. Utilizing three point counts per section detected significantly more species ($p<0.05$, $\alpha=.05$) than two. However, using four point counts per section did not detect significantly more species ($p=0.056$, $\alpha=.05$) (Figure 3).

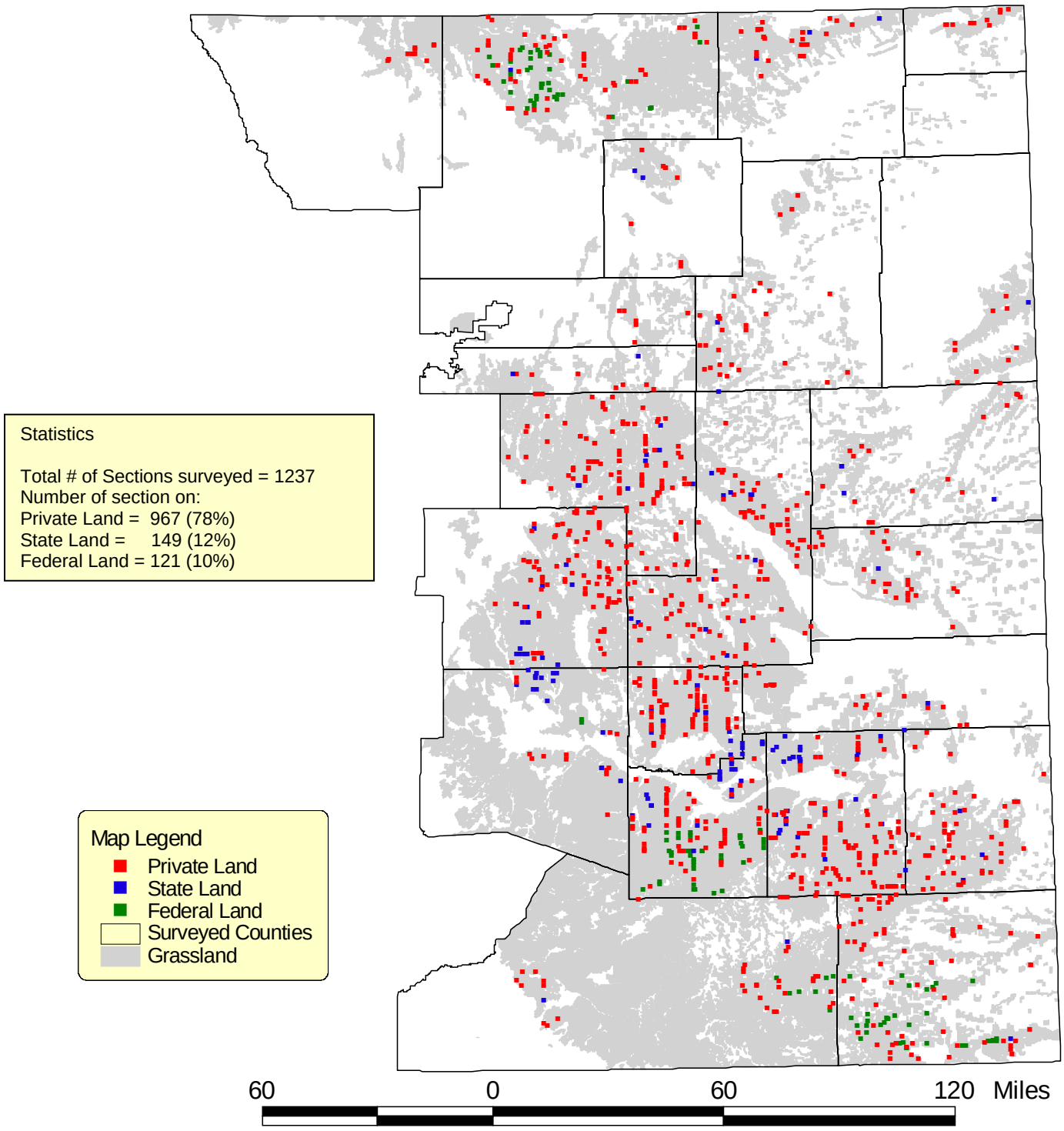


Figure 2. Random sections surveyed during the 2001 field season illustrated by ownership.

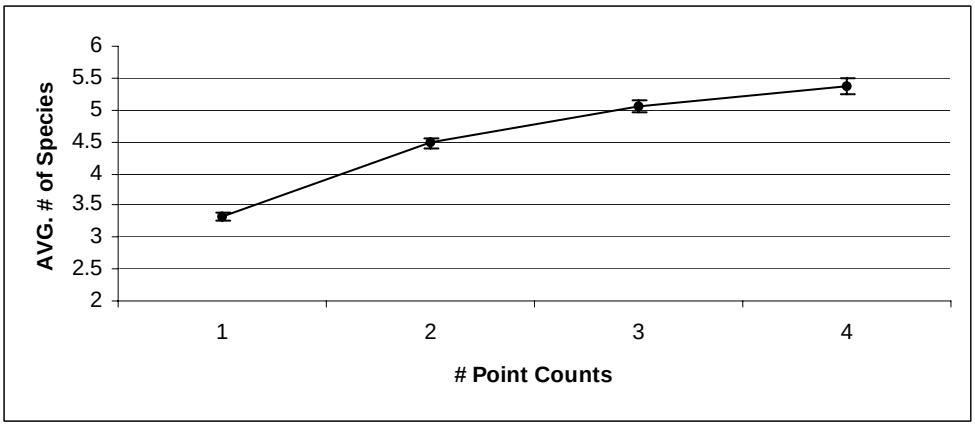


Figure 3. The relationship between the number of point counts conducted per section and the average number of species detected on road-based point counts in eastern Colorado, summer 2001.

I calculated density estimates for 29 species. Included are 4 species for which I obtained fewer than 25 detections. However, for these species the detection function formulated in program DISTANCE appeared to indicate a normal distribution and CV's generated by the distance were less than or equal to 50% indicating robust data (Table 1).

Table 1: Estimated densities and population estimates for 33 different species using data collected from the road-based point count technique. Asterisks indicate species that had fewer than 25 detections but with CV's of less than 50%.

SPECIES	D	D LCL	D UCL	D CV	n	N
Swainson's Hawk	0.004	0.003	0.005	11%	137	14,174
Red-tailed Hawk	0.002	0.001	0.003	22%	40	6,566
Ferruginous Hawk*	0.001	0.000	0.001	35%	20	2,237
American Kestrel*	0.001	0.001	0.003	43%	16	4,601
Scaled Quail*	0.001	0.001	0.003	38%	15	5,194
Killdeer	0.033	0.021	0.050	22%	119	118,410
Long-billed Curlew	0.003	0.001	0.005	37%	45	9,164
Mourning Dove	0.119	0.096	0.149	11%	558	429,853
Burrowing Owl	0.004	0.003	0.007	22%	76	15,796
Common Nighthawk	0.003	0.002	0.004	19%	57	10,228
Western Kingbird	0.094	0.081	0.110	8%	474	339,500
Eastern Kingbird	0.007	0.004	0.010	22%	31	23,599
Loggerhead Shrike	0.008	0.005	0.013	25%	32	28,685
Chihuahuan Raven	0.001	0.001	0.001	27%	36	3,104
Horned Lark	0.856	0.808	0.907	3%	4148	3,079,780
Cliff Swallow	0.340	0.186	0.622	31%	184	1,223,356
Barn Swallow	0.022	0.009	0.055	47%	39	80,876
Northern Mockingbird	0.006	0.004	0.008	18%	68	21,134
European Starling	0.012	0.006	0.028	42%	41	44,662
Cassin's Sparrow	0.070	0.055	0.088	12%	663	250,518
Brewer's Sparrow	0.045	0.034	0.060	14%	134	162,874

Vesper Sparrow*	0.004	0.002	0.008	39%	12	13,335
Lark Sparrow	0.117	0.094	0.145	11%	481	421,326
Lark Bunting	0.802	0.751	0.856	3%	6064	2,885,380
Grasshopper Sparrow	0.059	0.043	0.081	16%	93	211,141
McCown's Longspur	0.017	0.013	0.023	15%	150	61,101
Chestnut-collared Longspur	0.006	0.003	0.013	38%	26	22,775
Red-winged Blackbird	0.023	0.017	0.030	14%	101	81,513
Western Meadowlark	0.405	0.387	0.423	2%	3670	1,455,751
Common Grackle	0.026	0.016	0.042	24%	70	94,530
Brown-headed Cowbird	0.015	0.008	0.031	36%	49	55,701
Bullock's Oriole	0.007	0.004	0.013	33%	39	24,833

D=Density estimate expressed in birds/ha, DLCL & DUCL = lower and upper 95% confidence limits of D, n = number of detections used to calculate D, N = population estimate for each species located throughout the shortgrass prairie of eastern Colorado.

Interior line transects- We conducted a total of 48 transects and detected 8513 individuals of 36 species. We derived density and population estimates for 10 species (Table 2).

Table 2: Estimated densities and population estimates for 10 different species using data collected from the interior line transect technique.

Name	D	D LCL	D UCL	D CV	n	N
Mourning Dove	0.027	0.017	0.043	24%	51	96,466
Common Nighthawk	0.006	0.003	0.011	31%	28	20,988
Horned Lark	0.654	0.528	0.810	11%	991	2,353,560
Cassin's Sparrow	0.074	0.040	0.135	31%	141	265,356
Brewer's Sparrow	0.053	0.022	0.126	45%	70	190,762
Lark Bunting	0.532	0.412	0.686	13%	1207	1,913,524
Grasshopper Sparrow	0.066	0.039	0.109	26%	95	236,306
McCown's Longspur	0.193	0.118	0.313	25%	373	692,615
Chestnut-collared Longspur	0.028	0.013	0.063	41%	53	102,500
Western Meadowlark	0.159	0.134	0.189	9%	469	571,362

D=Density estimate expressed in birds/ha, DLCL & DUCL = lower and upper 95% confidence limits of D, n = number of detections used to calculate D, N = population estimate for each species located throughout the shortgrass prairie of eastern Colorado.

MCB point transects- We conducted 22 transects and detected 1307 individuals of 47 species. Density and population estimates for 10 species were calculated (Table 3).

Table 3: Estimated densities and population estimates for 10 different species using data collected using the Monitoring Colorado's Birds technique.

SPECIES	D	D LCL	D UCL	D CV	n	N
Mourning Dove	0.060	0.040	0.092	22%	70	215,880
Western Kingbird	0.070	0.040	0.122	29%	30	251,860
Horned Lark	0.488	0.411	0.580	9%	457	1,755,824

Cassin's Sparrow	0.020	0.012	0.034	26%	37	71,960
Vesper Sparrow	0.015	0.008	0.027	32%	28	53,970
Lark Sparrow	0.042	0.025	0.070	26%	33	151,116
Lark Bunting	0.611	0.506	0.738	10%	607	2,198,378
Grasshopper Sparrow	0.140	0.108	0.180	13%	121	503,720
McCown's Longspur	0.016	0.001	0.029	29%	25	57,568
Western Meadowlark	0.170	0.138	0.209	11%	494	611,660

D=Density estimate expressed in birds/ha, DLCL & DUCL = lower and upper 95% confidence limits of D, n = number of detections used to calculate D, N = population estimate for each species located throughout the shortgrass prairie of eastern Colorado.

30 mile driving line transects- We conducted 87 transects were completed and collected data on 1375 individuals of 40 different species. Density and population estimates were determined for 9 low density species (Table 4).

Table 4: Estimated densities and population estimates for 9 different species using the 30 mile driving transects technique.

Name	D	D LCL	D UCL	D CV	n	N
Northern Harrier	0.0009	0.0005	0.0017	32%	63	10,740
Swainson's Hawk	0.0056	0.0038	0.0083	20%	197	65,551
Red-tailed Hawk	0.0015	0.0007	0.0033	41%	58	17,674
Ferruginous Hawk	0.0004	0.0003	0.0006	20%	54	4,882
Mountain Plover	0.0004	0.0002	0.0008	33%	41	4,850
Long-billed Curlew	0.0002	0.0001	0.0005	37%	32	2,687
Burrowing Owl	0.0017	0.0012	0.0025	18%	290	20,408
Loggerhead Shrike	0.0169	0.0133	0.0215	12%	310	198,527
Chihuahuan Raven	0.0009	0.0003	0.0027	57%	34	11,010

D=Density estimate expressed in birds/ha, DLCL&DUCL = lower and upper 95% confidence limits of D, n = number of detections used to calculate D, N = population estimate for each species located throughout eastern Colorado.

SPECIES ACCOUNTS

This section shows the distribution and estimated densities of selected species as calculated from the four different techniques (road-based point counts, interior line transects, *MCB* point transects, and 30-mile driving line transects). These combined techniques yielded data on 82 different species, of which I present results for 34 grassland species for which I was able to calculate a density estimate from at least one of the four techniques.

I provide below, distribution maps for the selected species derived from data collected from the road-based point count technique. The distribution map for each species shows locations of all observations graded by the index of abundance of the species for each of the sections. The index of abundance was created to account for effort, and is defined as the total number of individuals for the species per point count conducted on a section. These maps are included to give information on the general distribution and abundance of the species in the shortgrass prairie of eastern Colorado.

In the graphs, I compare three techniques, road-based point counts, interior walking line transect and *MCB* point counts utilizing the density estimates derived from program DISTANCE. The fourth technique, 30-mile driving line transect, cannot be compared to the other three techniques due to spatial and temporal differences in the study. The 30-mile driving line transect technique was conducted across all habitats in eastern Colorado and, like the other three techniques, was not limited to just the shortgrass prairie portion.

The majority of the species included in the technique comparison had more than 25 observations used to calculate a density estimate. A few other species that had between 12 and 25 detections, from the road-based point count technique, were also included in the comparison, and caution must be used when comparing species that were rarely detected. Consideration of the CV is a good way to evaluate the robustness of the data.

Northern Harrier
(*Circus cyaneus*)

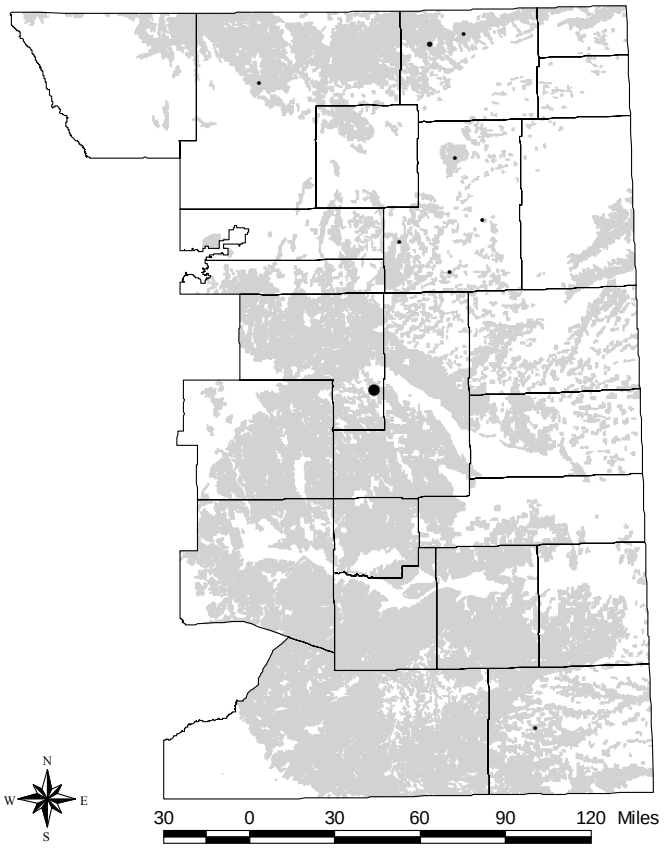
The Northern Harrier is sparsely distributed throughout eastern Colorado. I calculated density estimates for this species using the data collected from one technique: driving line transect.

Density estimate (D) and population estimate (N) for this species by technique:

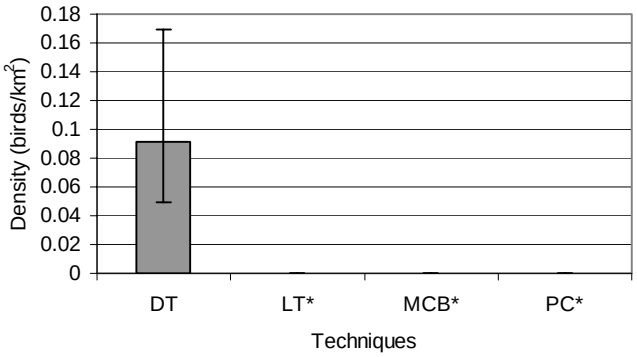
- Driving line transects
  D = 0.09 bird/km^2 (CV=32%)
  N = 10,740 individuals in eastern Colorado.

Northern Harrier was not well sampled in this study using the road-based point count technique. The Colorado Breeding Bird Atlas shows that there were almost twice as many detections in cropland than shortgrass prairie (Carter, 1998).

Future efforts to monitor this species should include the continuation of the driving line transects and/or expanding the road-based point count technique to cropland. This additional effort should increase the number of detections, and hence, the precision of the density estimate.



Index of abundance, expressed in birds per section / # of point counts, and breeding distribution of Northern Harrier in the shortgrass prairie of eastern Colorado, 2001.



Density of Northern Harrier by technique in the shortgrass prairie of eastern Colorado, 2001. Technique Codes: **DT**=30mi driving transect, **LT**=interior line transect, ***MCB***=*MCB* point transect, **PC**=road-based point count.
* Insufficient data for analysis.

Swainson's Hawk
(*Buteo swainsoni*)

The Swainson's Hawk is distributed fairly evenly throughout the shortgrass prairie of eastern Colorado, and is usually sympatric with the Red-tailed and Ferruginous Hawks. I calculated density estimates from data collected using two techniques; driving line transects and road-based point counts.

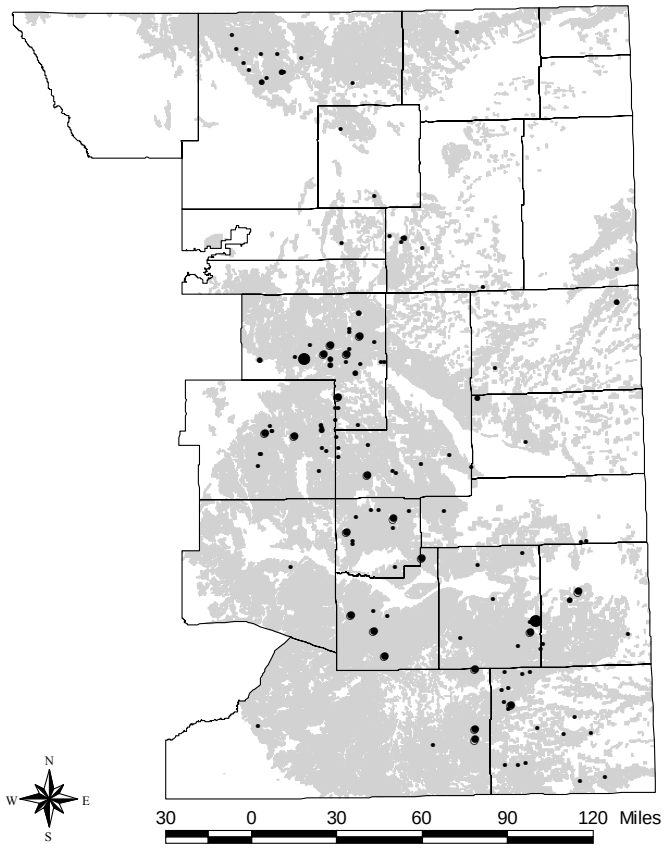
Density estimate (D) and population estimate (N) for this species by technique:

- Driving line transects
  D = 0.56 bird/km^2 (CV=20%)
  N = 65,551 individuals in eastern Colorado.
- Road-based point counts
  D = 0.39 bird/km^2 (CV=11%)
  N = 14,174 individuals in the shortgrass prairie of eastern Colorado.

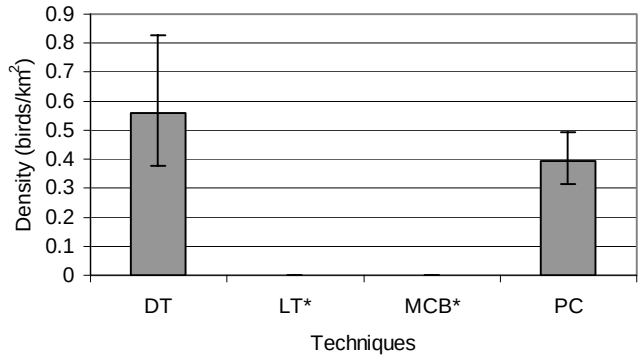
The two techniques presented here are not comparable due to the differences in time period the techniques were conducted, and the habitats of inference.

The density estimate derived from the road-based point count data looks more precise than the estimate from the driving line transects due to the lower CV, indicating more robust data.

Road-based point counts worked well to detect this species. We detected 170 individuals on 10 % of the sections surveyed. This number of detections should allow us to monitor trends and track the distributions of this species over time.



Index of abundance, expressed in individuals per section / # of point counts, and breeding distribution of Swainson's Hawk in the shortgrass prairie of eastern Colorado, 2001.



Density of Swainson's Hawk by technique in the shortgrass prairie of eastern Colorado, 2001. Technique Codes: **DT**=30mi driving transect, **LT**=interior line transect, ***MCB***=*MCB* point transect, **PC**=road-based point count.
* Insufficient data for analysis.

Red-tailed Hawk
(*Buteo jamaicensis*)

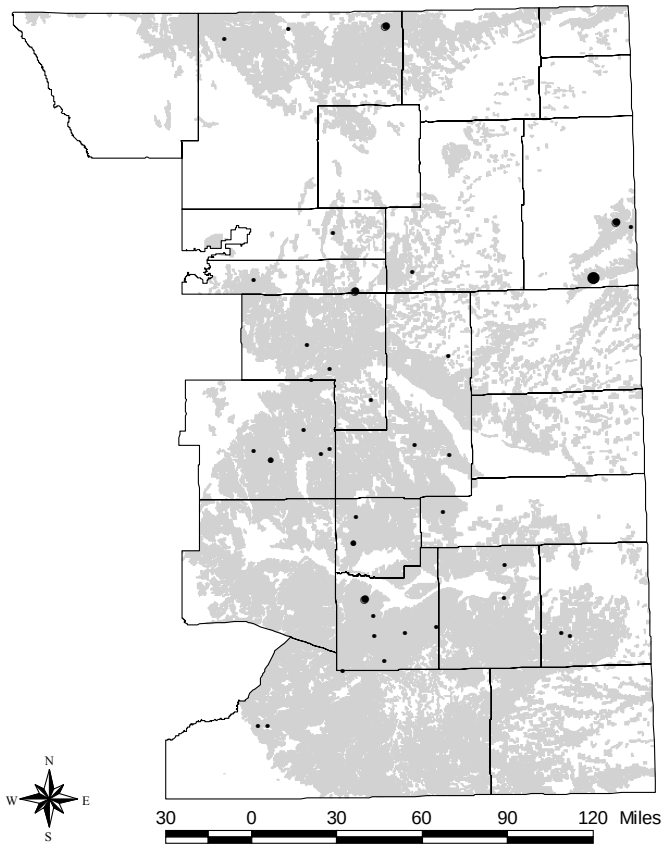
The Red-tailed Hawk is distributed throughout the shortgrass prairie of eastern Colorado and is usually sympatric with the Swainson's and Ferruginous Hawks. I calculated density estimates for this species using data from two techniques: driving line transects and road-based point counts.

Density estimates (D) and population estimates (N) for this species by technique:

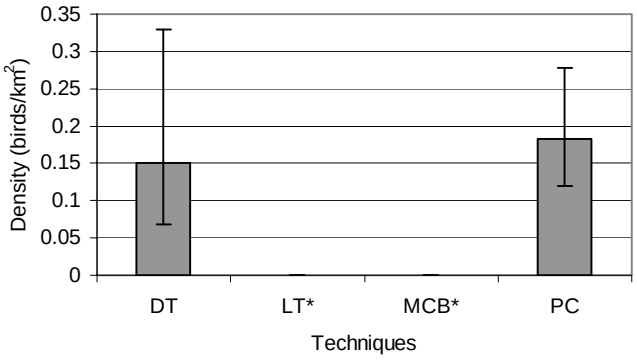
- Driving line transects
  D = 0.15 bird/km^2 (CV=41%)
  N = 17,674 individuals in eastern Colorado.
- Road based point counts
  D = 0.18 bird/km^2 (CV=22%)
  N = 6,566 individuals in the shortgrass prairie of eastern Colorado.

The distance estimates between the two techniques cannot be compared due to the differences in the time period and spatial variations between the two techniques. The density estimate from the road-based point counts looks more accurate due to the lower CV, which suggests more robust data.

The road-based point count technique worked well to detect this species. We detected 45 individuals on 3% of the sections surveyed. This number of detections should allow us to monitor population trends and track the distribution over time.



Index of abundance, expressed in birds per section / # of point counts, and breeding distribution of Red-tailed Hawk in the shortgrass prairie of eastern Colorado, 2001.



Density of Red-tailed Hawk by technique in the shortgrass prairie of eastern Colorado, 2001. Technique Codes: **DT**=30mi driving transect, **LT**=interior line transect, ***MCB***=*MCB* point transect, **PC**=road-based point count.
* Insufficient data for analysis.

Ferruginous Hawk
(*Buteo regalis*)

The Ferruginous Hawk is distributed in low densities throughout the shortgrass prairie in eastern Colorado. This species has historically nested on the ground, but will also use trees and similar structures. I calculated density estimates using two different techniques: driving line transects and road-based point counts.

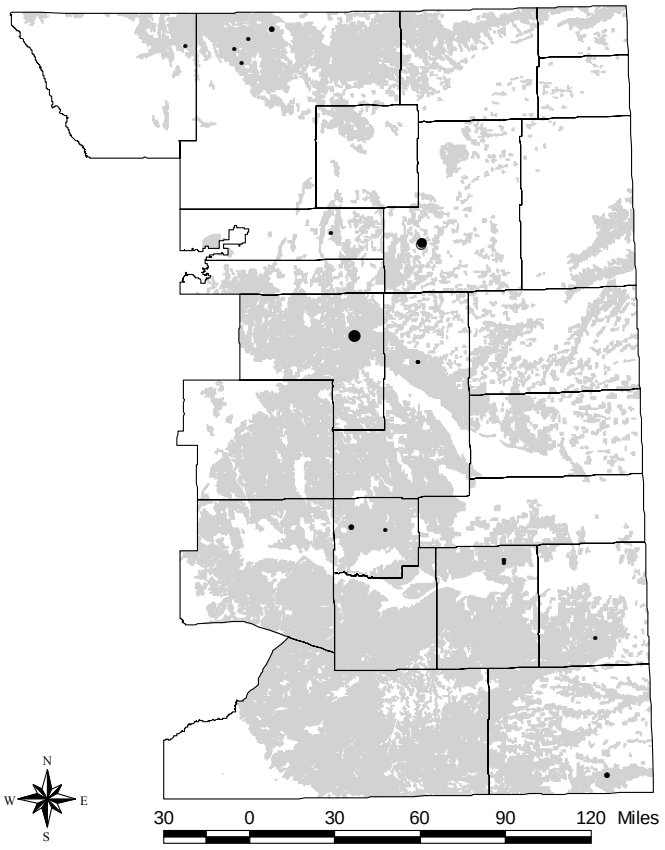
Density estimate (D) and population estimate (N) for this species by technique:

- Driving line transects
  D = 0.04 birds/km^2 (CV=20%)
  N = 4,882 individuals in eastern Colorado.
- Road-based point counts
  D = 0.06 birds/km^2 (CV=35%)
  N = 2,237 individuals in the shortgrass prairie of eastern Colorado.

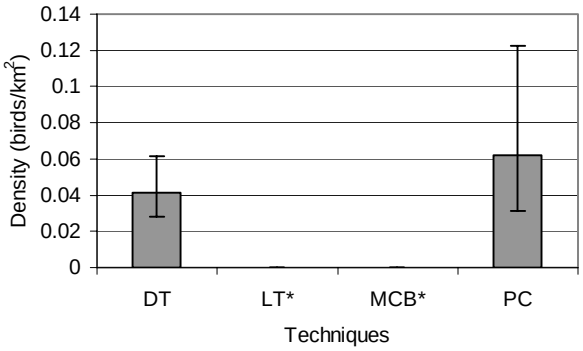
The density estimates for this species should not be compared due to the differences in the time period and the habitats of inference between the techniques. The distance estimate from the driving line transect is more accurate, due to the lower CV indicating more robust data.

The number of detections of this species was low using the road-based point count technique. We detected 23 individuals on 2% of the sections surveyed.

The driving line transect worked well in detecting this species. Future efforts to monitor this species should continue the driving line transect and/or monitor individual nests.



Index of abundance, expressed in birds per section / # of point counts, and breeding distribution of the Ferruginous Hawk in the shortgrass prairie of eastern Colorado, 2001.



Density of Ferruginous Hawk by technique in the shortgrass prairie of eastern Colorado, 2001. Technique Codes: **DT**=30mi driving transect, **LT**=interior line transect, ***MCB***=*MCB* point transect, **PC**=road-based point count.
* Insufficient data for analysis.

American Kestrel
(*Falco sparverius*)

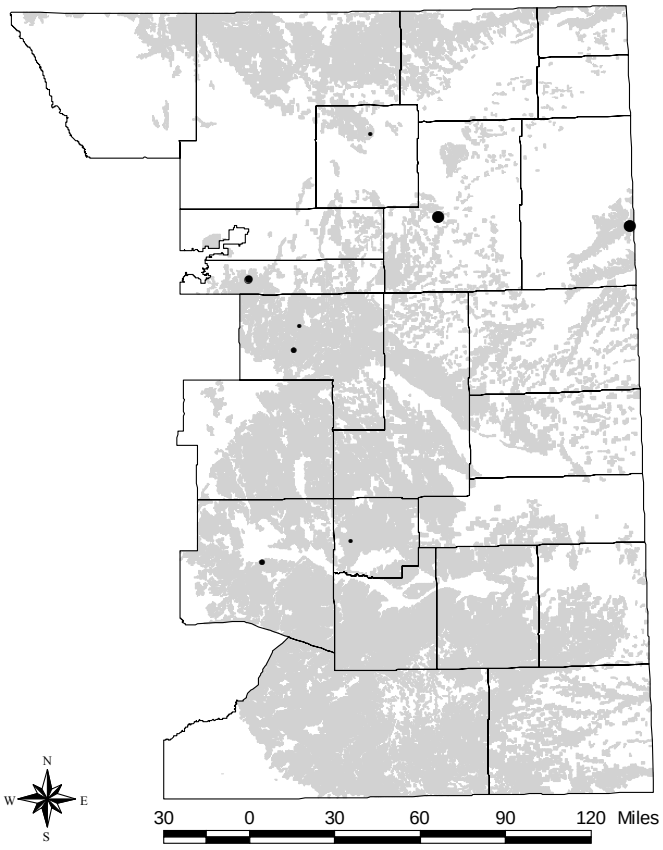
The American Kestrel is sparsely distributed throughout eastern Colorado. This species nests in cavities throughout the shortgrass prairie and needs perches from where they hunt. This species is usually associated with human habitation on the prairie. I calculated density estimates for this species using the data from one technique: road-based point counts.

Density estimate (D) and population estimate (N) for this species by technique:

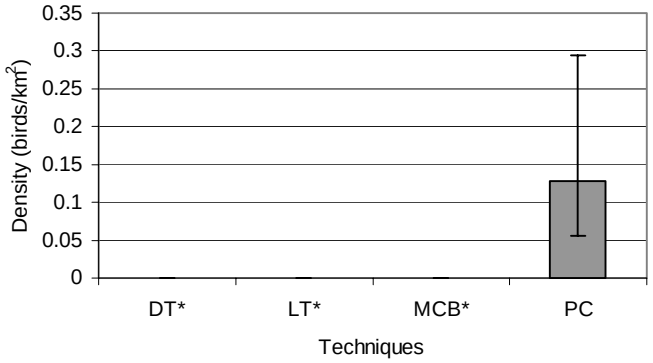
- Road-based point count
  D = 0.13 bird/km^2 (CV=43%)
  N = 4,601 individuals in the shortgrass prairie of eastern Colorado.

All techniques had difficulty detecting this species. We located 17 individuals on 1% of the sections we surveyed.

To effectively monitor for this species the road-based point count technique should be expanded to different habitat types throughout eastern Colorado. This additional effort should increase the number of detections, and hence, the precision of the density estimate.



Index of abundance, expressed in individuals per section / # of point counts, and breeding distribution of American Kestrel in the shortgrass prairie of eastern Colorado, 2001.



Density of American Kestrel by technique in the shortgrass prairie of eastern Colorado, 2001. Technique Codes: **DT**=30mi driving transect, **LT**=interior line transect, ***MCB***=*MCB* point transect, **PC**=road-based point count.
* Insufficient data for analysis.

Scaled Quail
(*Callipepla squamata*)

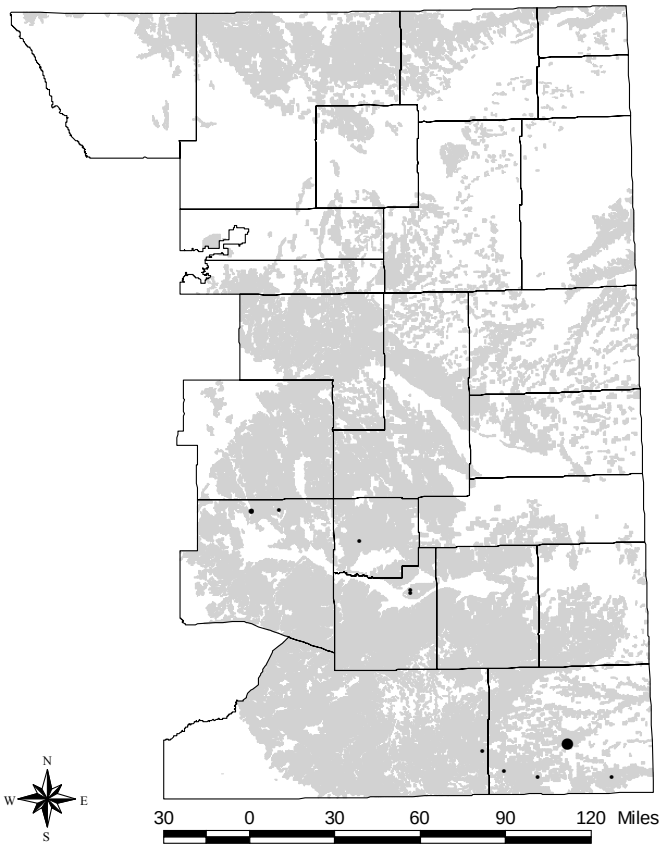
The Scaled Quail appears to be sparsely distributed in the southern portion of the shortgrass prairie in eastern Colorado. The species usually inhabits grasslands scattered with cacti and shrubs. I calculated density estimates for this species using data collected from one technique: road-based point counts.

Distance estimate (D) and population estimate (N) for this species by technique:

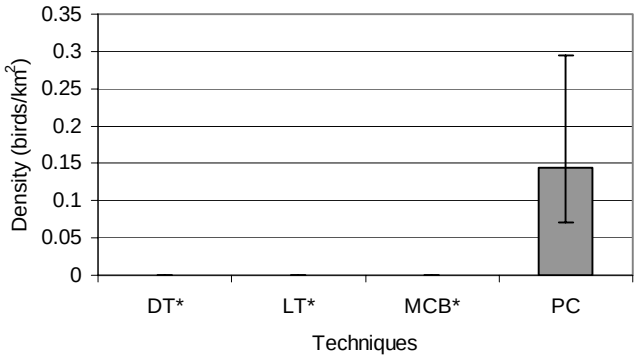
- Road-based point counts
  D = 0.14 bird/km^2 (CV=38%)
  N = 5,194 individuals in the shortgrass prairie of eastern Colorado.

The number of detections for this species, using the road-based point count technique, was low. We detected 17 individuals on less than 1% of the sections we surveyed.

Expanding road-based point counts, into sand sage and cacti habitats, should increase the number of detections for this species, which should increase the precision of the density estimate. With an increased number of detections, this technique should generate a density estimate that could be used to monitor trends in population and distribution.



Index of abundance, expressed in individuals per section / # of point counts, and breeding distribution of Scaled Quail in the shortgrass prairie of eastern Colorado, 2001.



Density of Scaled Quail by technique in the shortgrass prairie of eastern Colorado, 2001. Technique Codes: **DT**=30mi driving transect, **LT**=interior line transect, ***MCB***=*MCB* point transect, **PC**=road-based point count.
* Insufficient data for analysis.

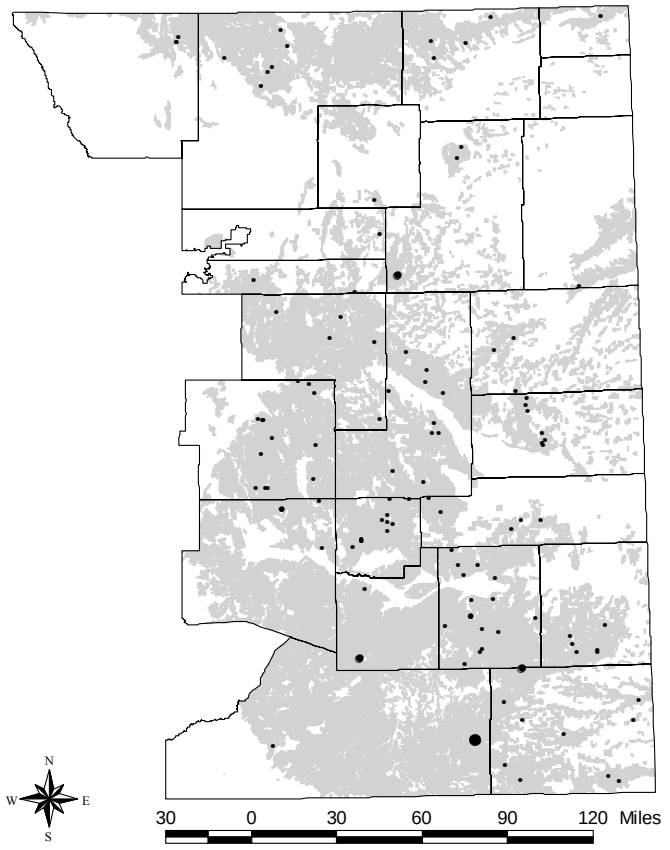
Killdeer
(*Charadrius vociferous*)

The Killdeer is distributed throughout the shortgrass prairie, usually near water (e.g., stock tanks). However, they can easily adapt to nest in smaller patches that other shortgrass prairie bird species, like the Mountain Plover, do not prefer. I calculated a density estimate using data collected from one technique: road-based point counts.

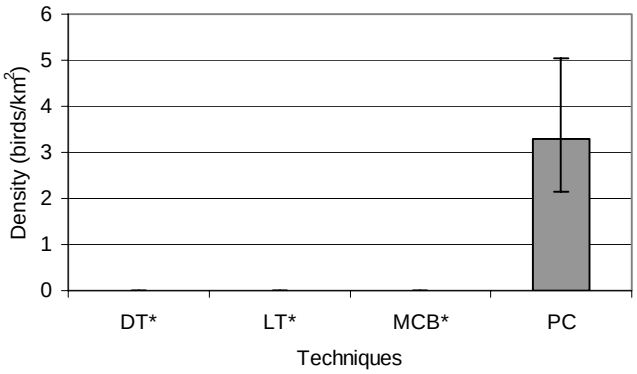
Distance estimate (D) and population estimate (N) for this species by technique:

- Road-based point counts
  D = 3.3 bird/km^2 (CV=22%)
  N = 118,410 individuals in the shortgrass prairie of eastern Colorado.

The road-based point count techniques should work well to detect the species in the shortgrass prairie of eastern Colorado. We detected 165 individuals on 9% of the sections we surveyed using this technique. The road-based point count technique could be used to monitor the distribution and population trends of the Killdeer.



Index of abundance, expressed in individuals per section / # of point counts, and breeding distribution of Killdeer in the shortgrass prairie of eastern Colorado, 2001.



Density of Killdeer by technique in the shortgrass prairie of eastern Colorado, 2001. Technique Codes: **DT**=30mi driving transect, **LT**=interior line transect, ***MCB***=*MCB* point transect, **PC**=road-based point count. * Insufficient data for analysis.

Mountain Plover
(*Charadrius montanus*)

The Mountain Plover is sparsely distributed throughout eastern Colorado. In the shortgrass prairie this species is usually found in areas with very short grass with bare ground. I calculated a density estimate for this species using data collected from one technique: driving line transects.

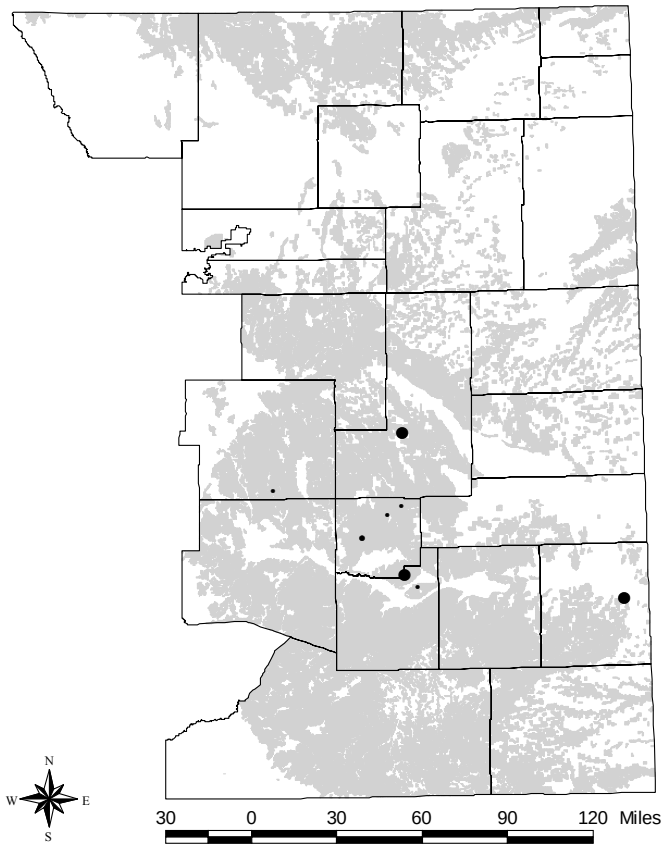
Density estimate (D) and population estimate (N) for this species by technique:

- Driving line transects
  D = 0.04 bird/km^2 (CV=33%)
  N = 4,850 individuals in eastern Colorado

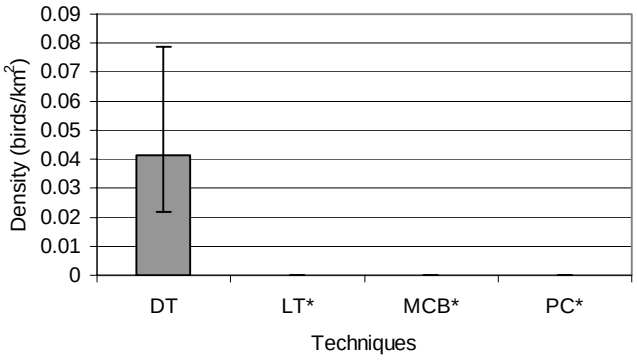
The Mountain Plover has eluded most of the techniques used to monitor shortgrass prairie species. Driving line transects detected 41 individuals; this estimate has a low CV, which would suggest robust data.

Future efforts to monitor this species should include the continuation of the driving line transects and/or the expansion of the road-based point count technique to cropland. The expansion to cropland should increase the number of detections for this species, which should increase the precision of the density estimate.

Another method to consider would be the implementation of a project to inventory Black-tailed Prairie Dog colonies and playas. The increased effort to monitor the colonies and playas could increase detections for other low-density species in eastern Colorado (e.g., Snowy Plover, Burrowing Owl).



Index of abundance, expressed in individuals per section / # of point counts, and breeding distribution of Mountain Plover in the shortgrass prairie of eastern Colorado, 2001.



Density of Mountain Plover by technique in the shortgrass prairie of eastern Colorado, 2001. Technique Codes: **DT**=30mi driving transect, **LT**=interior line transect, ***MCB***=*MCB* point transect, **PC**=road-based point count.
* Insufficient data for analysis.

Long-billed Curlew
(*Numenius americanus*)

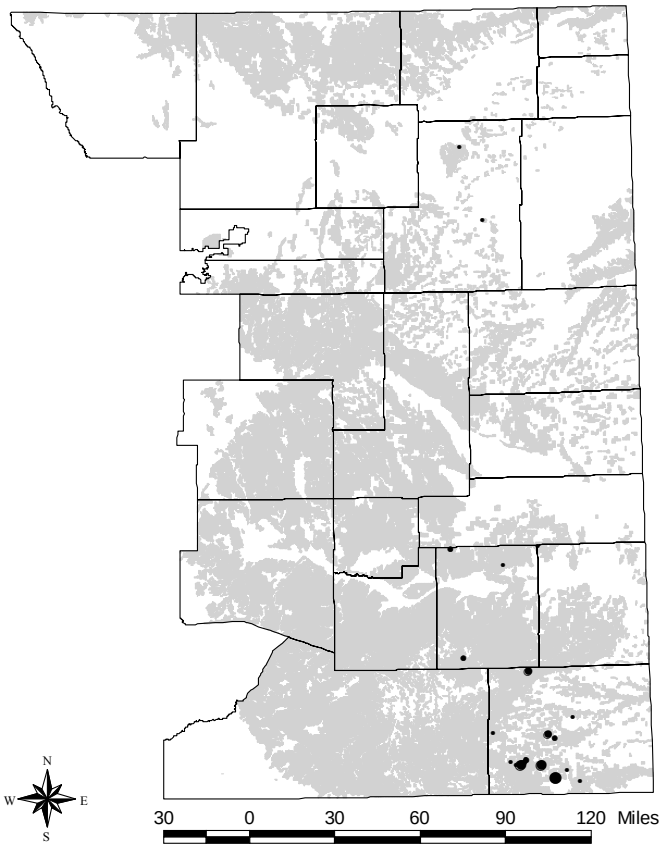
In Colorado, Long-billed Curlew breeding distribution is nearly restricted to the southeastern corner. However, there were a few individuals detected in the north central portion of the state. I calculated density estimates using the data from two techniques: driving line transects and road-based point counts.

Density estimate (D) and population estimate (N) for this species by technique:

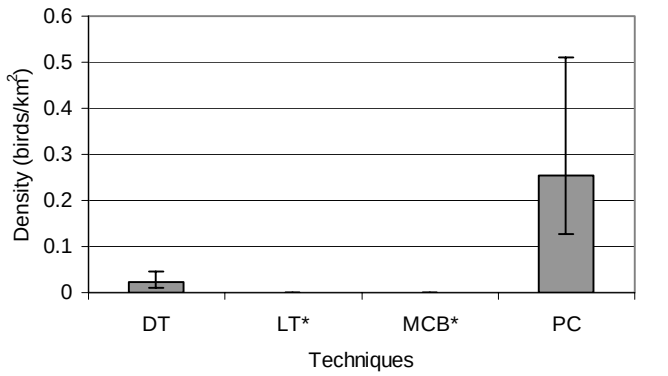
- Driving line transects
  D = 0.02 bird/km^2 (CV=37%)
  N = 2,687 individuals in eastern Colorado.
- Road-based point counts
  D = 0.3 bird/km^2 (CV=37%)
  N = 9,164 individuals in the shortgrass prairie of eastern Colorado.

The density estimates cannot be compared due to the differences in the time period and area from which the data was collected. The driving line transect and road-based point count technique generated a sufficient number of detections to calculate a density estimate. The road-based point count technique detected 135 individuals on 2% of the sections surveyed. Either of the two techniques should be able to monitor the population trend over time.

The expansion of road-based point counts to cropland should increase the number of detections and the precision of the density estimate for this species. The road-based point count technique should also be capable of monitoring the distribution of the species.



Index of abundance, expressed in individuals per section / # of point counts, and breeding distribution of Long-billed Curlew in the shortgrass prairie of eastern Colorado, 2001.



Density of Long-billed Curlew by technique in the shortgrass prairie of eastern Colorado, 2001. Technique Codes: **DT**=30mi driving transect, **LT**=interior line transect, ***MCB***=*MCB* point transect, **PC**=road-based point count. * Insufficient data for analysis.

Mourning Dove
(*Zenaida macroura*)

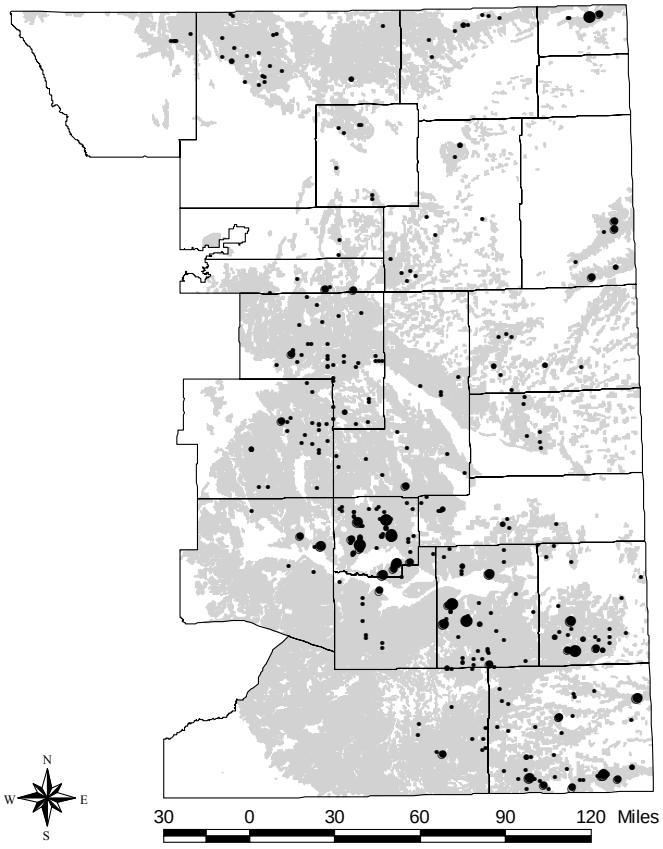
The Mourning Dove is distributed throughout the shortgrass prairie of eastern Colorado. I calculated density estimates using the data from three different techniques, interior line transects, *MCB* point transects and road-based point counts.

Distance estimate (D) and population estimate (N) for this species by technique:

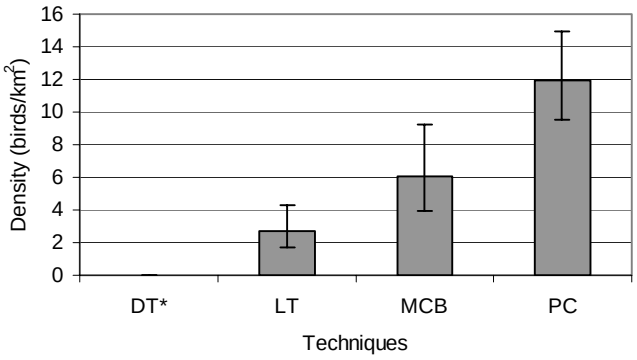
- Interior line transects
  D = 2.7 bird/km^2 (CV=24%)
  N = 96,466 individuals in the shortgrass prairie of eastern Colorado.
- *MCB* point transects
  D = 6.0 bird/km^2 (CV=22%)
  N = 215,880 individuals in the shortgrass prairie of eastern Colorado.
- Road-based point transects
  D = 11.9 bird/km^2 (CV=11%)
  N = 429,853 individuals in the shortgrass prairie of eastern Colorado.

These three techniques should be able to monitor the population trend of this species over time, due to the CVs less than 50%, which suggests robust data. In addition to population trend, the road-based point count technique should monitor the distribution of this species.

The comparison of the road-based point count technique, to the other two techniques, reveal a bias for roads in this species. Future efforts will work to determine a correction factor for this "bias", this should create a more accurate density estimate.



Index of abundance, expressed in individuals per section / # of point counts, and breeding distribution of Mourning Dove in the shortgrass prairie of eastern Colorado, 2001.



Density of Morning Dove by technique in the shortgrass prairie of eastern Colorado, 2001. Technique Codes: **DT**=30mi driving transect, **LT**=interior line transect, ***MCB***=*MCB* point transect, **PC**=road-based point count.
***** Insufficient data for analysis.

Burrowing Owl
(*Athene cunicularia*)

The distribution of the Burrowing Owl is tightly tied with the distribution of black-tailed prairie dog colonies. This map shows that most of the birds were discovered in the southern half of the state. I calculated density estimates using data collected from two techniques: driving line transects and road-based point counts.

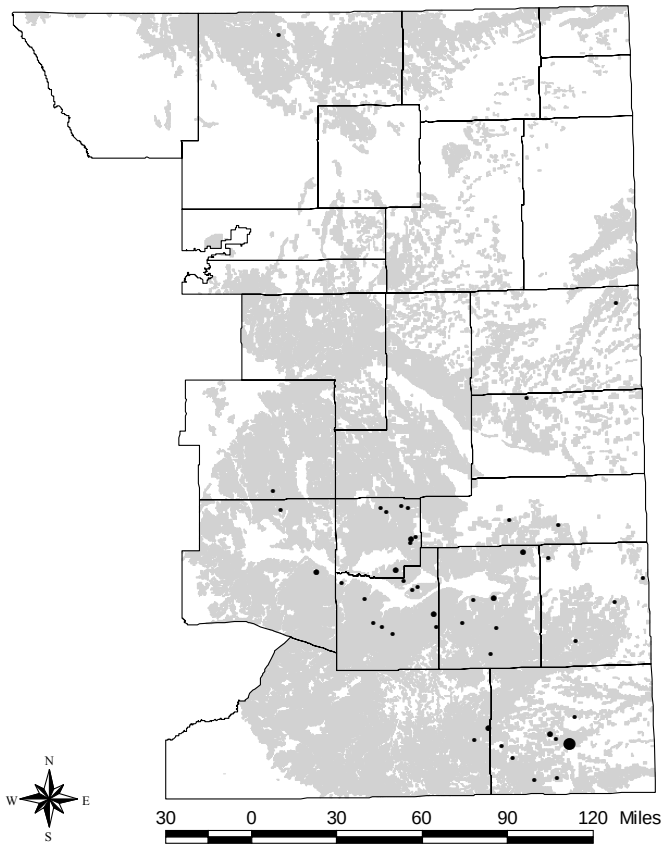
Distance estimate (D) and population estimate (N) for this species by technique:

- Driving line transects
  D = 0.17 bird/km^2 (CV=18%)
  N = 20,408 individuals in eastern Colorado.
- Road-based point counts
  D = 0.44 bird/km^2 (CV=22%)
  N = 15,796 individuals in the shortgrass prairie of eastern Colorado.

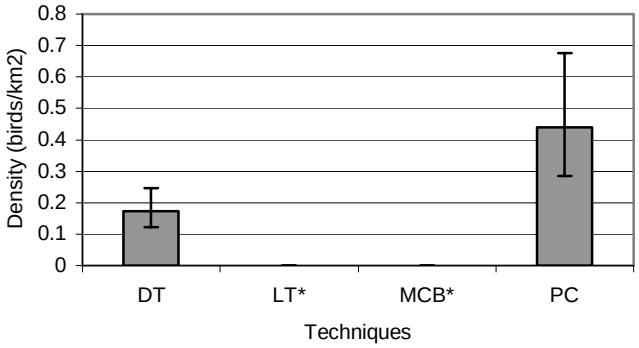
Each of the techniques was able to sufficiently detect this species. These techniques should be able to monitor population trend in this species over time.

In addition to monitoring population trend, the road-based point count technique should also be able to monitor the distribution of this species in eastern Colorado.

Future efforts in monitoring for this species should use the road-based point counts to monitor the population trend and distribution of this species. I would also advise the implementation of a program that would inventory black-tailed prairie dog colonies, which should increase the number of detections of this species and monitor individual colonies.



Index of abundance, expressed in individuals per section / # of point counts, and breeding distribution of Burrowing Owl in the shortgrass prairie of eastern Colorado, 2001.



Density of Burrowing Owl by technique in the shortgrass prairie of eastern Colorado, 2001. Technique Codes: **DT**=30mi driving transect, **LT**=interior line transect, ***MCB***=*MCB* point transect, **PC**=road-based point count.
* Insufficient data for analysis.

Common Nighthawk
(*Chordeiles minor*)

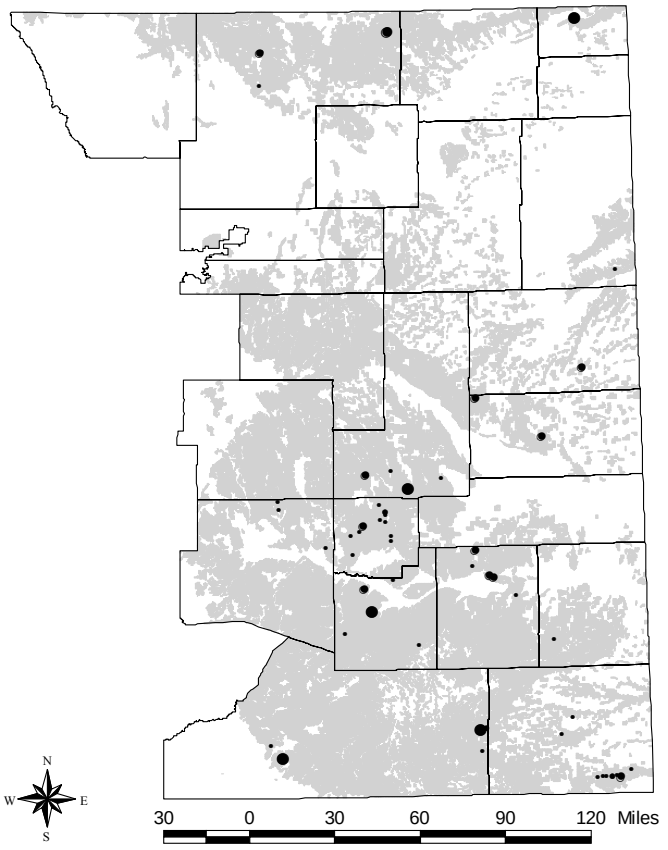
The Common Nighthawk is distributed throughout the shortgrass prairie of eastern Colorado. This species commonly nests on bare ground in the shortgrass prairie. I calculated density estimates using data from two techniques: interior line transects and road-based point counts.

Distance estimate (D) and population estimate (N) for this species by technique:

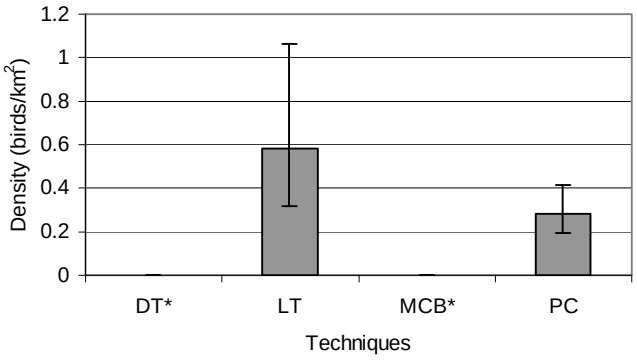
- Interior line transects
  D = 0.58 bird/km^2 (CV=31%)
  N = 20,988 individuals in the shortgrass prairie of eastern Colorado.
- Road-based point counts
  D = 0.28 bird/km^2 (CV=19%)
  N = 10,228 individuals in the shortgrass prairie of eastern Colorado.

The two techniques detected enough individuals of this species to monitor the trend in population size. The road-based point count technique detected 98 individuals on 5% of the sections surveyed. In addition to monitoring the trend in population size, the road-based point count technique can also look at trend in distribution.

Future efforts to monitor this species should continue conducting the road-based point count technique for two reasons. One, the ability of the technique to determine trend in distribution, and two, due to the more precise density estimate.



Index of abundance, expressed in individuals per section / # of point counts, and breeding distribution of Common Nighthawk in the shortgrass prairie of eastern Colorado, 2001.



Density of Common Nighthawk by technique in the shortgrass prairie of eastern Colorado, 2001. Technique Codes: **DT**=30mi driving transect, **LT**=interior line transect, ***MCB***=*MCB* point transect, **PC**=road-based point count. * Insufficient data for analysis.

Western Kingbird
(*Tyrranus verticalis*)

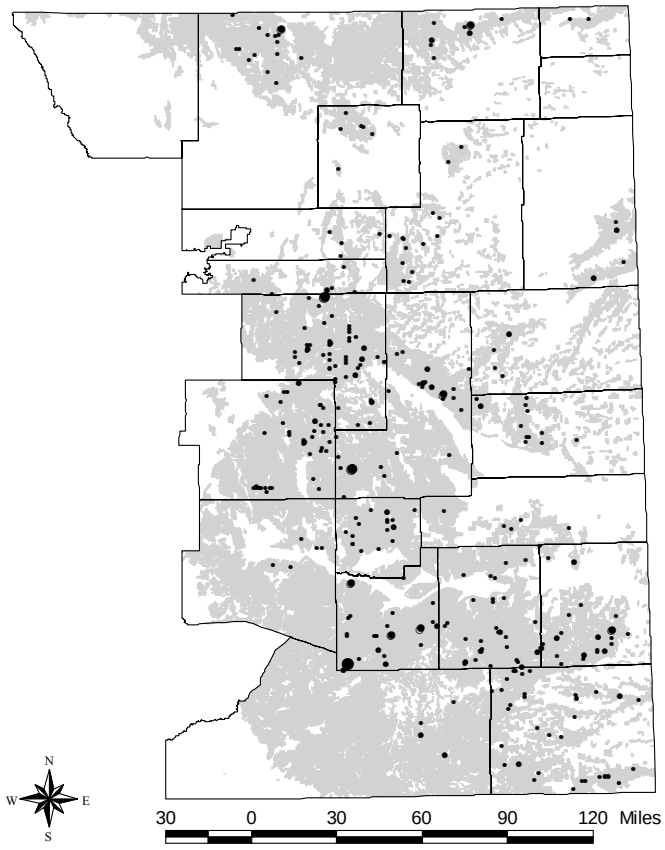
The Western Kingbird is distributed throughout the shortgrass prairie of eastern Colorado. This species is usually found nesting in trees in and around human habitation. I calculated density estimates for this species using the data collected from two techniques: *MCB* point transects and road-based point counts.

Density estimate (D) and population estimate (N) for this species by technique:

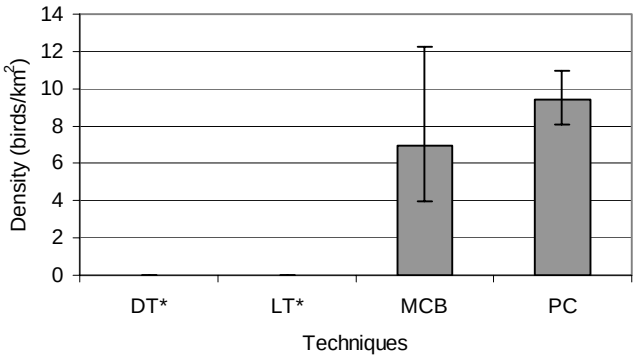
- *MCB* point transects
  D = 7.0 bird/km^2 (CV=29%)
  N = 251,860 individuals in the shortgrass prairie of eastern Colorado.
- Road-based point counts
  D = 9.4 bird/km^2 (CV=8%)
  N = 339,500 individuals in the shortgrass prairie of eastern Colorado.

Two techniques, *MCB* point transects and road-based point counts, detected enough individuals to calculate density estimates to determine trend in population. The road-based point count technique detected 634 individuals on 25% of the sections surveyed. In addition to population trend, road-based point counts should be able to illustrate trend in distribution.

Future efforts to monitor this species should continue to conduct road-based point counts due to the more precise density estimate and the ability to show trend in distribution.



Index of abundance, expressed in individuals per section / # of point counts, and breeding distribution of Western Kingbird in the shortgrass prairie of eastern Colorado, 2001.



Density of Western Kingbird by technique in the shortgrass prairie of eastern Colorado, 2001. Technique Codes: **DT**=30mi driving transect, **LT**=interior line transect, ***MCB***=*MCB* point transect, **PC**=road-based point count.
* Insufficient data for analysis.

Eastern Kingbird
(*Tyrannus tyrannus*)

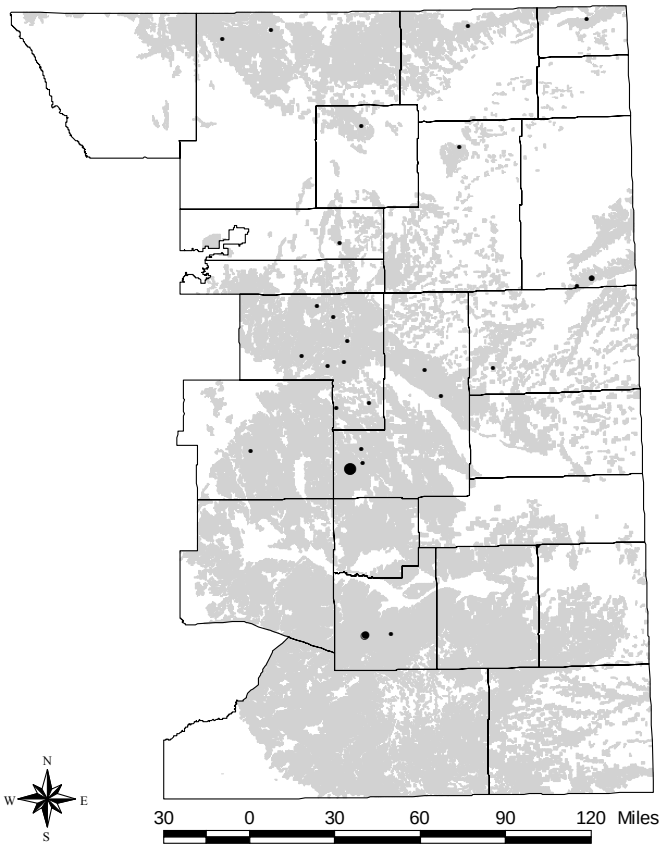
The Eastern Kingbird is distributed throughout eastern Colorado usually nesting in wooded areas. I calculated a density estimate using data collected from one technique: Road-based point counts.

Density estimate (D) and population estimate (N) for this species by technique:

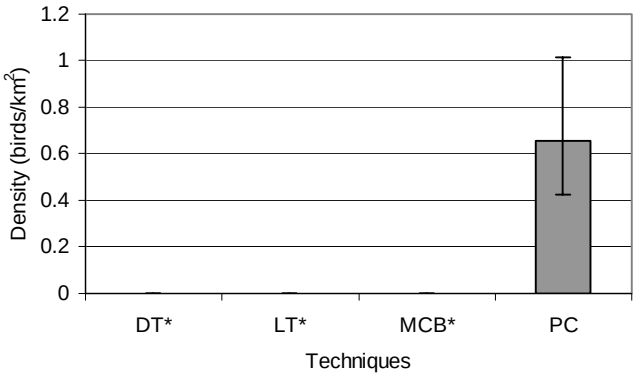
- Road-based point counts
  D = 0.7 bird/km^2 (CV=22%)
  N = 23,599 individuals in the shortgrass prairie of eastern Colorado.

The road-based point count was the only technique that detected enough individuals to calculate a density estimate for this species. This technique detected 37 individuals on 2% of the sections surveyed.

Future efforts should continue to use road-based point counts to monitor trends in population size and distribution of this species in eastern Colorado.



Index of abundance, expressed in individuals per section / # of point counts, and breeding distribution of Eastern Kingbird in the shortgrass prairie of eastern Colorado, 2001.



Density of Eastern Kingbird by technique in the shortgrass prairie of eastern Colorado, 2001. Technique Codes: **DT**=30mi driving transect, **LT**=interior line transect, ***MCB***=*MCB* point transect, **PC**=road-based point count.
* Insufficient data for analysis.

Loggerhead Shrike
(*Lanius ludovicianus*)

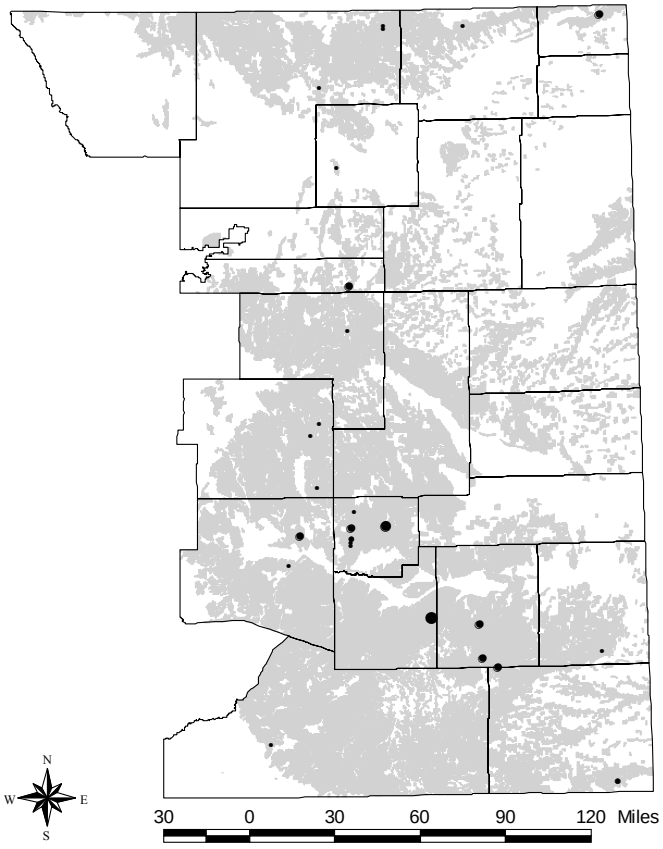
The Loggerhead Shrike is distributed throughout eastern Colorado. In the shortgrass prairie this species nests in trees and shrubs. I calculated density estimates using data collected from two techniques: driving line transects and road-based point counts.

Density estimate (D) and population estimate (N) for this species by technique:

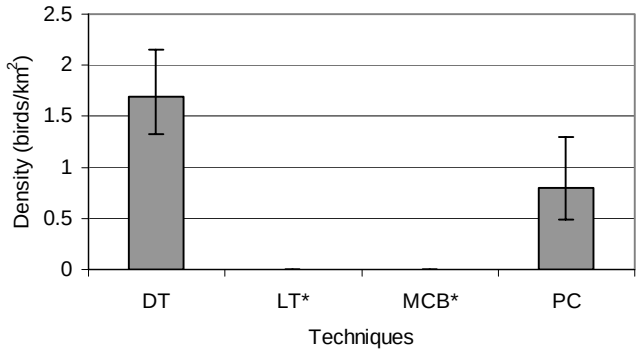
- Driving line transects
  D = 1.69 bird/km^2 (CV=12%)
  N = 198,527 individuals in eastern Colorado
- Road-based point counts
  D = 0.80 bird/km^2 (CV=25%)
  N = 28,685 individuals in the shortgrass prairie of eastern Colorado

The two density estimates generated by the data from the different techniques cannot be compared due to differences in the time period collected and the area of inference of the studies. The two techniques faired well in detecting this species and each generated density estimates that could be used to monitor population trend and distribution.

Future efforts should continue to conduct the road-based point counts due to the ability of the technique to detect trend in distribution and abundance of this species.



Index of abundance, expressed in individuals per section / # of point counts, and breeding distribution of Loggerhead Shrike in the shortgrass prairie of eastern Colorado, 2001.



Density of Loggerhead Shrike by technique in the shortgrass prairie of eastern Colorado, 2001. Technique Codes: **DT**=30mi driving transect, **LT**=interior line transect, ***MCB***=*MCB* point transect, **PC**=road-based point count.
***** Insufficient data for analysis.

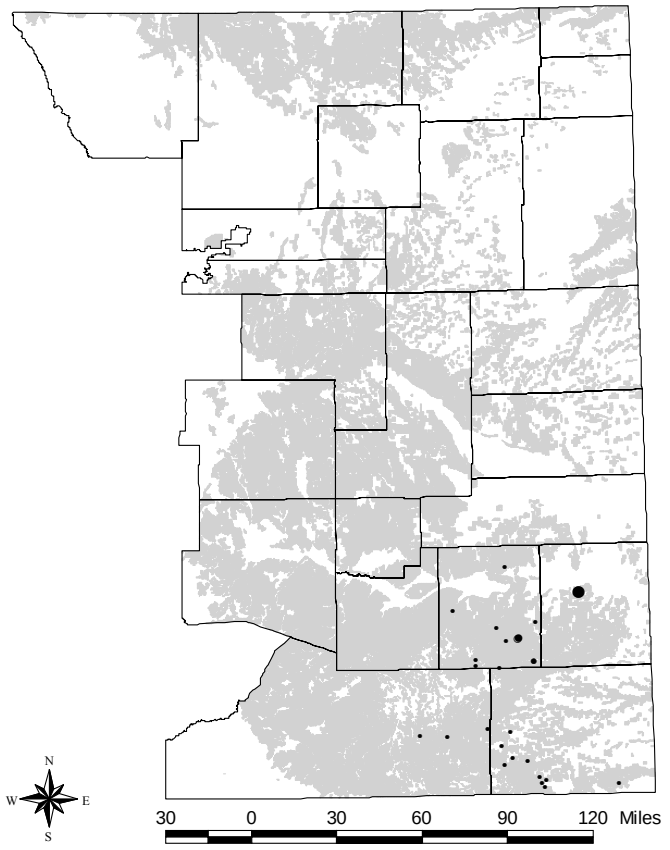
Chihuahuan Raven
(*Corvus cryptoleucus*)

The Chihuahuan Raven is distributed throughout the southeastern part of eastern Colorado. This species can be found nesting in old windmill towers and power poles. I calculated density estimates for this species using data collected from two different techniques: driving line transects and road-based point counts.

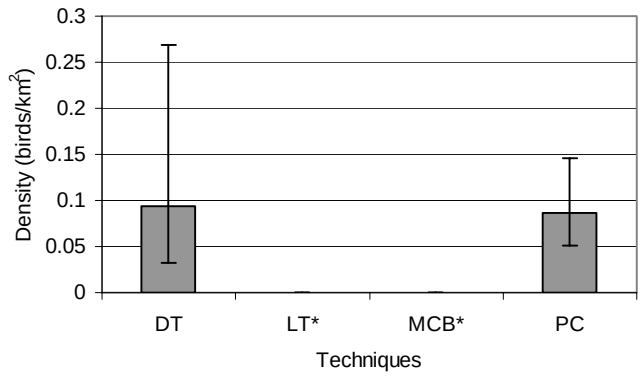
Density estimate (D) and population estimate (N) for this species by technique:

- Driving line transects
  D = 0.09 bird/km^2 (CV 57%)
  N = 11,010 individuals in eastern Colorado.
- Road-based point counts
  D = 0.1 bird/km^2 (CV 27%)
  N = 3,104 individuals in the shortgrass prairie of eastern Colorado.

The density estimates generated from the two different techniques could not be compared due to differences in the time period and area of inference. The two techniques could monitor population trend over time. The road-based point transects gave the most precise density estimate for this species and can also determine trends in distribution and abundance. This technique should work best to monitor this species.



Index of abundance, expressed in individuals per section / # of point counts, and breeding distribution of Chihuahuan Raven in the shortgrass prairie of eastern Colorado, 2001.



Density of Chihuahuan Raven by technique in the shortgrass prairie of eastern Colorado, 2001. Technique Codes: **DT**=30mi driving transect, **LT**=interior line transect, ***MCB***=*MCB* point transect, **PC**=road-based point count.
* Insufficient data for analysis.

Horned Lark
(*Eremophila alpestris*)

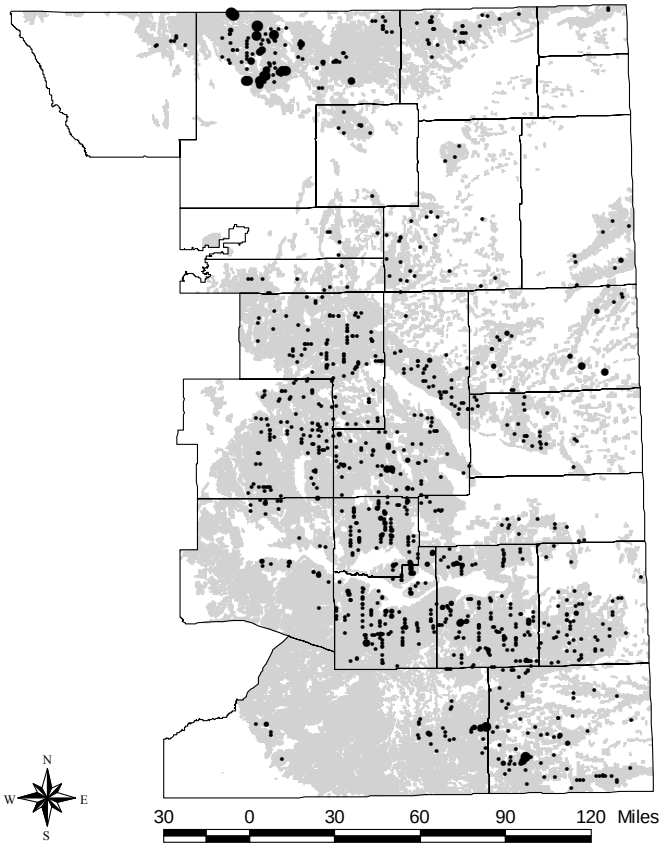
The Horned Lark is distributed throughout the eastern plains in Colorado. This species was one of the most abundant with 6,901 individuals detected on 77% of the sections. I calculated density estimates using data collected from three different techniques: interior line transects, *MCB* point transects, and road-based point counts.

Density estimate (D) and population estimate (N) for this species by technique:

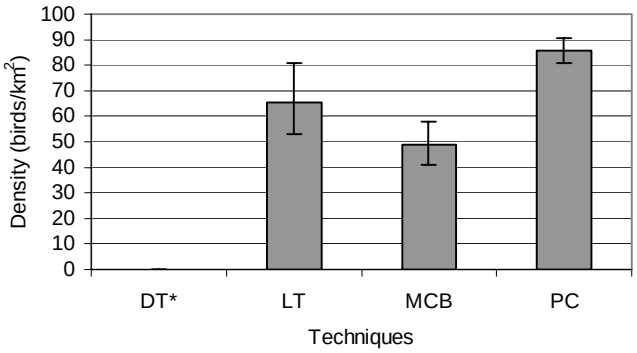
- Interior line transects
  D = 65.4 bird/km^2 (CV=11%)
  N = 2,353,560 individuals in the shortgrass prairie of eastern Colorado.
- *MCB* point transects
  D = 48.8 bird/km^2 (CV=9%)
  N = 1,755,824 individuals in the shortgrass prairie of eastern Colorado.
- Road-based point counts
  D = 85.6 bird/km^2 (CV=3%)
  N = 3,079,780 individuals in the shortgrass prairie of eastern Colorado.

Any of these techniques could be used to monitor population trends in this species. The road-based point count technique has additional value. This technique is able to look at trends in distribution and abundance.

Future efforts to monitor this species should continue to conduct the road-based point count technique. The comparison of the road-based point count technique and the *MCB* point transect technique reveal a "bias" for roads in this species in the shortgrass prairie of eastern Colorado. Currently, we are trying to determine a correction factor for this "bias" in this species to create a more accurate density estimate.



Index of abundance, expressed in individuals per section / # of point counts, and breeding distribution of Horned Lark in the shortgrass prairie of eastern Colorado, 2001.



Density of Horned Lark by technique in the shortgrass prairie of eastern Colorado, 2001. Technique Codes: **DT**=30mi driving transect, **LT**=interior line transect, ***MCB***=*MCB* point transect, **PC**=road-based point count.
* Insufficient data for analysis.

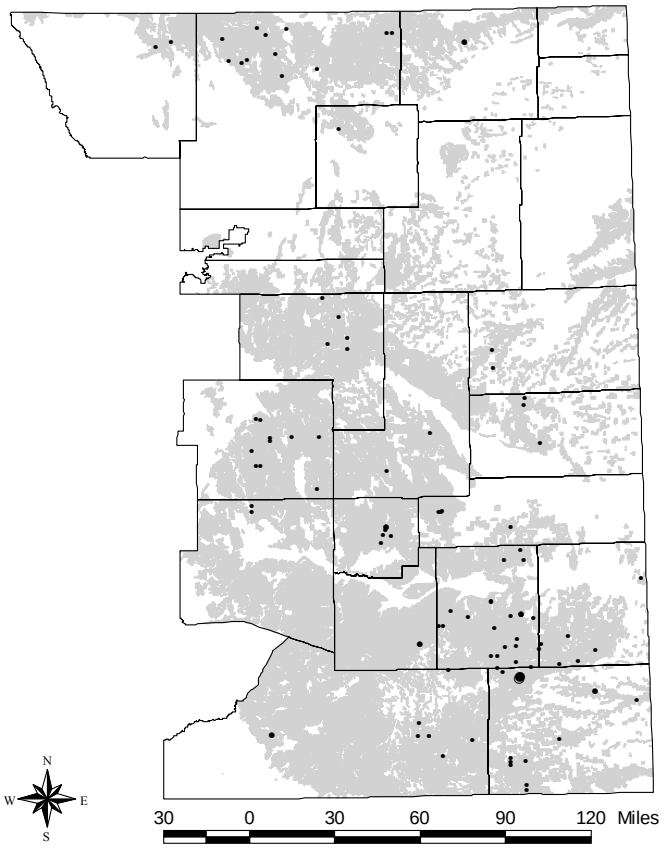
Cliff Swallow
(*Petrochelidon pyrrhonota*)

The Cliff Swallow is distributed throughout the plains of eastern Colorado. This species can be found nesting on vertical faces of cliffs, canyons and also on the undersides of bridges and culverts. One distance estimate was calculated for this species using data collected from the road-based point count technique.

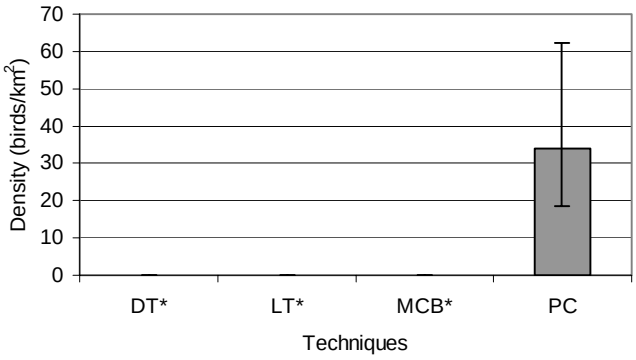
Density estimate (D) and population estimate for this species by technique:

- Road-based point counts
  D = 34.0 bird/km^2 (CV=31%)
  N = 1,223,356 individuals in the shortgrass prairie of estern Colorado.

This species was well detected using the road-based point count technique. 453 individuals were located on 8% of the sections surveyed. The road-based point count technique could be used to monitor population trend, and distribution of this species.



Index of abundance, expressed in individuals per section / # of point counts, and breeding distribution of Cliff Swallow in the shortgrass prairie of eastern Colorado, 2001.



Density of Cliff Swallow by technique in the shortgrass prairie of eastern Colorado, 2001. Technique Codes: **DT**=30mi driving transect, **LT**=interior line transect, ***MCB***=*MCB* point transect, **PC**=road-based point count.
* Insufficient data for analysis.

Barn Swallow
(*Hirundo rustica*)

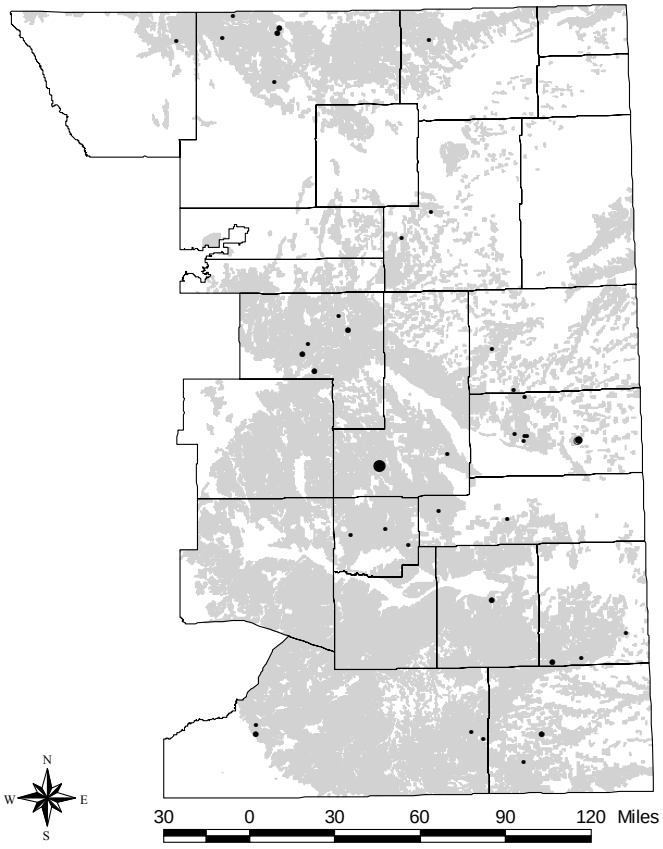
The Barn Swallow is distributed throughout eastern Colorado using primarily man-made structures, to which they attach their nest. I calculated density estimates using the data from one technique: road-based point counts.

Distance estimate (D) and population estimate (N) for this species by technique:

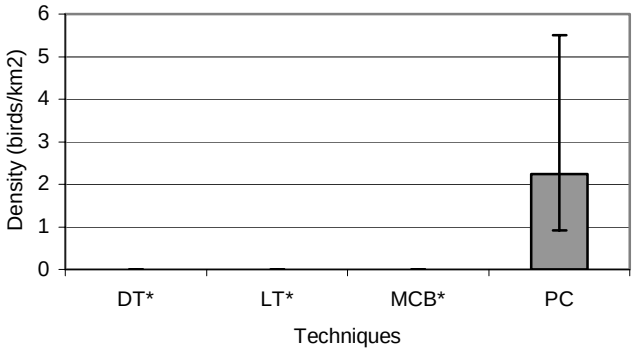
- Road-based point counts
  D = 2.2 bird/km^2 (CV=47%)
  N = 80,876 individuals in the shortgrass prairie of eastern Colorado.

This species was well detected using the road-based point count technique. 72 individuals were detected on 3 % of the sections surveyed. This technique should be able to detect trends in population and abundance in this species.

Future efforts to monitor this species should continue the road-based point count technique and expand this technique to other habitats throughout eastern Colorado. This expansion should increase the number of detections and the precision of the density estimate.



Index of abundance, expressed in individuals per section / # of point counts, and breeding distribution of Barn Swallow in the shortgrass prairie of eastern Colorado, 2001.



Density of Barn Swallow by technique in the shortgrass prairie of eastern Colorado, 2001. Technique Codes: **DT**=30mi driving transect, **LT**=interior line transect, ***MCB***=*MCB* point transect, **PC**=road-based point count.
***** Insufficient data for analysis.

Northern Mockingbird
(*Mimus polyglottos*)

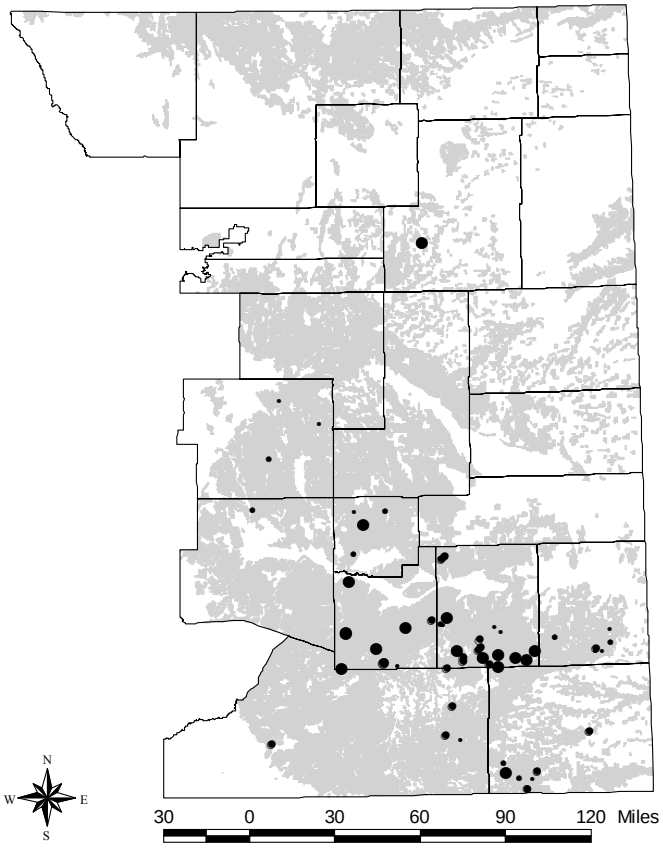
The Northern Mockingbird is distributed throughout eastern Colorado weighted toward the southern portion. This species nests in trees and shrubs that occur around human habitation located in the shortgrass prairie. I calculated a density estimate for this species using data from one technique: road-based point counts.

Distance estimate (D) and population estimate (N) for this species by technique:

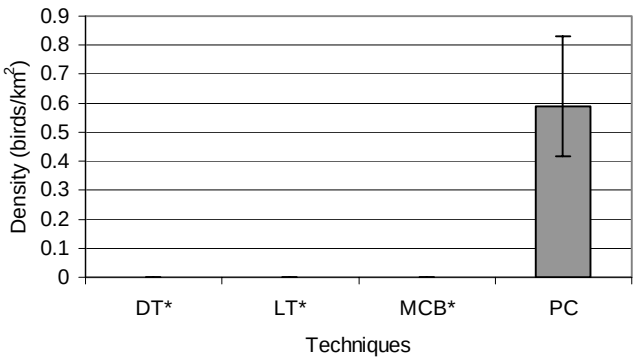
- Road-based point count
  D = 0.6 bird/km^2 (CV=18%)
  N = 21,134 individuals

The road-based point count technique detected this species well with 73 individuals on 5% of the sections surveyed.

The road-based point count technique should be effective in monitoring the population trend and distribution of this species. The expansion of this technique to other habitats should yield more detections of this species, and hence, increase the precision of the density estimate.



Index of abundance, expressed in individuals per section / # of point counts, and breeding distribution of Northern Mockingbird in the shortgrass prairie of eastern



Density of Northern Mockingbird by technique in the shortgrass prairie of eastern Colorado, 2001. Technique Codes: **DT**=30mi driving transect, **LT**=interior line transect, ***MCB***=*MCB* point transect, **PC**=road-based point count. * Insufficient data for analysis.

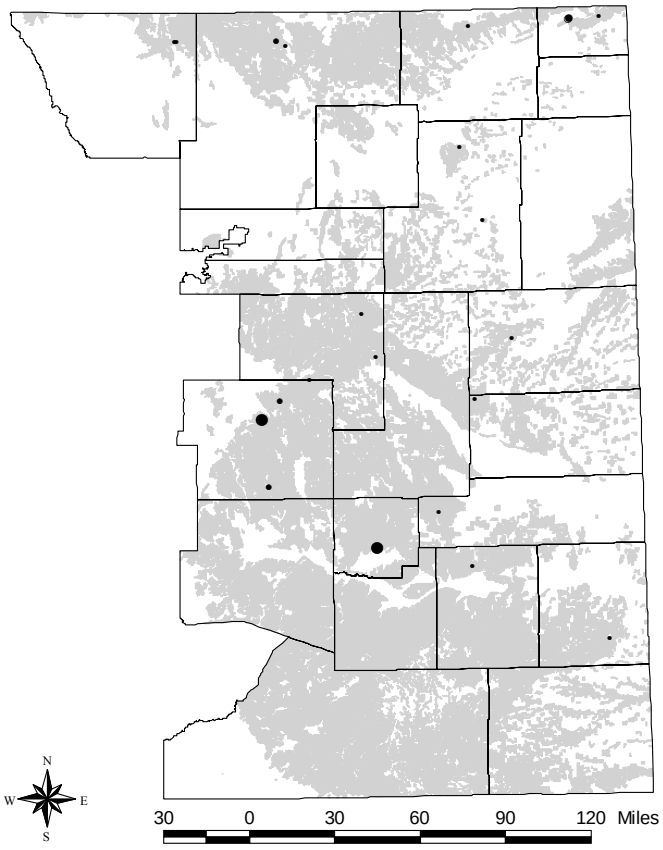
European Starling
(*Sturnus vulgaris*)

The European Starling is distributed throughout eastern Colorado, but is rare in shortgrass prairie areas, except where anthropogenic changes (e.g., homesteads) have provided nesting opportunities. I calculated a density estimate using the data from one technique: road-based point counts.

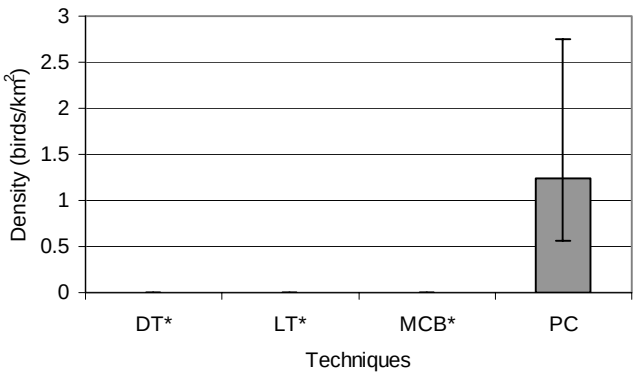
Distance estimate (D) and population estimate (N) for this species by technique:

- Road-based point counts
  D = 1.2 bird/km^2 (CV=42%)
  N = 44,662 individuals in the shortgrass prairie of eastern Colorado.

This species was well detected using this technique. Unfortunately, we detected 69 individuals on 32% of the sections surveyed. This technique should be able to detect a population trend and track changes in distribution over time..



Index of abundance, expressed in individuals per section / # of point counts, and breeding distribution of European Starling in the shortgrass prairie of eastern Colorado, 2001.



Density of European Starling by technique in the shortgrass prairie of eastern Colorado, 2001. Technique Codes: **DT**=30mi driving transect, **LT**=interior line transect, ***MCB***=*MCB* point transect, **PC**=road-based point count.
* Insufficient data for analysis.

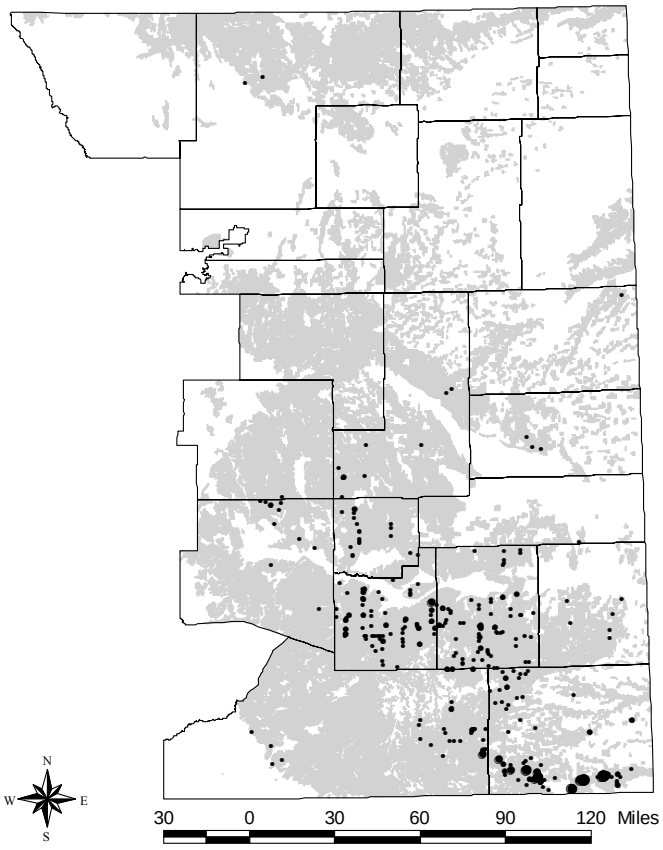
Cassin's Sparrow
(*Aimophila cassinii*)

The Cassin's Sparrow is distributed throughout eastern Colorado, in most years concentrated in the southeastern portion. Though it breeds in numbers in this area every year, this species' occurrence in the rest of Colorado is variable in extent and numbers due to its nomadic nature. I calculated a density estimate using data collected from three techniques: interior line transects, *MCB* point transects, and road-based point counts.

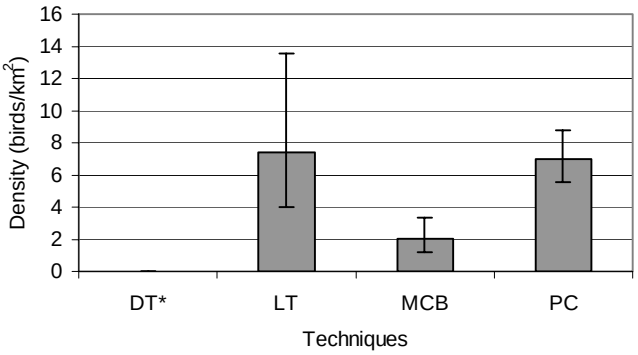
Distance estimate (D) and population estimate (N) for this species by technique:

- Interior line transects
  D = 0.074 bird/km^2 (CV=31%)
  N = 265,356 individuals in the shortgrass prairie of eastern Colorado.
- *MCB* point transects
  D = 0.020 bird/km^2 (CV=26%)
  N = 71,960 individuals in the shortgrass prairie of eastern Colorado.
- Road-based point counts
  D = 0.070 bird/km^2 (CV=12%)
  N = 250,518 individuals in the shortgrass prairie of eastern Colorado.

This species was well detected by all of the techniques. The road-based point count technique detected 835 individuals on 22% of the sections surveyed. The advantage to conducting the road-based point counts for this nomadic species is to track the changes in distribution.



Index of abundance, expressed in individuals per section / # of point counts, and breeding distribution of Cassin's Sparrow in the shortgrass prairie of eastern Colorado, 2001.



Density of Cassin's Sparrow by technique in the shortgrass prairie of eastern Colorado, 2001. Technique Codes: **DT**=30mi driving transect, **LT**=interior line transect, ***MCB***=*MCB* point transect, **PC**=road-based point count.
* Insufficient data for analysis.

Brewer's Sparrow
(*Spizella beweri*)

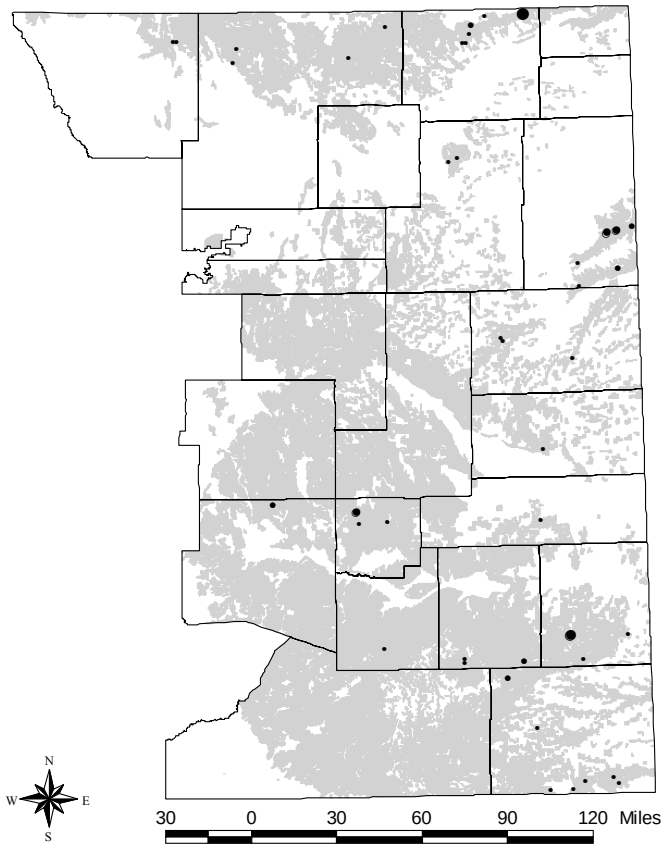
The Brewers Sparrow has a scattered distribution throughout the eastern plains of Colorado. This species prefers to nest and breed in areas that contain sage brush (*Artemisia* spp.). I calculated density estimates for this species using the data collected from two techniques interior line transects and road-based point counts:

Distance estimate (D) and population estimate (N) for this species by technique:

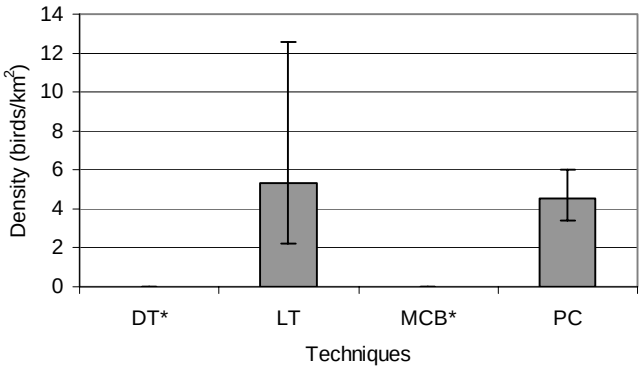
- Interior line transects
  D = 5.3 bird/km^2 (CV=45%)
  N = 190,762 individuals in the shortgrass prairie of eastern Colorado.
- Road-based point counts
  D = 4.5 bird/km^2 (CV=14%)
  N = 162,874 individuals in the shortgrass prairie of eastern Colorado.

Two techniques did well in detecting this species and should be able to monitor population trend and distribution in eastern Colorado. Road-based point counts detected 254 individuals on 5% of the sections surveyed.

The road-based point count technique yielded a more accurate density estimate, based on the lower CV. This should allow trends in population and distribution to be revealed is a shorter time period.



Index of abundance, expressed in individuals per section / # of point counts, and breeding distribution of Brewer's Sparrow in the shortgrass prairie of eastern Colorado, 2001.



Density of Brewer's Sparrow by technique in the shortgrass prairie of eastern Colorado, 2001. Technique Codes: **DT**=30mi driving transect, **LT**=interior line transect, ***MCB***=*MCB* point transect, **PC**=road-based point count.
* Insufficient data for analysis.

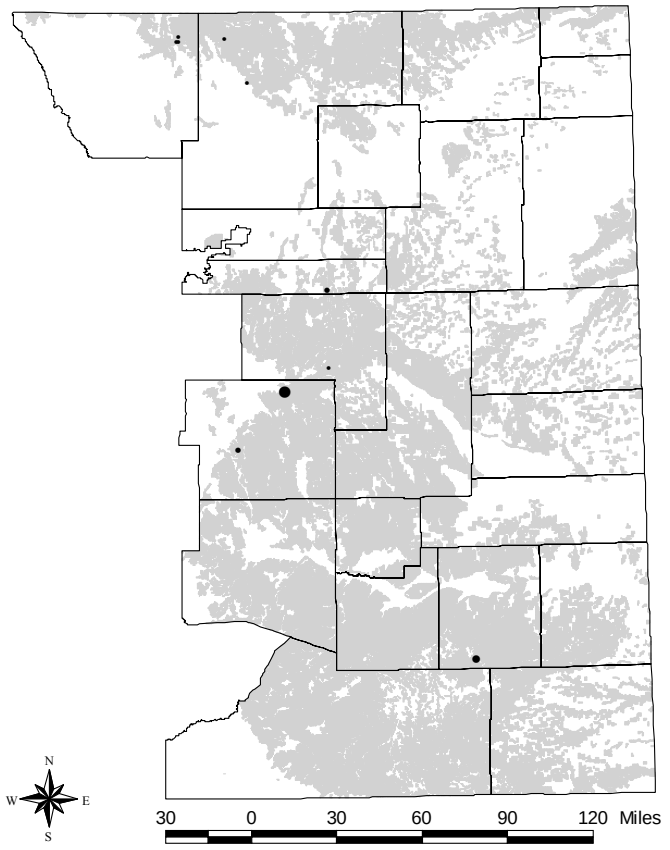
Vesper Sparrow
(*Pooecetes gramineus*)

The Vesper sparrow is found in distinct vegetation communities that are locally distributed and biased toward the front range. I calculated density estimates for this species using data collected from two different techniques: *MCB* point transect and road-based point count.

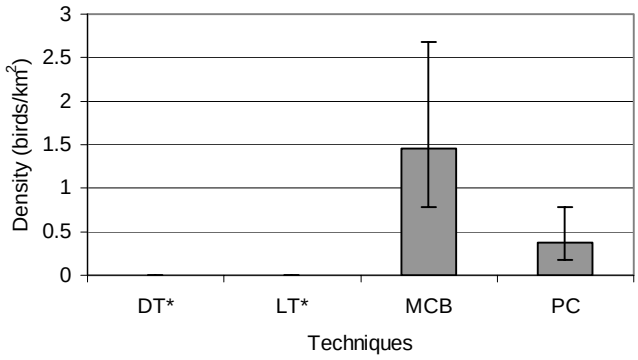
Distance estimate (D) and population estimate (N) for this species by technique:

- *MCB* point transects
  D = 1.5 bird/km2 (CV=32%)
  N = 53,970 individuals in the shortgrass prairie of eastern Colorado.
- Road-based point counts
  D = 0.4 bird/km2 (CV=39%)
  N = 13,335 individuals in the shortgrass prairie of eastern Colorado.

This species was poorly detected using these techniques. The expansion into shrub habitats in eastern Colorado should increase the number of detections of this species, and, hence, increase the precision of the density estimate.



Index of abundance, expressed in individuals per section / # of point counts, and breeding distribution of Vesper Sparrow in the shortgrass prairie of eastern Colorado, 2001.



Density of Vesper Sparrow by technique in the shortgrass prairie of eastern Colorado, 2001. Technique Codes: **DT**=30mi driving transect, **LT**=interior line transect, ***MCB***=*MCB* point transect, **PC**=road-based point count.
* Insufficient data for analysis.

Lark Sparrow
(*Chondestes grammacus*)

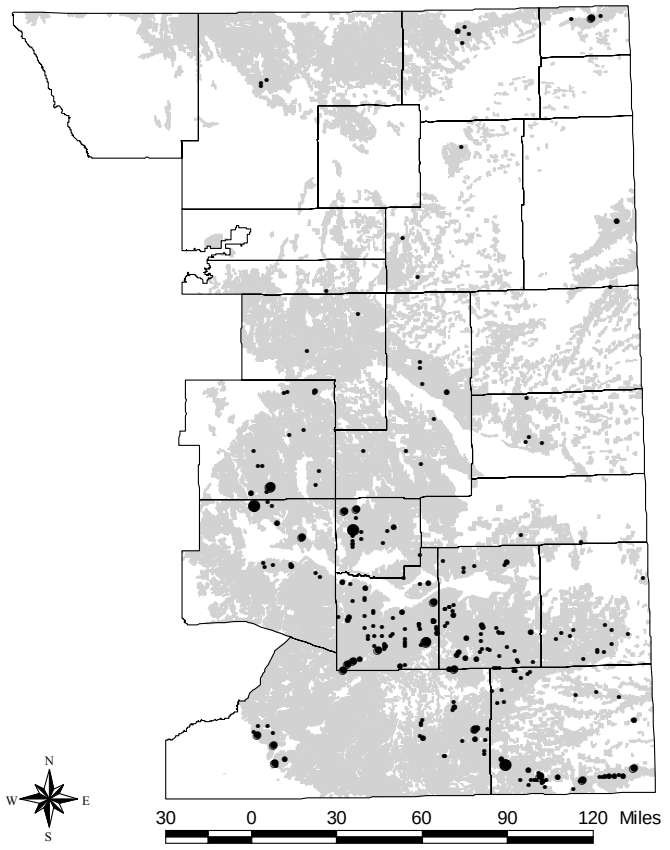
The Lark Sparrow is distributed throughout the shortgrass prairie of eastern Colorado. This species prefers to nest in areas with a variety of structure in the vegetation scattered with shrubs. I calculated density estimates using data from two of the techniques: *MCB* point transects and road-based point transects.

Distance estimate (D) and population estimate (N) for this species by technique:

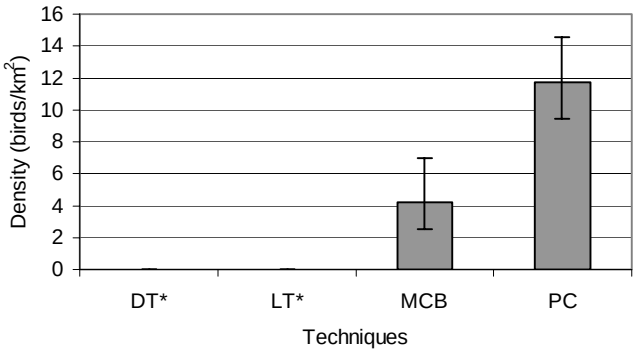
- *MCB* point transect
  D = 4.2 bird/km^2 (CV 26%)
  N = 151,116 individuals
- Road-based point count
  D = 11.7 bird/km^2 (CV 11%)
  N = 421,326 individuals

This species was well detected using the road-based point count technique. 585 individuals were detected on 20% of the sections we surveyed. The expansion to other habitats including shrublands should increase the number of detections for this species in eastern Colorado.

The estimated densities of this species are significantly different based on the separation between the 95 %confidence limit bars. This difference in density estimates suggests a road bias in this species. Future efforts will work toward determining a variable to adjust for such a bias that we can use to calculate more accurate density estimates.



Index of abundance, expressed in individuals per section / # of point counts, and breeding distribution of Lark Sparrow in the shortgrass prairie of eastern Colorado, 2001.



Density of Lark Sparrow by technique in the shortgrass prairie of eastern Colorado, 2001. Technique Codes: **DT**=30mi driving transect, **LT**=interior line transect, ***MCB***=*MCB* point transect, **PC**=road-based point count.
* Insufficient data for analysis.

Lark Bunting
(*Calamospiza melanocorys*)

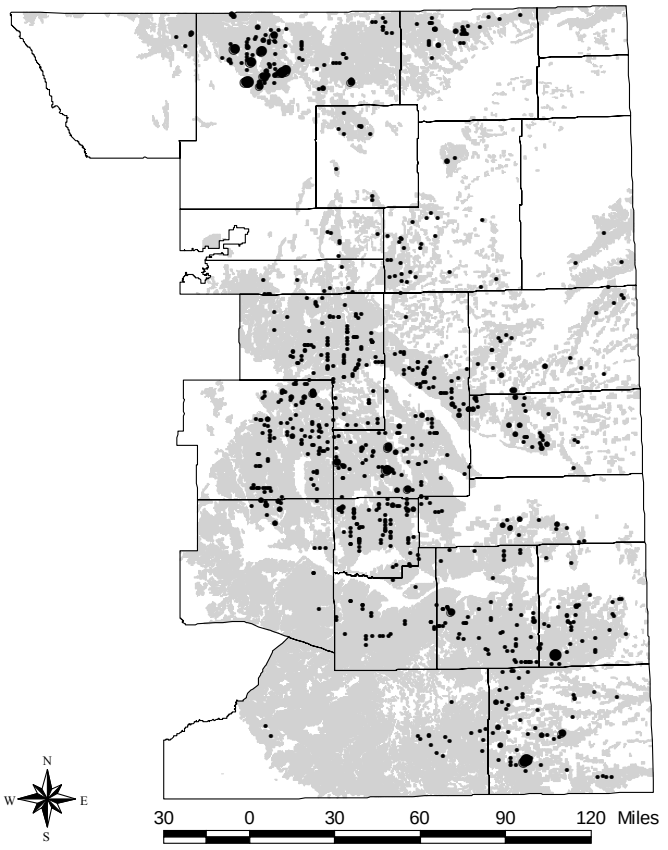
The Lark Bunting, the species with the highest number of detections using the road-based point counts, is distributed throughout the shortgrass prairie in eastern Colorado. I calculated density estimates for this species using data from three different techniques: Interior line transects, *MCB* point transects, and road-based point counts.

Distance estimate (D) and population estimate (N) for this species by technique:

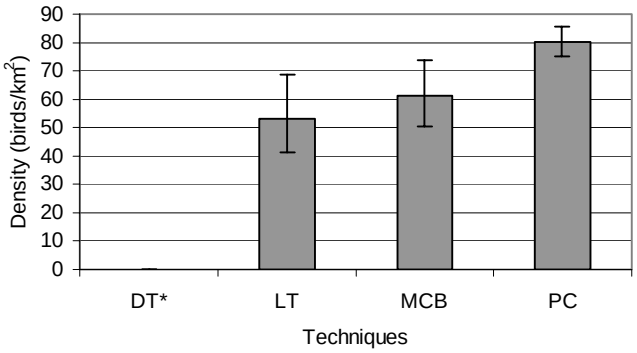
- Interior line transects
  D = 53.2 bird/km^2 (CV=13%)
  N = 1,913,524 individuals in the shortgrass prairie of eastern Colorado.
- *MCB* point transects
  D = 61.1 bird/km^2 (CV=10%)
  N = 2,198,378 individuals in the shortgrass prairie of eastern Colorado.
- Road-based point counts
  D = 80.2 bird/km^2 (CV=3%)
  N = 2,885,380 individuals in the shortgrass prairie of eastern Colorado.

This species was well detected by all of the techniques. The road-based point count technique detected 8,927 individuals on 64% of the sections surveyed.

The density estimate derived from the road-based point count technique is significantly different than the other two techniques due to the 95% confidence limit bars not overlapping. This difference suggest that the Lark Bunting is slightly bias towards the road. Future efforts will work to determine a variable to adjust for this road bias in all species.



Index of abundance, expressed in individuals per section / # of point counts, and breeding distribution of Lark Bunting in the shortgrass prairie of eastern Colorado, 2001.



Density of Lark Bunting by technique in the shortgrass prairie of eastern Colorado, 2001. Technique Codes: **DT**=30mi driving transect, **LT**=interior line transect, ***MCB***=*MCB* point transect, **PC**=road-based point count.
* Insufficient data for analysis.

Grasshopper Sparrow
(*Ammodrammus savannarum*)

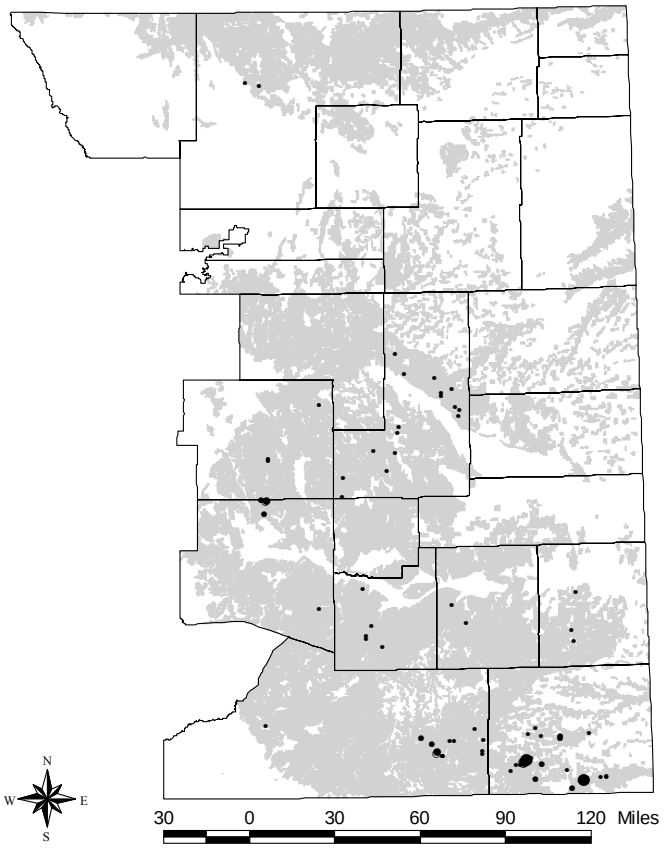
The Grasshopper Sparrow occurs as a breeder in the shortgrass prairie of eastern Colorado where the grass is taller than average. I calculated density estimates for this species using data collected using three different techniques: Interior line transects, *MCB* point counts, and road-based point counts.

Distance estimate (D) and population estimate (N) for this species by technique:

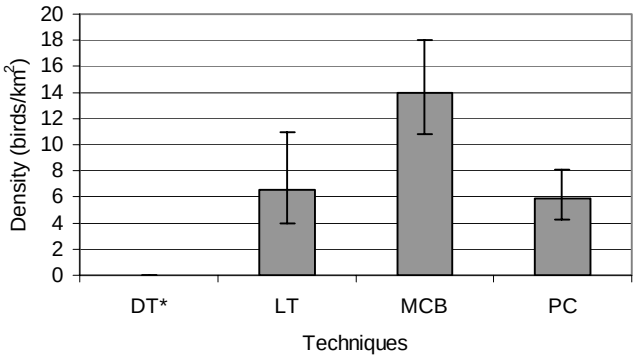
- Interior line transects
  D = 6.6 bird/km^2 (CV=26%)
  N = 236,306 individuals in the shortgrass prairie of eastern Colorado.
- *MCB* point transects
  D = 14.0 bird/km^2 (CV=13%)
  N = 503,720 individuals in the shortgrass prairie of eastern Colorado.
- Road-based point counts
  D = 5.9 bird/km^2 (CV=16%)
  N = 211,141 individuals in the shortgrass prairie of eastern Colorado.

This species was well detected by all of the techniques. The road-based point count technique detected 199 individuals on 6% of the sections surveyed.

Each of these techniques is capable of monitoring this species. However, he road-based transect technique would be able to track the distribution of this species along with the population trend.



Index of abundance, expressed in individuals per section / # of point counts, and breeding distribution of Grasshopper Sparrow in the shortgrass prairie of eastern



Density of Grasshopper Sparrow by technique in the shortgrass prairie of eastern Colorado, 2001. Technique Codes: **DT**=30mi driving transect, **LT**=interior line transect, ***MCB***=*MCB* point transect, **PC**=road-based point count. * Insufficient data for analysis.

McCown's Longspur
(*Calcarius mccownii*)

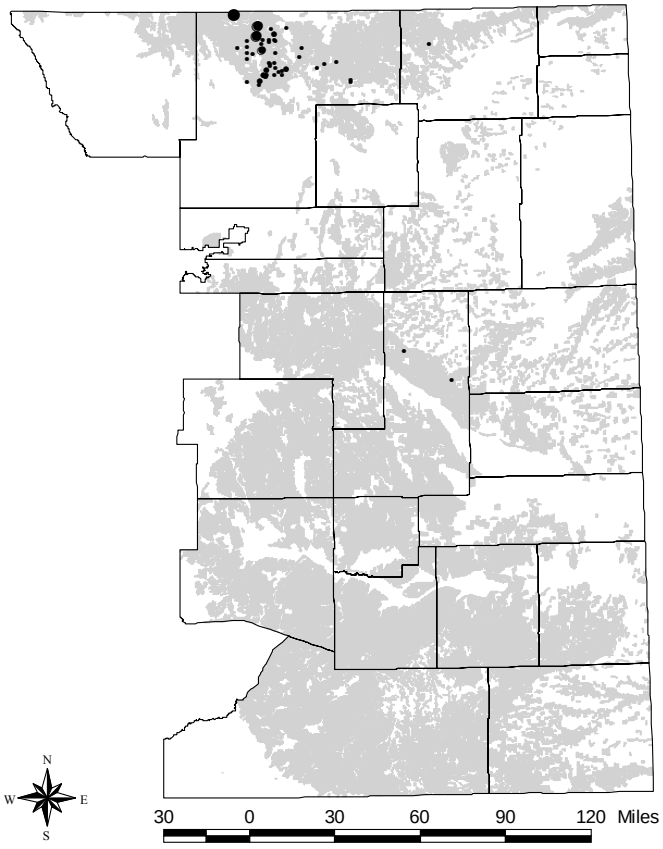
The McCo33wn's Longspur is distributed throughout the northern portion of the shortgrass prairie in eastern Colorado. This species prefers short, grazed grass. I calculated density estimates for this species using data from three different techniques: interior line transect, *MCB* point transect, and road-based point counts.

Distance estimate (D) and population estimate (N) for this species by technique:

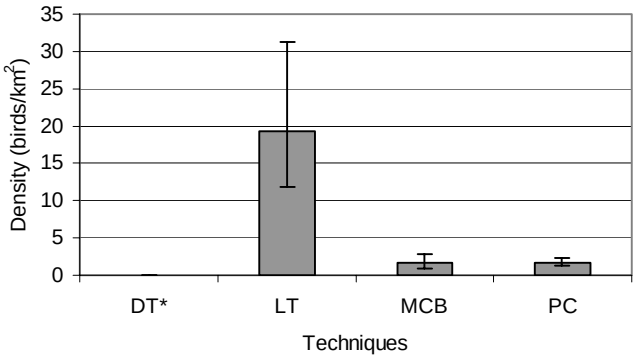
- Interior line transect
  D = 19.3 bird/km^2 (CV=25%)
  N = 692,615 individuals in the shortgrass prairie of eastern Colorado.
- *MCB* point transect
  D = 1.6 bird/km^2 (CV=29%)
  N = 57,568 individuals in the shortgrass prairie of eastern Colorado.
- Road-based point count
  D = 1.7 bird/km^2 (CV=15%)
  N = 61,101 individuals in the shortgrass prairie of eastern Colorado.

This species was well detected by the three techniques. The road-based point count technique detected 629 individuals on 4% of the sections surveyed.

Density estimates generated from road-based point counts are significantly different from the density estimate derived from the interior line transect data. This difference in density estimates suggests that this species could have a bias for the interior. Future efforts will be focused on determining a variable to adjust for these types of biases in species and calculate more accurate density estimates.



Index of abundance, expressed in individuals per section / # of point counts, and breeding distribution of McCown's Longspur in the shortgrass prairie of eastern



Density of McCown's Longspur by technique in the shortgrass prairie of eastern Colorado, 2001. Technique Codes: **DT**=30mi driving transect, **LT**=interior line transect, ***MCB***=*MCB* point transect, **PC**=road-based point count. * Insufficient data for analysis.

Chestnut-collared Longspur
(*Calcarius ornatus*)

The Chestnut-collared Longspur is distributed throughout the northern part of the shortgrass prairie located in Colorado. This species prefers areas of shortgrass with patches of taller bunch grass. I calculated density estimates for this species from data collected from two different techniques: interior line transects and road-based point counts.

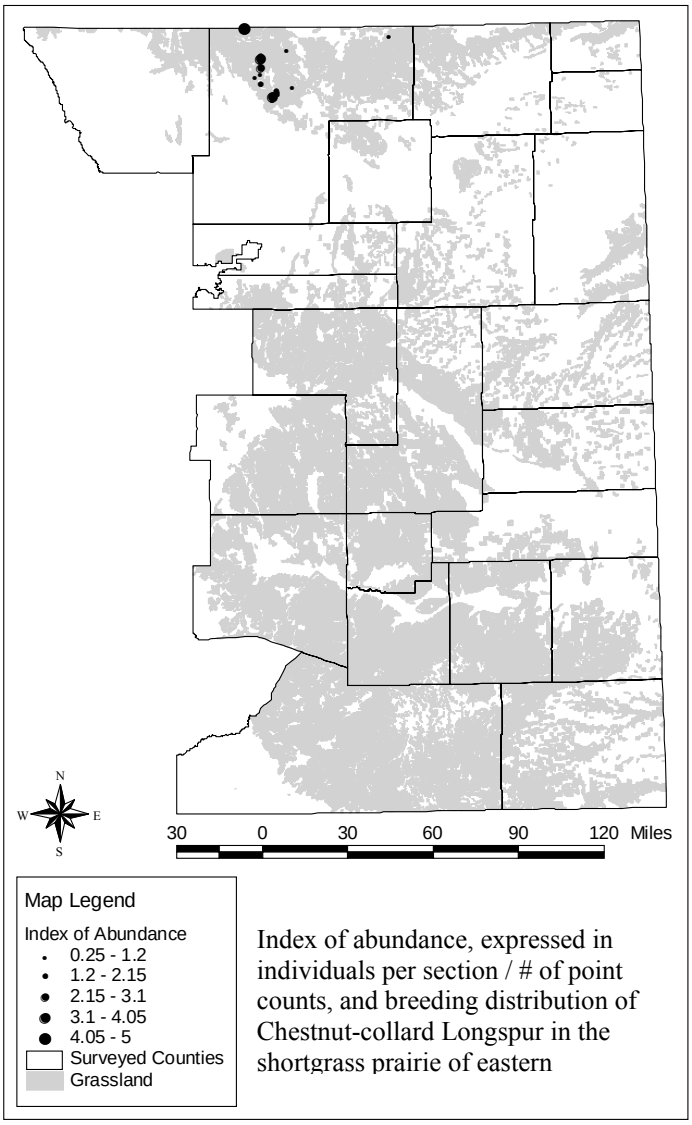
Distance estimate (D) and population estimate (N) for this species by technique:

- Interior line transects
  D = 2.8 bird/km^2 (CV=41%)
  N = 102,500 individuals in the shortgrass prairie of eastern Colorado.
- Road-based point counts
  D = 1.7 bird/km^2 (CV=15%)
  N = 22,775 individuals in the shortgrass prairie of eastern Colorado.

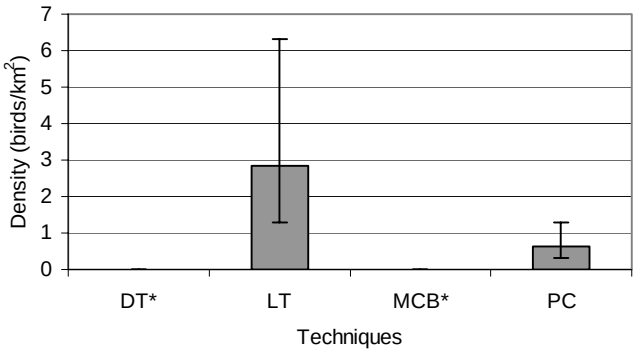
This species was well detected using interior line transects and road-based point counts. The road-based point count technique detected 99 individuals on 2% of the sections surveyed.

The two density estimates derived from the two techniques seem to be significantly different based on the non overlapping 95% confidence limit bars. This suggests that this species is biased against roads.

Future efforts will. Be directed to determine a correction factor to adjust for the road bias in each of the species. This adjustment will allow for more accurate and unbiased population estimates in the future.



Index of abundance, expressed in individuals per section / # of point counts, and breeding distribution of Chestnut-collard Longspur in the shortgrass prairie of eastern



Density of Chestnut-collared Longspur by technique in the shortgrass prairie of eastern Colorado, 2001. Technique Codes: **DT**=30mi driving transect, **LT**=interior line transect, ***MCB***=*MCB* point transect, **PC**=road-based point count. * Insufficient data for analysis.

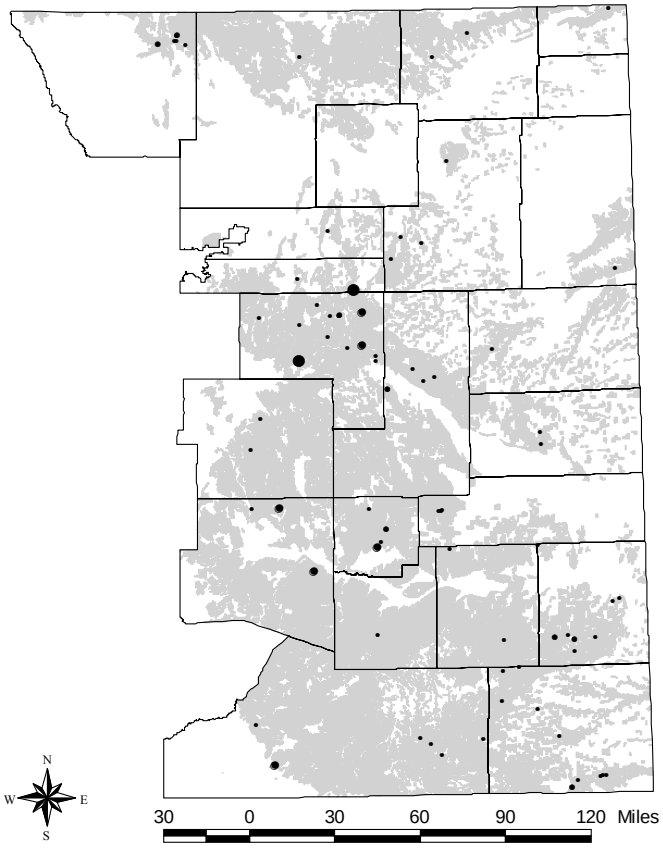
Red-winged Blackbird
(*Agelaius phoeniceus*)

Though typically an in habitat of marshes, the Red-winged Blackbird is distributed throughout the shortgrass prairie of eastern Colorado. In the prairie this species will nest in particular types of prairie. I calculated density estimates for this species using data collected from one technique: road-based point counts.

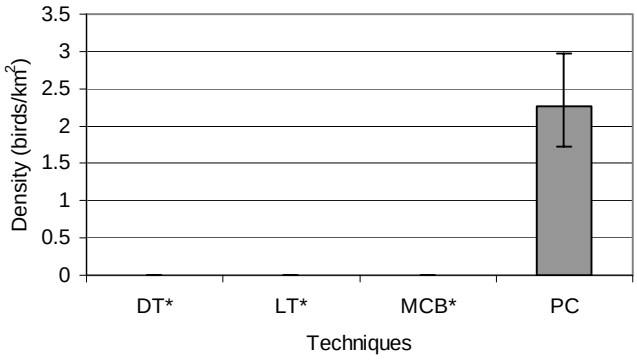
Distance estimate (D) and population estimate (N) for this species by technique:

- Road-based point counts
  D = 2.3 bird/km^2 (CV=14%)
  N = 81,513 individuals in the shortgrass prairie of eastern Colorado.

The density estimate for this species will allow us to measure trends in population over time. Increasing population estimates of this species in the shortgrass prairie may indicate that shortgrass prairie is being converted to cropland.



Index of abundance, expressed in individuals per section / # of point counts, and breeding distribution of Red-winged Blackbird in the shortgrass prairie of eastern



Density of Red-winged Blackbird by technique in the shortgrass prairie of eastern Colorado, 2001. Technique Codes: **DT**=30mi driving transect, **LT**=interior line transect, ***MCB***=*MCB* point transect, **PC**=road-based point count. * Insufficient data for analysis.

Western Meadowlark
(*Sturnella neglecta*)

The Western Meadowlark is found commonly throughout the shortgrass prairie of eastern Colorado. This species prefers open grasslands with taller vegetation. Density estimates for this species were calculated using data collected from three different techniques: interior line transect, *MCB* point transects, and road-based point counts.

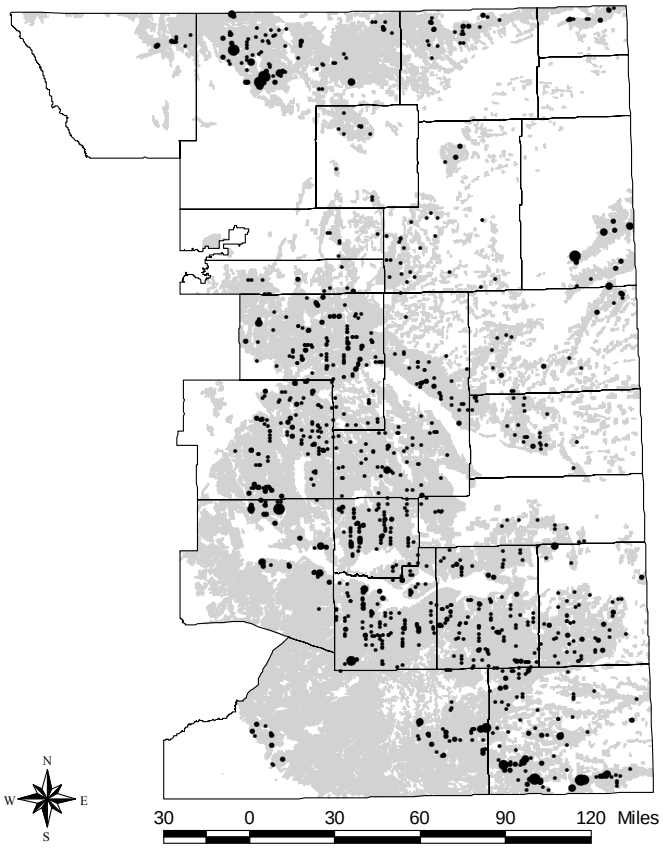
Distance estimate (D) and population estimate (N) for this species by technique:

- Interior line transects
  D = 1.59 bird/km^2 (CV 9%)
  N = 571,362 individuals in the shortgrass prairie of eastern Colorado.
- *MCB* point transects
  D = 17.0 bird/km^2 (CV 11%)
  N = 611,660 individuals in the shortgrass prairie of eastern Colorado.
- Road-based point counts
  D = 40.5 bird/km^2 (CV 2%)
  N = 1,455,751 individuals in the shortgrass prairie of eastern Colorado.

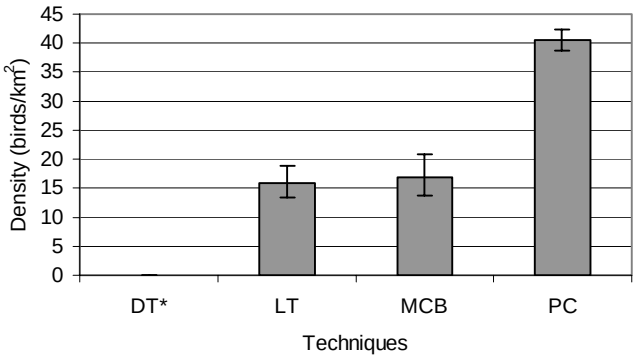
This species was well detected by all of the techniques. The road-based point count technique detected 4,376 individuals on 80% of the sections surveyed.

Density estimates derived from the interior line transect technique and the *MCB* point counts are accurate and significantly different from the road-based point count technique. This difference suggests that the Western Meadowlark is biased toward roads.

Future efforts will be directed toward determining a correction factor to adjust for this bias for each species. This variable should allow us to calculate accurate population estimates for these species in the shortgrass prairie of eastern Colorado.



Index of abundance, expressed in individuals per section / # of point counts, and breeding distribution of Western Meadowlark in the shortgrass prairie of eastern



Density of Western Meadowlark by technique in the shortgrass prairie of eastern Colorado, 2001. Technique Codes: **DT**=30mi driving transect, **LT**=interior line transect, ***MCB***=*MCB* point transect, **PC**=road-based point count. * Insufficient data for analysis.

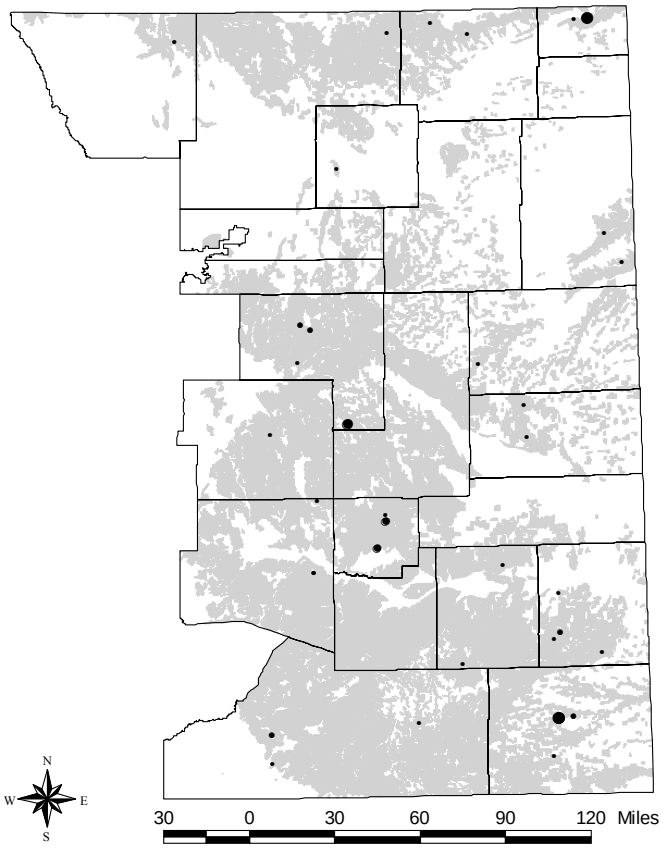
Common Grackle
(*Quiscalus quiscula*)

The Common Grackle is distributed throughout eastern Colorado, but is not an inhabitant of native grassland, preferring anthropogenic habitats. I calculated a density estimate using data from the road-based point count technique.

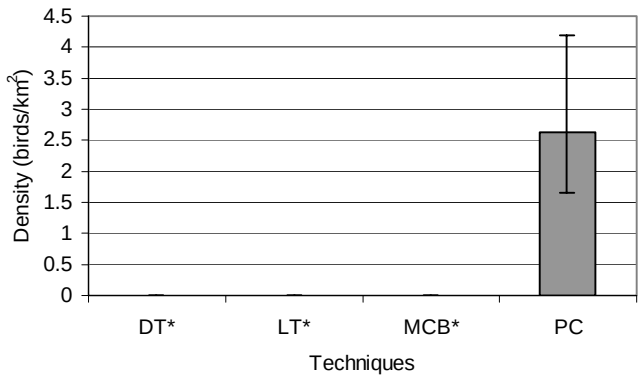
Distance estimate (D) and population estimate (N) for this species by technique:

- Road-based point counts
  D = 2.6 bird/km^2 (CV=24%)
  N = 94,530 individuals in the shortgrass prairie of eastern Colorado.

This species was well detected by the road-based point count technique. The technique detected 92 individuals on 3 % of the sections surveyed. This technique should detect population and distribution trends in this species.



Index of abundance, expressed in individuals per section / # of point counts, and breeding distribution of Common Grackle in the shortgrass prairie of eastern Colorado, 2001.



Density of Common Grackle by technique in the shortgrass prairie of eastern Colorado, 2001. Technique Codes: **DT**=30mi driving transect, **LT**=interior line transect, ***MCB***=*MCB* point transect, **PC**=road-based point count.
***** Insufficient data for analysis.

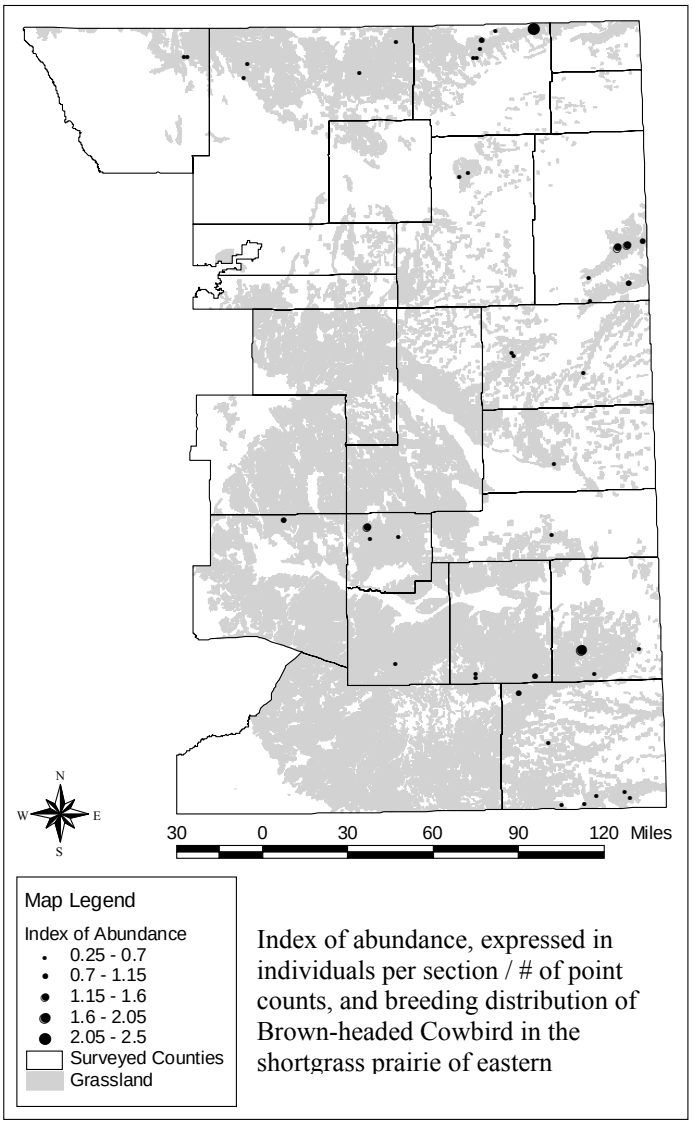
Brown-headed Cowbird
(*Molothrus ater*)

The Brown-headed Cowbird is distributed across the shortgrass prairie of eastern Colorado. This species is an edge species and prefers areas of human habitation and feedlots in the eastern portion of Colorado. A density estimate for this species was calculated using the data from the road-based point count technique.

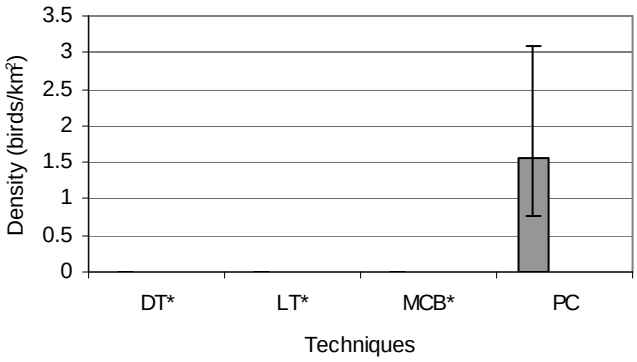
Distance estimate (D) and population estimate (N) for this species by technique:

- Road-based point counts
  D = 1.5 bird/km^2 (CV=36%)
  N = 55,701 individuals in the shortgrass prairie of eastern Colorado.

Only one of the techniques had enough detections to calculate an estimated density. This technique detected 72 individuals on 4% of the sections surveyed.



Index of abundance, expressed in individuals per section / # of point counts, and breeding distribution of Brown-headed Cowbird in the shortgrass prairie of eastern



Density of Brown-headed Cowbird by technique in the shortgrass prairie of eastern Colorado, 2001. Technique Codes: **DT**=30mi driving transect, **LT**=interior line transect, ***MCB***=*MCB* point transect, **PC**=road-based point count. * Insufficient data for analysis.

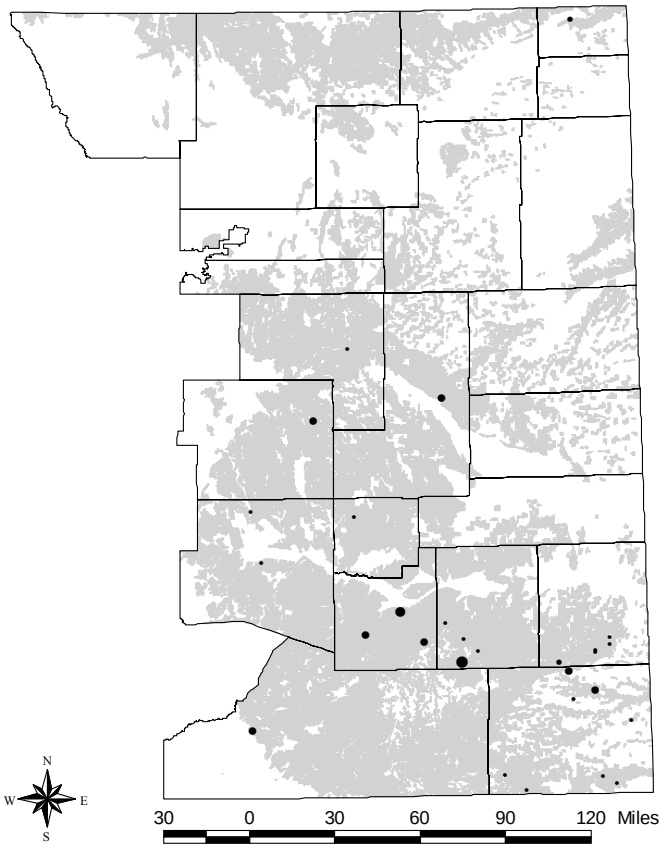
Bullock's Oriole
(*Icterus bullockii*)

Bullock's Oriole occupies habitats with at least some deciduous trees, thus rare in the shortgrass prairie. I calculated a density estimate using data from one of the techniques: road based point count.

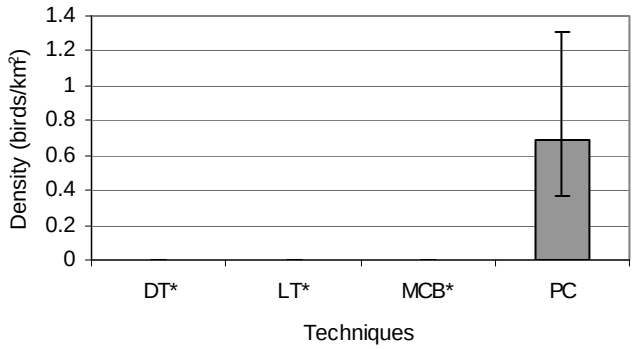
Distance estimate (D) and population estimate (N) for this species by technique:

- Road-based point counts
  D = 0.7 bird/km^2 (CV=33%)
  N = 24,833 individuals in the shortgrass prairie of eastern Colorado.

Only the road based point counts were able to generate enough detections to calculate a density estimate for this species. The density estimate calculated using this technique can be used to determine population and distribution trends in the future.



Index of abundance, expressed in individuals per section / # of point counts, and breeding distribution of Bullock's Oriole in the shortgrass prairie of eastern Colorado, 2001.



Density of Bullock's Oriole by technique in the shortgrass prairie of eastern Colorado, 2001. Technique Codes: **DT**=30mi driving transect, **LT**=interior line transect, ***MCB***=*MCB* point transect, **PC**=road-based point count.
* Insufficient data for analysis.

DISCUSSION

In 2001 we were able to compare four techniques (road-based point counts, interior line transects, *MCB* point transects, and driving line transects). Each of these techniques has advantages and disadvantages.

Road-based point counts: There are several advantages of using this technique to monitor birds in the shortgrass prairie of eastern Colorado: 1) This technique can be used to monitor not only population trends, but changes in distribution and abundance of individual species across eastern Colorado; 2) The technique can be implemented at a variety of scales from a large geographic area to a smaller, site-specific, area; 3) The technique can collect information on vegetation characteristics and management practices that could be compared to the bird community; and 4) This technique can aid us in determining areas in eastern Colorado in which to focus conservation efforts.

The road-based point count technique should be able to detect population trends similar to the BBS, and also detect, local trends in distributions and abundance of species in eastern Colorado. The species distribution and abundance maps can be compared over time, using GIS, to see how bird species react to various changes in the ecosystem. This technique provided data sufficient to obtain density estimates for 33 different shortgrass prairie bird species within eastern Colorado. Thus, road-based point counts permit monitoring nearly the entire shortgrass prairie bird community.

This technique can be used on a variety of scales from large to small. Since these point counts are conducted from the road the data collection process is more efficient, collecting over twice the amount of information in the same amount of time. This efficiency allows large geographic areas to be sampled. This technique can also be conducted on small, site specific, areas since the sampling unit is small, the section. This is an advantage due to the fact that land managers of relatively small management units need a monitoring protocol that can be compared to the regional level to compare site level changes to regional changes.

Road-based point counts can be designed to collect information on the vegetation community at section level, the common management unit in Colorado. This information along with data on the management practices occurring at this level can be used to relate management practices to the bird communities. At the present time, the BBS technique does not collect this type of information, and I foresee it being years before this type of data collection is initiated. Once this information form the road-based point count technique is fused together we should be able to use this information to determine where to focus effective conservation efforts in eastern Colorado.

One disadvantage to the road-based point count technique, which is shared by the BBS, is that it is biased toward roads. This technique is conducted from the road and several of the species, documented in the species accounts section, show a bias either towards (e.g., Mourning Dove, Horned Lark, Lark Sparrow, Lark Bunting and Western Meadowlark) or against (e.g., McCown's Longspur, Chestnut-collared Longspur) roads. This road bias is

also present in the data collected from BBS routes but is not corrected. I plan to address this issue by calculating a correction factor for these species by comparing the *MCB* point transect technique to the road-based point count technique.

This year we did not include all habitats in eastern Colorado (e.g., CRP and cropland). Including all habitat types in eastern Colorado should allow for more detections of species that use other habitats other than shortgrass. The final disadvantage is that this technique did not provide sufficient sample size for species that are found in very low densities, such as Mountain Plover, or species that are aggregated in space, such as the Burrowing Owl.

Interior line transects: This technique was conducted on the interior of sections. The advantage to this technique is that it provided data away from the main anthropogenic influences in shortgrass prairie (roads and fences) to assist in the determination of the presence, if any, of artifacts of road-biased sampling. The comparison of the results of the interior line transects and the road-based point transects illustrated that at least a few species seemed to select for (e.g., Horned Lark and Western Meadowlark) or against (e.g., McCown's longspur and Chestnut-collared Longspur) the effects of roads, thus biasing each data set. Interior line transects cannot be used to calculate a correction factor since it is biased to the interior of the section.

***MCB* point transects:** The *MCB* program has been active in the shortgrass prairie of eastern Colorado for three years. The primary advantage of this technique is that it is not biased toward or against roads, as starting points and transect bearings are randomly determined. This technique can be compared to the road-based point technique to determine a correction factor for the road bias for individual species in the shortgrass prairie of eastern Colorado. This comparison can be made between the two techniques only if accurate density estimates are calculated for the two techniques.

Disadvantages of this technique are 1) that it is difficult to conduct on private lands due to the involved task of obtaining landowner permission, 2) the program obtains insufficient data to calculate densities for low-density species, and 3) it completely misses some species of very limited distribution, such as Chestnut-collared Longspur. This technique, alone, is less efficient than are road-based point counts but the availability of the non-biased comparison is important.

30-mile driving line transects: This technique was able to provide estimates for a majority of the low-density species. However, the density estimates derived from this technique are not directly comparable to that of the other techniques due to spatial differences in the study area and temporal differences in the survey period.

This technique was able to generate density estimates for several species that occur in low densities in eastern Colorado. This was the only technique that was able to effectively sample some species (e.g., Northern Harrier and Mountain Plover). The species detected using this technique are early breeders and should potentially represent the breeding population of these species.

FUTURE RECOMMENDATIONS

In future years, the number of sections surveyed in the shortgrass prairie should be reduced, and there should be corresponding additions of sections in other habitats (e.g., cropland, shrubland, and CRP). Expanding to these habitats will allow us to increase the number of detections, and therefore, the accuracy of the density estimates, for species using these habitats in addition to shortgrass prairie. Program expansion will also enable the comparison of densities between species across ownership and habitats in eastern Colorado.

Currently, we are working toward determining a correction factor to adjust for the selection that some species show for or against roads. The road-based point counts can be compared to the *MCB* point transects to determine a variable for each species for which we were able to obtain density estimates from both techniques. The correction factor will compensate for the density estimate generated, from road-based point counts, and should offer an unbiased population estimate for individual species

Initiation of new projects should focus on obtaining data for species that occur in low densities across this region (e.g., raptors and Mountain Plover). The implementation of nest monitoring for the raptors would give us information on location of nest sites, productivity, and population estimates for raptor species. The expansion of the RMBO program *Colonywatch* to prairie dog colonies and playas located on the plains in eastern Colorado will increase the number of detections of species that are associated with these landscape features (e.g., Mountain Plover and Burrowing Owl).

Future efforts to collect objective data for vegetation and information on the management practices at each point will allow us to evaluate the effects of vegetation characteristics and management practices on birds in eastern Colorado. This will enable managing ecosystems for communities of birds, which, is one of the goals shared by *Prairie Partners,* within RMBO, and CDOW.

ACKNOWLEGEMENTS

I would like to thank the Colorado Division of Wildlife for seeing the importance of this project, through funds provided by Great Outdoors Colorado Trust Fund.. We value the partnerships that were created in the pursuit of the same goals. I would especially like to thank Gary Skiba with the CDOW for all of the logistical and administrative support provided during the contract. Many heads were put together to determine techniques to monitor shortgrass prairie birds successfully. People involved include : Mike Carter, Tony Leukering, Doug Faulkner, Tammy VerCauteren, Ted Toombs, and Scott Hutchings).

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This project could not have been completed with out the help of the 2001 field crew (Meg McLachlan, David Rubenstein, Nathan Hurst, Katie Fisk, Jason Meglich, Matt Duforth, Jsason Marrow, Tammy VerCauteren, Ted Toombs). I would also like to recognize and thank Tammy VerCauteren and Megan McLachlan for all of the GIS and technical support.

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Appendix A: Species detected during field work conducted in Eastern Colorado (2001)

COMMON NAME	SCIENTIFIC NAME
Double-crested Cormorant	*Phalacrocorax auritus*
Great Blue Heron	*Ardea herodias*
Turkey Vulture	*Cathartes aura*
Gadwall	*Anas strepera*
Mallard	*Anas platyrhynchos*
Blue-winged Teal	*Anas discors*
Northern Pintail	*Anas acuta*
Mississippi Kite	*Ictinia mississippiensis*
Northern Harrier	*Circus cyaneus*
Cooper's Hawk	*Accipiter cooperii*
Swainson's Hawk	*Buteo swainsoni*
Red-tailed Hawk	*Buteo jamaicensis*
Ferruginous Hawk	*Buteo regalis*
Golden Eagle	*Aquila chrysaetos*
American Kestrel	*Falco sparverius*
Prairie Falcon	*Falco mexicanus*
Ring-necked Pheasant	*Phasianus colchicus*
Scaled Quail	*Callipepla squamata*
Northern Bobwhite	*Colinus virginianus*
Killdeer	*Charadrius vociferus*
Mountain Plover	*Charadrius montanus*
Black-necked Stilt	*Himantopus mexicanus*
American Avocet	*Recurvirostra americana*
Long-billed Curlew	*Numenius americanus*
Least Sandpiper	*Calidris minutilla*
Rock Dove	*Columba livia*
Mourning Dove	*Zenaida macroura*
Burrowing Owl	*Athene cunicularia*
Common Nighthawk	*Chordeiles minor*
Broad-tailed Hummingbird	*Selasphorus platycercus*
Lewis's Woodpecker	*Melanerpes lewis*
Red-headed Woodpecker	*Melanerpes erythrocephalus*
Willow Flycatcher	*Empidonax traillii*
Say's Phoebe	*Sayornis saya*
Cassin's Kingbird	*Tyrannus vociferans*
Western Kingbird	*Tyrannus verticalis*
Eastern Kingbird	*Tyrannus tyrannus*
Scissor-tailed Flycatcher	*Tyrannus forficatus*
Loggerhead Shrike	*Lanius ludovicianus*
Blue Jay	*Cyanocitta cristata*
Black-billed Magpie	*Pica hudsonia*
American Crow	*Corvus brachyrhynchos*
Chihuahuan Raven	*Corvus cryptoleucus*
Common Raven	*Corvus corax*

Horned Lark	*Eremophila alpestris*
Tree Swallow	*Tachycineta bicolor*
Violet-green Swallow	*Tachycineta thalassina*
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*
Cliff Swallow	*Petrochelidon pyrrhonota*
Barn Swallow	*Hirundo rustica*
House Wren	*Troglodytes aedon*
Eastern Bluebird	*Sialia sialis*
Mountain Bluebird	*Sialia currucoides*
Swainson's Thrush	*Catharus ustulatus*
American Robin	*Turdus migratorius*
Northern Mockingbird	*Mimus polyglottos*
Sage Thrasher	*Oreoscoptes montanus*
Brown Thrasher	*Toxostoma rufum*
European Starling	*Sturnus vulgaris*
Common Yellowthroat	*Geothlypis trichas*
Cassin's Sparrow	*Aimophila casssinii*
Chipping Sparrow	*Spizella passerina*
Brewer's Sparrow	*Spizella breweri*
Vesper Sparrow	*Pooecetes gramineus*
Lark Sparrow	*Chondestes grammacus*
Lark Bunting	*Calamospiza melanocorys*
Grasshopper Sparrow	*Ammodramus savannarum*
Song Sparrow	*Melospiza melodia*
McCown's Longspur	*Calcarius mccownii*
Chestnut-collared Longspur	*Calcarius ornatus*
Blue Grosbeak	*Guiraca caerulea*
Lazuli Bunting	*Passerina amoena*
Dickcissel	*Spiza americana*
Red-winged Blackbird	*Agelaius phoeniceus*
Western Meadowlark	*Sturnella neglecta*
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*
Brewer's Blackbird	*Euphagus cyanocephalus*
Common Grackle	*Quiscalus quiscula*
Great-tailed Grackle	*Quiscalus mexicanus*
Brown-headed Cowbird	*Molothrus ater*
Bullock's Oriole	*Icterus bullockii*
House Sparrow	*Passer domesticus*