Monitoring Breeding Birds along the Cache la Poudre River in the City of Fort Collins Natural Areas

2022 Technical Report

Bird Conservancy of the Rockies
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Technical Report: FCNAP-MTP21-25-Poudre River

Bird Conservancy of the Rockies

Mission: To conserve birds and their habitats

Vision: Native bird populations are sustained in healthy ecosystems

Core Values: (Our goals for achieving our mission)

1. **Science** provides the foundation for effective bird conservation.
2. **Education** is critical to the success of bird conservation.
3. **Stewardship** of birds and their habitats is a responsibility we all share.

Bird Conservancy accomplishes its mission by:

Monitoring long-term trends in bird populations as a scientific foundation for conservation action.

Researching bird ecology and response to anthropogenic and natural processes. Our research informs management and conservation strategies using the best available science.

Educating people of all ages to instill an awareness and appreciation for birds and a conservation ethic.

Fostering good stewardship on private and public lands through voluntary, cooperative partnerships that create win-win solutions for wildlife and people.

Partnering with local, state and federal agencies, private citizens, schools, universities, and other organizations for bird conservation.

Sharing the latest information on bird populations, land management and conservation practices to create informed publics.

Delivering bird conservation at biologically relevant scales by working across political and jurisdictional boundaries in the Americas.

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EXECUTIVE SUMMARY

The riparian Natural Areas are of high conservation value due to the high biodiversity, social, and economic services it provides to our community. Monitoring wildlife populations can be an effective tool for guiding management decisions. The City of Fort Collins manages several natural areas along the Poudre River urban corridor. The objective of this program is to determine population density and distributions of breeding birds that inhabit these natural areas to assist with management planning.

We surveyed 144 points in 2022. Surveys were conducted from 13 May to 23 June in riparian natural areas along the Poudre River urban corridor. We observed 76 species, eight of which species are priority species designated by Colorado Parks and Wildlife and Partners In Flight (Appendix A).

We generated estimates of density and population size for 73 of the 76 species detected in 2022, including the six focal species; Bullock's Oriole, Common Yellowthroat, Northern Flicker, Song Sparrow, Western Wood-Pewee, and Yellow Warbler. Density and population results are presented in Table 1.

The focal species integrate ecological processes that contribute to the maintenance of riparian ecosystem function. Management actions aimed at conserving these focal species will also protect a larger number of species occurring in the management areas.

Starting this year, we have incorporated the City of Fort Collins Natural Areas Program (FCNAP) data into the analyses of our Integrated Monitoring in Bird Conservation Regions (IMBCR) bird data. Due to the way the data are structured in our database, we were only able to incorporate the 2019 and 2022 data into analyses. We plan to modify the data structure for previous years to allow the entire Soapstone data set to be analyzed next year. There are several advantages to this approach, including:

1. Efficiency – The FCNAP data can be analyze alongside IMBCR data annually to produce density estimates.
2. Sample size – We are able to pool detections for each species across the entire IMBCR and FCNAP data sets, which means we are able to produce density estimates for more species.
4. Advanced Analytical Techniques – The IMBCR analysis uses state-of-the-art Bayesian analysis framework that produces estimates with a high level of precision.
5. Trends – Once all FCNAP data have been reformatted, we will automatically generate trend estimates at the species level for FCNAP projects with at least five years of data.
6. Hierarchical Structure – IMBCR uses a nested design, meaning we can generate density estimates at the stratum level, or combine several strata together to generate a superstratum estimate that accounts for differing sample efforts and areas in each stratum. For example, we were able to generate estimates for each individual pasture in Soapstone Prairie Natural Area, as well as density estimates for the entire property as a whole.

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INTRODUCTION

Approximately only one third of the world's longest rivers remain free flowing. Free flowing rivers create a dynamic network of ecological and economic services across the landscape. These dynamic waterways are crucial for the economy and health of our communities by providing sediment and water for crops, mitigating the impact of floods and droughts, drinking water, recreation opportunities and habitat for fish and wildlife. Western riparian ecosystems and wetlands occupy from 0.8 to 2% of the landscape (Naiman et al. 2005), but provide habitat, water, and other resources to over half the wildlife species in the region. They maintain the highest bird, reptile/amphibian, insect, plant and mammal biodiversity of any terrestrial ecosystem.

Anthropogenic disturbances to riparian ecosystems are well documented and increasing due to human population growth. Extensive modification of natural flow regimes, development, grazing, conversion of lands to agriculture, and forest clearing along many rivers in the western U.S. have led to loss and simplification of native riparian forests and to population declines of riparian-dependent bird species (Skagen et al. 2005).

Rivers continue to tie communities to the land even in the face of increased degradation. Human modification, pollution and fragmentation of our rivers are a stark reality we must tackle. These threats have reduced water flows, reduced water quality and habitat for wildlife. In Colorado 63% of all rivers and streams have been altered by humans and less than 80% of all rivers in the West are flowing at their natural levels (Harrison-Atlas et al. 2017).

The Poudre River flows from the Rocky Mountains down to its confluence with the South Platte River, a designated "urban waters location" under the Urban Waters Federal Partnership. The Colorado Poudre River Basin faces enormous challenges in sustaining these important economic and ecological functions. This basin is home to the growing Front Range communities (such as Boulder, Loveland, Greeley, and Fort Collins) which account for much of the Front Range's economic activity.

The Lower Poudre River Flood Recovery and Resilience Master Plan and the Cache la Poudre River Natural Areas Management Plan address these challenges by identifying and prioritizing opportunities to improve river health, enhance recreation opportunities, manage the river to minimize potentially hazardous conditions, encourage learning and community awareness.

The Colorado State Wildlife Action Plan (SWAP) identifies water management, natural system modification and urbanization as major threats to aquatic systems. Past bird monitoring along the Poudre River has documented twenty-six bird species of Species of Greatest Conservation Need (SGCN). The Poudre River urban corridor is an Important Bird Area crucial for breeding and migratory bird species. The diversity of species is high with Bald Eagles and Ospreys, Eastern Screech-Owl, Sora, Northern Flicker, Western Wood-Pewee, Yellow Warbler, Common Yellowthroat, Bullock's Oriole and Song Sparrow breeding along the river.

Bird Conservancy of the Rockies has partnered with the City of Fort Collins Natural Areas Program (FCNAP) since 2009 to aid in the conservation and management of this important conservation and recreation destination through bird inventory and monitoring, providing the FCNAP with data and management recommendations that benefit the bird and wildlife community along the Poudre River corridor.

Management for most species requires reliable abundance estimates (Bowden et al. 2003). Abundance estimates allow us to measure changes in population size and to assess the impact of habitat loss or harvesting (Buckland et al. 2008). Royle (2004) developed hierarchical models that account for spatial variation in abundance and detection probability at sampling units.

We used a focal species approach and identified six focal species; Northern Flicker, Western Wood-Pewee, Yellow Warbler, Common Yellowthroat, Bullock's Oriole and Song Sparrow. These species integrate ecological processes that contribute to the maintenance of riparian ecosystem function. Understanding the habitat use and distribution of these focal species can help to guide management actions and protect a larger number of species occurring in the same areas.

The Northern Flicker nests in cavities of tree snags (Burkett 1989). Results will help inform whether there are ample dead trees for North Flickers and other cavity nesters like woodpeckers (Family Picidae) and chickadees (Paridae) (Martin et al. 2004). Western Wood-Pewees, Yellow Warblers, Common Yellowthroat, and Bullock's Oriole are all species that nest in riparian forests that contain cottonwoods (*Populus* sp*.)* and willows (*Salix* sp*.*)(Bemis and Rising 2020; Lowther et al. 2020; Guzy and Ritchison 2020; Flood et al. 2020). Presence and high densities can indicate a healthy riparian forest along the Poudre River. Song Sparrows are a common, generalist species and breed on forest edge habitats in brushy fields. This species is good baseline for generalist bird habitat compared to the other five focal species that require more specialized habitat to breed (Arcese et al. 2020).

METHODS

Study Area

The City of Fort Collins surveys were located in Natural Areas along the Cache la Poudre River Corridor at Buttery Woods, North Shields Ponds, Magpie Meander, Salyer, McMurry, River's Edge, Udall, Homestead, Springer, Kingfisher Point, Cattail Chorus, Riverbend Ponds, Cottonwood, Running Deer, Environmental Learning Center, Arapaho Bend, and Topminnow (Figure 1).

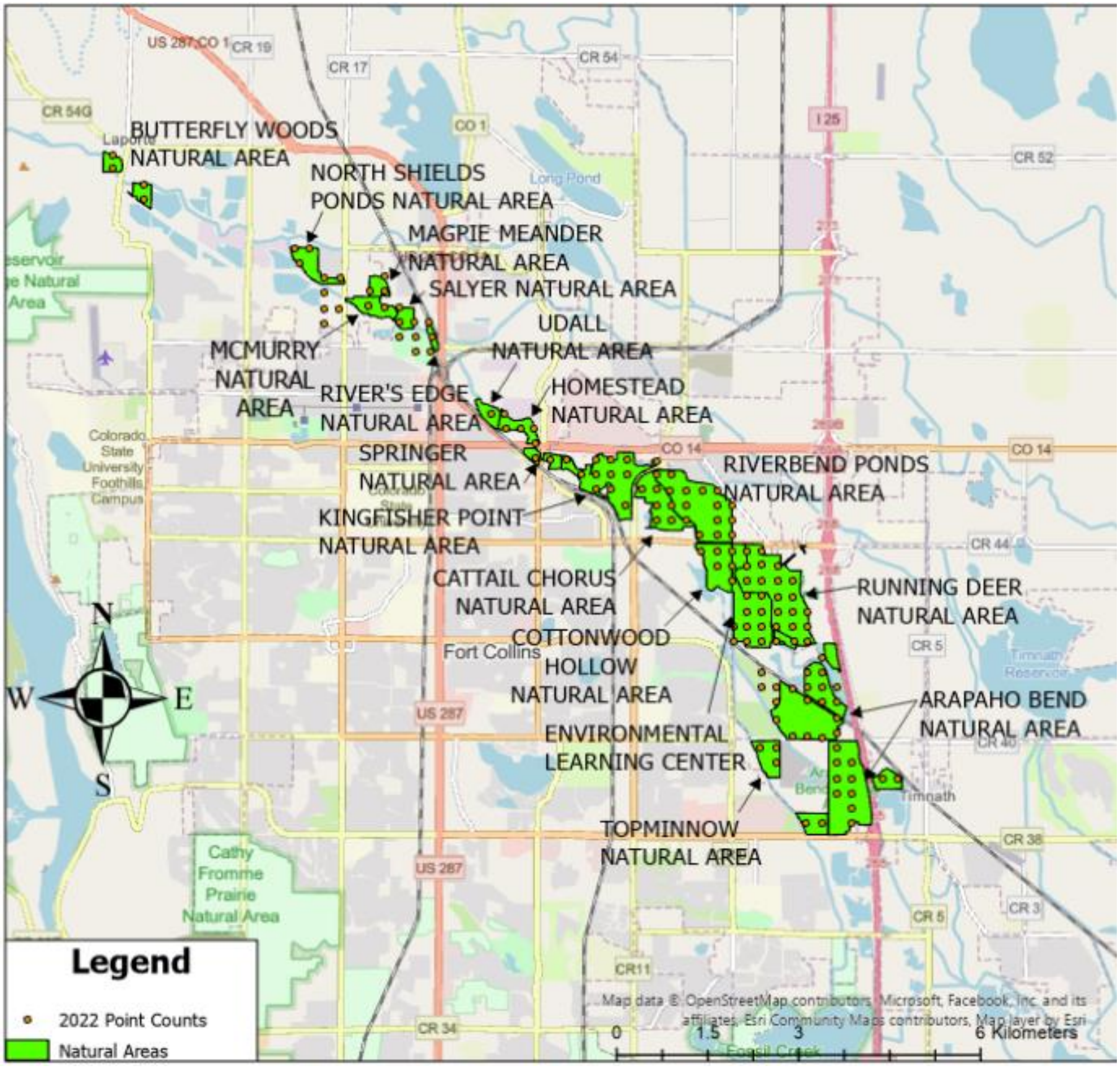

Figure 1. Visited point count stations within City of Fort Collins Riparian Natural Areas, 2022.

Sampling Design and Methods

Within the study area, we used a systematic grid of point count stations at 250-meter intervals created in Arc Map 9.3.1 to survey the properties. There are a total of 160 point count stations; however, 16 points were not visited in 2022 because of access issues due to high water. We successfully surveyed at 144 point count stations between 13 May and 23 June (Fig 1).

Point count locations were navigated to on foot using a handheld GPS unit. Point count surveys started one half-hour before sunrise and ended by 11 a.m., often earlier. We recorded atmospheric data (temperature, cloud cover, precipitation, and wind speed) and time of day at the start and end of each daily survey effort.

At each station, we conducted a 6-minute point count survey consisting of six consecutive 1-minute intervals. This protocol, which is described more fully by Youngberg (2022), uses Distance sampling (Buckland et al. 2001) and removal sampling (Farnsworth et al. 2002). For each bird detected, observers recorded species, sex, how it was detected (call, song, visual, wing beat, other), distance from observer at time of detection, and the 1-minute interval in which it was detected. We measured distances using a laser rangefinder.

Point counts were not conducted during periods of heavy snow, rain, or wind greater than 19 mph. Between point count surveys, we recorded the presence of high-priority and other rare or unusual bird species, but we did not use these observations in our analyses. We also noted the presence of any other wildlife or interesting site observations.

After each avian point count survey, we completed a rapid habitat survey by estimating several vegetation parameters within a 50m radius of the point. We document the primary habitat type and record the presence of roads, cliff/rock, prairie dog town, and exotic vegetation. We record the two most prevalent overstory species (3m or taller), their average height cover, and relative abundance. We repeat this for the shrub layer, defined as anything equal to or taller than 0.25m, but shorter than 3m. We then estimate the cover provided by six different ground cover types – grass, forb, woody/succulent, bare ground, rock, litter, and other.

Data Analysis

Starting this year, we have incorporated the FCNAP data into the analyses of our Integrated Monitoring in Bird Conservation Regions (IMBCR) bird data. The following sections describe the analysis approach in detail.

Distance Analysis Assumptions

Distance sampling theory was developed to account for the decreasing probability of detecting an object of interest (e.g., a bird) with increasing distance from the observer to the object (Buckland et al., 2001). The detection probability is used to adjust the count of birds to account for birds that were present but undetected. Application of distance theory requires that five critical assumptions be met: 1) all birds at and near the sampling location (distance = 0) are detected; 2) distances to birds are measured accurately; 3) birds do not move in response to the observer's presence (Buckland et al., 2001; Thomas et al., 2010); 4) cluster sizes are recorded without error; and 5) the sampling units are representative of the entire survey region (Buckland et al. 2008).

Density Estimation

We developed a Bayesian, zero-inflated N-mixture model (Royle 2004, Sillett et al. 2012) to estimate density and abundance for all strata and superstrata across all species with sufficient data. We used distance sampling to estimate detection probabilities and adjust counts accordingly.

Bayesian approaches to density estimation provide several benefits over traditional distance sampling analyses, while providing similar and unbiased estimates of density and abundance. First, with the nested design of IMBCR, point count locations within a 1-km^2 grid cell are not independent. Therefore, with traditional methods, it is necessary to treat each point as a spatial replicate within the grid cell(i.e., average counts across points). However, it is unlikely that bird densities are uniform within a grid cell, and a better solution would be to estimate density at the point count location. Bayesian models provide the flexibility to do this, while correctly accounting for the lack of independence among points. This also allows us to incorporate the FCNAP data, which are point-based rather than aggregated into grid cells.

The second benefit, also provided by this flexibility, is the ability to include covariates to explain changes in density. This allows us to explicitly estimate the response of bird density to variables, such as habitat variables, management actions, or time (i.e., trend). Finally, Bayesian approaches allow for sharing of information across parameters. This can assist in obtaining estimates at sites with little data or provide measures of uncertainty when no birds were detected, such as at low densities and/or small sample sizes.

We fit a series of models to the data from each species that had the same model structure describing density estimation but varied in detection structure (see Observation process section below). We used zero-inflation to account for excess zeros in the data, where abundance at a point count location (N) is conditional on the point's true occupancy state (z) of a species at the point count location, and the mean abundance within a 1-km^2 grid cell was modeled as a function of year to estimate stratum-specific trends.

All points within a grid cell shared a mean abundance to account for the lack of independence of those points, but abundance was allowed to vary spatially within a grid cell (i.e., by point) through Poisson variation. To avoid predicting species occurrence outside of observed ranges, we fixed occupancy probabilities to 0 for all strata in which the species was never observed and used a prior informed by the observed proportion of grid-year combinations in a stratum in which the species was detected.

We derived density at the point count location by dividing the estimated abundance by the area of the point count circle (see Observation process section below) and multiplying by cluster size. We derived stratum-level density estimates by averaging all point-level density estimates within each stratum, and we took the area-weighted average of strata estimates to obtain superstratum estimates.

Observation process

We estimated the probability of detecting an independent cluster of individuals by fitting distance functions to the distance data collected during surveys (Buckland et al. 2001). We fit four detection models including:

1. half-normal constant (HN(.))
2. hazard rate constant (Haz(.))
3. half-normal year (HN(t))
4. hazard rate year (Haz(t))

We removed the furthest 10% of observed detection distances from the data set and binned the remaining detections into 10 evenly spaced distance classes. The furthest remaining detection distance became the radius of the point count circle with which we estimated density.

Detection model selection

To minimize computing time but find the most parsimonious detection function, we fit detection-only models to the distance data, using the four model structures described above. We used the Watanabe-Akaike Information Criterion (WAIC; Watanabe 2010, Hobbs and Hooten 2015) to select the most parsimonious detection structure and then used that structure for detection probabilities in the full model to estimate density and abundance.

Automated Analysis

In 2019, we updated our analytical methods to use Bayesian hierarchical models specifically designed for analysis of IMBCR data. We performed all data and output manipulation in R (R Core Team, 2022) and model fitting in JAGS (Plummer 2003, 2017) using the R package jagsUI (Kellner 2018). The R code called the raw data from the IMBCR Structured Query Language (SQL) server database and reformatted the data into a form usable with the JAGS code. We allowed the input of all data collected in a manner consistent with the IMBCR design to increase the number of detections available for estimating global detection rates for population density and site occupancy. The R code provided an automated framework for combining stratum-level estimates of population density and site occupancy at multiple spatial scales, as well as estimating the standard deviations and credible intervals for the combined estimates.

We fit initial models to all species with at least 30 detections for density estimation and 10 detections for occupancy estimation. For density estimation, we fit the full model after determining whether there were enough detections based on results from the detection-only model fits. In some cases for both density and occupancy estimation, it was necessary to use a less parsimonious detection structure or simplified model structure to facilitate model convergence. We currently maintain version control of the automated analysis code in the Bird Conservancy repository on www.github.com.

RESULTS

We surveyed 144 points in 2022. Surveys were conducted from 13 May to 23 June in riparian natural areas along the Poudre River urban corridor. We observed 76 species, eight of which species are priority species designated by Colorado Parks and Wildlife and Partners In Flight (Appendix A).

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In Table 1, we provide the coefficient of variation (% CV) associated with each density and population estimate for each species. The % CV is the ratio of the standard deviation to the mean (smaller is better) or an indicator of reliability for the density and population metric. We recommend using population estimates with % CVs less than 50% to inform decisions.

Table 1. Density estimates across City of Fort Collins Natural Areas in riparian habitat, 2019-2022. D = number of birds/km^2, % CV = Percent Coefficient of Variation, N = Population estimate, 95% lower (LCL) and upper (UCL) confidence limits on D and N, and n = number of detections used in analyses. Focal species are bolded.

Common Name	**Year**	**D**	**% CV**	**LCL_D**	**UCL_D**	**N**	**LCL_N**	**UCL_N**	**n**
American Avocet	2019	0.48	95	0.203	1.89	3.503	1.483	13.794	4
American Avocet	2022	0.54	100	0.206	1.877	3.944	1.502	13.7	4
American Coot	2019	0.049	472	0.012	0.474	0.358	0.09	3.463	1
American Crow	2019	0.154	201	0.086	0.26	1.127	0.631	1.895	11
American Crow	2022	0.031	137	0.006	0.096	0.228	0.046	0.7	1
American Goldfinch	2019	25.493	57	22.081	48.282	186.1	161.193	352.456	94
American Goldfinch	2022	10.489	58	8.016	21.078	76.569	58.515	153.871	32
American Kestrel	2019	0.455	38	0.238	0.779	3.319	1.738	5.689	6
American Kestrel	2022	0.197	66	0.066	0.482	1.441	0.48	3.522	2
American Robin	2019	35.095	24	31.425	40.478	256.191	229.401	295.489	193
American Robin	2022	13.593	27	11.31	16.596	99.23	82.567	121.152	70
American White Pelican	2019	0.456	160	0.24	3.474	3.33	1.749	25.357	20
American White Pelican	2022	0.307	135	0.14	2.299	2.238	1.019	16.784	11
Bald Eagle	2019	0.078	59	0.031	0.191	0.571	0.226	1.392	3
Bald Eagle	2022	0.068	62	0.024	0.172	0.498	0.174	1.259	2
Bank Swallow	2019	4.767	151	2.656	35.815	34.802	19.388	261.449	7
Bank Swallow	2022	16.251	154	11.212	104.108	118.63	81.846	759.986	28
Barn Swallow	2019	24.036	114	17.639	68.692	175.466	128.764	501.449	40
Barn Swallow	2022	14.683	128	9.874	40.909	107.184	72.077	298.636	24
Belted Kingfisher	2019	1.172	40	0.648	2.069	8.554	4.732	15.106	10
Belted Kingfisher	2022	0.303	59	0.126	0.657	2.213	0.923	4.794	2
Black-billed Magpie	2019	0.335	66	0.185	0.777	2.449	1.35	5.672	7
Black-billed Magpie	2022	0.49	54	0.295	0.945	3.576	2.153	6.898	10
Black-capped Chickadee	2019	14.907	34	12.455	23.004	108.824	90.919	167.928	64
Black-capped Chickadee	2022	13.679	35	10.928	20.394	99.854	79.772	148.88	46
Black-chinned Hummingbird	2019	3.412	102	0.679	16.78	24.905	4.956	122.491	1
Black-headed Grosbeak	2019	1.111	27	0.741	1.799	8.112	5.408	13.134	9
Blue Grosbeak	2019	1.206	25	0.81	1.769	8.805	5.913	12.914	11

Common Name	Year	D	% CV	LCL_D	UCL_D	N	LCL_N	UCL_N	n
Blue Grosbeak	2022	0.57	43	0.285	1.059	4.163	2.081	7.734	4
Blue Jay	2019	9.298	29	7.806	12.603	67.878	56.983	91.999	92
Blue Jay	2022	7.101	33	5.694	10.225	51.839	41.563	74.646	61
Blue-gray Gnatcatcher	2019	2.284	53	1.268	4.31	16.675	9.254	31.463	4
Blue-winged Teal	2019	0.567	99	0.204	2.014	4.138	1.487	14.701	3
Blue-winged Teal	2022	0.194	122	0.039	1.022	1.419	0.285	7.459	1
Bobolink	2019	0.121	87	0.061	0.425	0.886	0.443	3.1	1
Brewer's Blackbird	2022	2.457	100	1.248	12.035	17.936	9.107	87.855	8
Brewer's Sparrow	2019	0.406	73	0.162	1.011	2.965	1.186	7.383	2
Broad-tailed Hummingbird	2019	7.534	40	3.888	13.61	54.999	28.386	99.351	5
Broad-tailed Hummingbird	2022	2.462	74	0.492	6.894	17.973	3.595	50.325	1
Brown-headed Cowbird	2019	14.947	48	12.591	29.287	109.11	91.918	213.799	63
Brown-headed Cowbird	2022	10.537	54	8.043	19.04	76.918	58.71	138.995	36
Bullock's Oriole	**2019**	**7.099**	**31**	**5.374**	**10.337**	**51.822**	**39.231**	**75.46**	**35**
Bullock's Oriole	**2022**	**4.505**	**31**	**3.196**	**6.776**	**32.889**	**23.333**	**49.465**	**16**
California Gull	2019	0.072	311	0.009	1.111	0.524	0.068	8.112	1
Canada Goose	2019	0.606	179	0.433	5.366	4.427	3.158	39.174	51
Canada Goose	2022	0.468	189	0.302	3.861	3.419	2.207	28.188	30
Cedar Waxwing	2019	19.513	108	14.297	87.558	142.444	104.368	639.172	35
Chimney Swift	2022	0.815	104	0.256	2.677	5.951	1.868	19.544	2
Chipping Sparrow	2019	4.277	70	2.897	6.87	31.224	21.151	50.154	11
Cinnamon Teal	2019	0.142	160	0.029	1.241	1.034	0.215	9.06	1
Clay-colored Sparrow	2019	1.711	32	0.95	2.851	12.488	6.938	20.813	7
Cliff Swallow	2019	25.19	339	20.466	198.332	183.887	149.403	1447.821	52
Cliff Swallow	2022	34.732	324	28.875	272.025	253.543	210.788	1985.783	64
Common Grackle	2019	42.359	153	36.539	230.349	309.221	266.732	1681.547	138
Common Grackle	2022	13.473	151	10.619	69.482	98.355	77.516	507.216	44
Common Merganser	2019	0.727	105	0.272	2.695	5.305	1.989	19.674	5
Common Merganser	2022	0.446	109	0.171	1.827	3.256	1.246	13.339	2
Common Raven	2022	0.052	225	0.024	0.107	0.38	0.177	0.782	4
Common Yellowthroat	**2019**	**10.308**	**11**	**8.544**	**12.168**	**75.247**	**62.37**	**88.83**	**70**

Common Name	Year	D	% CV	LCL_D	UCL_D	N	LCL_N	UCL_N	n
Common Yellowthroat	**2022**	**6.717**	**13**	**5.491**	**8.383**	**49.031**	**40.083**	**61.199**	**39**
Cooper's Hawk	2019	0.33	85	0.051	1.034	2.409	0.369	7.55	1
Cooper's Hawk	2022	0.235	91	0.051	1.037	1.712	0.374	7.569	1
Double-crested Cormorant	2019	0.941	318	0.647	9.968	6.873	4.72	72.769	24
Double-crested Cormorant	2022	0.348	333	0.194	3.756	2.539	1.414	27.416	8
Downy Woodpecker	2019	9.249	32	6.537	13.587	67.516	47.718	99.188	23
Downy Woodpecker	2022	1.366	54	0.537	2.83	9.975	3.923	20.662	2
Dusky Flycatcher	2019	0.57	60	0.285	1.426	4.164	2.082	10.411	2
Eastern Kingbird	2019	3.286	43	2.281	5.223	23.985	16.648	38.131	17
Eastern Kingbird	2022	1.945	42	1.094	3.673	14.201	7.989	26.815	8
Eurasian Collared-Dove	2019	1.592	102	0.955	2.964	11.619	6.972	21.639	10
Eurasian Collared-Dove	2022	2.565	90	1.708	4.361	18.721	12.467	31.838	17
European Starling	2019	25.229	292	21.116	90.848	184.17	154.145	663.189	109
European Starling	2022	9.134	299	6.348	34.215	66.68	46.337	249.77	26
Forster's Tern	2019	0.049	90	0.025	0.163	0.359	0.179	1.187	1
Forster's Tern	2022	0.051	81	0.025	0.171	0.37	0.182	1.246	1
Gadwall	2019	0.081	300	0.027	0.521	0.593	0.198	3.804	1
Gadwall	2022	0.082	330	0.027	0.622	0.601	0.2	4.538	1
Grasshopper Sparrow	2022	0.221	70	0.221	1.106	1.614	1.614	8.071	1
Gray Catbird	2019	1.406	51	0.75	3.284	10.266	5.475	23.975	4
Great Blue Heron	2019	1.403	140	0.994	3.833	10.244	7.253	27.984	34
Great Blue Heron	2022	1.566	138	1.071	4.904	11.431	7.82	35.8	26
Great Horned Owl	2019	0.05	76	0.016	0.148	0.366	0.115	1.081	2
Great Horned Owl	2022	0.032	71	0.008	0.088	0.233	0.058	0.64	1
Great-tailed Grackle	2019	0.556	202	0.214	3.684	4.056	1.56	26.892	2
Great-tailed Grackle	2022	2.619	183	1.447	14.436	19.116	10.56	105.385	12
Green Heron	2019	0.593	80	0.23	1.53	4.329	1.682	11.166	4
Green-tailed Towhee	2022	0.171	87	0.085	0.598	1.248	0.624	4.369	1
Green-winged Teal	2019	0.1	210	0.03	0.811	0.732	0.222	5.918	1
Hairy Woodpecker	2019	0.54	65	0.18	1.531	3.945	1.315	11.179	2
Hairy Woodpecker	2022	0.365	73	0.091	1.004	2.664	0.666	7.327	1

Common Name	Year	D	% CV	LCL_D	UCL_D	N	LCL_N	UCL_N	n
Hammond's Flycatcher	2019	1.425	50	0.712	3.324	10.4	5.2	24.266	3
Horned Lark	2019	1.803	47	1.127	2.817	13.161	8.226	20.564	7
Horned Lark	2022	1.826	48	1.142	3.082	13.333	8.333	22.5	7
House Finch	2019	11.771	57	9.126	22.838	85.926	66.62	166.72	36
House Finch	2022	9.034	67	6.754	18.26	65.947	49.301	133.3	29
House Sparrow	2019	4.608	112	2.394	22.135	33.642	17.476	161.583	8
House Sparrow	2022	1.282	146	0.38	5.369	9.361	2.772	39.197	1
House Wren	2019	51.432	9	46.415	57.777	375.45	338.827	421.772	193
House Wren	2022	50.702	9	44.307	58.365	370.122	323.438	426.067	147
Killdeer	2019	3.136	28	2.495	4.462	22.894	18.211	32.57	33
Killdeer	2022	5.295	27	4.062	7.544	38.657	29.655	55.073	45
Lark Sparrow	2019	0.535	59	0.274	1.374	3.905	1.999	10.033	3
Lark Sparrow	2022	0.309	77	0.077	0.943	2.259	0.565	6.887	1
Lazuli Bunting	2019	0.844	43	0.422	1.772	6.16	3.08	12.936	3
Lazuli Bunting	2022	2.992	28	1.966	4.393	21.842	14.354	32.066	11
Least Flycatcher	2019	0.535	66	0.165	1.6	3.903	1.201	11.68	2
Lesser Goldfinch	2019	1.037	76	0.346	2.656	7.571	2.524	19.39	2
Lincoln's Sparrow	2019	0.425	61	0.213	1.169	3.104	1.552	8.535	2
MacGillivray's Warbler	2019	1.608	45	0.804	3.217	11.74	5.87	23.481	4
Mallard	2019	4.322	91	3.018	18.054	31.554	22.032	131.797	45
Mallard	2022	4.957	95	3.169	21.122	36.185	23.137	154.19	32
Marsh Wren	2019	1.805	40	1.041	3.332	13.175	7.601	24.323	7
Mourning Dove	2019	4.379	107	3.621	5.412	31.965	26.435	39.508	60
Mourning Dove	2022	3.774	115	3.074	4.717	27.547	22.441	34.436	53
Northern Flicker	**2019**	**3.214**	**18**	**2.51**	**4.047**	**23.465**	**18.325**	**29.542**	**31**
Northern Flicker	**2022**	**2.999**	**17**	**2.345**	**3.782**	**21.891**	**17.121**	**27.611**	**32**
Northern Harrier	2022	0.087	73	0.023	0.261	0.636	0.165	1.909	2
Northern Rough-winged Swallow	2019	6.449	133	3.85	22.024	47.079	28.102	160.777	12
Northern Rough-winged Swallow	2022	10.419	132	6.376	33.473	76.061	46.544	244.349	17
Northern Shoveler	2019	0.161	121	0.046	0.822	1.176	0.335	5.997	2
Orchard Oriole	2019	0.552	85	0.184	1.429	4.029	1.343	10.431	2

Common Name	Year	D	% CV	LCL_D	UCL_D	N	LCL_N	UCL_N	n
Osprey	2019	0.15	54	0.075	0.336	1.092	0.549	2.454	4
Osprey	2022	0.171	58	0.083	0.341	1.247	0.604	2.487	5
Pied-billed Grebe	2019	0.056	54	0.023	0.119	0.406	0.165	0.866	4
Pine Siskin	2019	0.395	243	0.197	1.386	2.882	1.441	10.118	1
Plumbeous Vireo	2019	0.971	33	0.54	1.618	7.085	3.94	11.808	5
Prairie Falcon	2022	0.042	117	0.008	0.218	0.308	0.061	1.589	1
Redhead	2019	0.114	131	0.021	0.613	0.836	0.154	4.474	1
Redhead	2022	0.105	150	0.021	0.684	0.769	0.151	4.993	1
Red-tailed Hawk	2019	0.638	30	0.437	1.003	4.658	3.194	7.324	16
Red-tailed Hawk	2022	0.276	42	0.137	0.495	2.018	0.997	3.612	6
Red-winged Blackbird	2019	55.536	19	51.337	59.812	405.411	374.762	436.624	446
Red-winged Blackbird	2022	51.021	20	47.618	55.769	372.451	347.615	407.111	400
Ring-billed Gull	2019	0.17	197	0.045	1.369	1.238	0.325	9.995	2
Rock Pigeon	2019	0.683	204	0.208	8.997	4.989	1.521	65.678	4
Savannah Sparrow	2019	1.532	44	0.882	2.626	11.182	6.436	19.17	6
Say's Phoebe	2019	0.52	35	0.301	0.863	3.794	2.197	6.298	7
Song Sparrow	**2019**	**15.255**	**15**	**12.762**	**19.081**	**111.365**	**93.165**	**139.293**	**71**
Song Sparrow	**2022**	**16.838**	**16**	**13.444**	**20.473**	**122.917**	**98.142**	**149.455**	**62**
Sora	2019	0.337	34	0.182	0.55	2.461	1.325	4.017	7
Spotted Sandpiper	2019	6.502	42	4.639	9.228	47.465	33.868	67.365	42
Spotted Sandpiper	2022	1.722	55	0.76	2.829	12.573	5.545	20.652	8
Swainson's Hawk	2019	0.049	55	0.019	0.112	0.355	0.142	0.816	3
Swainson's Thrush	2019	3.428	18	2.534	4.546	25.026	18.497	33.186	17
Swainson's Thrush	2022	0.421	61	0.151	1.057	3.073	1.102	7.716	1
Tree Swallow	2019	17.911	97	12.583	48.125	130.747	91.858	351.315	29
Tree Swallow	2022	9.013	111	5.522	22.877	65.797	40.308	167.005	13
Turkey Vulture	2019	0.242	139	0.099	0.743	1.765	0.722	5.426	6
Turkey Vulture	2022	0.266	137	0.126	0.818	1.94	0.917	5.973	4
Vesper Sparrow	2022	0.433	38	0.271	0.865	3.163	1.977	6.318	4
Violet-green Swallow	2019	7.412	111	4.813	31.495	54.111	35.135	229.914	15
Virginia Rail	2019	0.168	116	0.042	0.987	1.229	0.307	7.204	1

Common Name	Year	D	% CV	LCL_D	UCL_D	N	LCL_N	UCL_N	n
Warbling Vireo	2019	4.519	18	3.515	6.026	32.99	25.659	43.987	19
Warbling Vireo	2022	2.543	27	1.628	3.81	18.567	11.883	27.814	8
Western Grebe	2019	0.024	143	0.004	0.134	0.177	0.032	0.979	1
Western Grebe	2022	0.035	120	0.004	0.194	0.256	0.03	1.42	1
Western Kingbird	2019	2.643	42	1.777	5.28	19.294	12.97	38.545	17
Western Kingbird	2022	1.513	40	0.924	2.836	11.046	6.746	20.7	8
Western Meadowlark	2019	4.657	20	4.041	5.406	33.996	29.502	39.467	82
Western Meadowlark	2022	2.955	21	2.44	3.606	21.575	17.814	26.325	45
Western Tanager	2019	2.166	23	1.524	3.209	15.811	11.126	23.424	12
Western Wood-Pewee	**2019**	**4.369**	**15**	**3.622**	**5.372**	**31.896**	**26.44**	**39.219**	**34**
Western Wood-Pewee	**2022**	**5.475**	**14**	**4.4**	**6.873**	**39.966**	**32.121**	**50.17**	**35**
White-breasted Nuthatch	2019	1.426	43	0.917	2.342	10.409	6.691	17.1	7
White-crowned Sparrow	2019	0.334	54	0.111	0.724	2.44	0.813	5.287	2
Wild Turkey	2019	0.041	111	0.012	0.12	0.3	0.086	0.878	2
Wild Turkey	2022	0.03	112	0.006	0.11	0.217	0.043	0.802	1
Willow Flycatcher	2019	0.551	70	0.138	1.439	4.021	1.005	10.505	2
Wilson's Phalarope	2019	0.215	274	0.043	1.891	1.566	0.313	13.804	1
Wilson's Snipe	2019	0.074	49	0.033	0.16	0.54	0.24	1.166	3
Wilson's Warbler	2019	0.387	72	0.194	1.161	2.826	1.413	8.478	1
Wood Duck	2019	3.308	78	1.42	12.181	24.148	10.366	88.918	8
Wood Duck	2022	1.045	95	0.328	4.378	7.625	2.395	31.96	2
Yellow Warbler	**2019**	**20.521**	**12**	**17.101**	**24.442**	**149.804**	**124.837**	**178.429**	**73**
Yellow Warbler	**2022**	**7.498**	**19**	**5.592**	**10.057**	**54.739**	**40.825**	**73.418**	**25**
Yellow-breasted Chat	2019	0.181	69	0.06	0.422	1.32	0.44	3.081	2
Yellow-headed Blackbird	2019	1.291	308	0.817	6.257	9.427	5.96	45.676	12
Yellow-headed Blackbird	2022	0.231	325	0.048	0.973	1.686	0.354	7.099	1
Yellow-rumped Warbler	2019	17.481	11	14.596	21.045	127.612	106.55	153.631	48
Yellow-rumped Warbler	2022	1.719	41	0.86	3.267	12.552	6.276	23.848	3

DISCUSSION AND MANAGEMENT RECOMMENDATIONS

From 2019 to 2022, Northern Flicker density decreased (*D*) from 3.21 to 3.00 birds/km^2 (Table 1) and population estimates (*N*) for the study area decreased from 23.47 to 21.89 individuals. The confidence intervals for both of these estimates overlapped. This mostly likely means the population is stable and not a significant decrease between 2019 and 2022. This could be an indicator that the number of standing dead trees in the study area have stayed the same. Northern Flickers place nests in cavities of dead, standing trees. (Burkett 1989). Northern Flicker site density started to decrease with the removal of standing trees from study sites (Scott and Oldemeyer 1983; Raphael and White 1984). Northern Flickers are an important species in woodlands because they are primary excavators, meaning they are capable of excavating their own cavities by drilling and chipping away at dead wood (Wiebe and Moore 2020). This creates cavities for other species of birds and mammals that are unable to create their own cavities, but require cavity sites for reproduction (Martin et al. 2004). These species are called secondary cavity nesters and they were detected on surveys in 2022 (Appendix A). These secondary cavity nesters include Wood Ducks, Black-capped Chickadees, Tree Swallows, American Kestrels, and House Wrens.

Western Wood-Pewee increased in density from 4.37 to 5.47 individuals/km^2 and population from 31.90 to 39.97 individuals between 2019 to 2022 (Table 1). The change in density and abundance had overlapping 95% confidence levels between years, which indicates this population is most likely stable. This is a sign there are healthy stands of live cottonwoods along the Cache la Poudre River. Western Wood-Pewees build their nests on the outer branches of cottonwoods (*Populus* sp.) and willows (*Salix* sp.) (Bemis and Rising, 2020). Song Sparrows had an increase in density and population estimates on the study area. The density went from 15.26 to 16.84 individuals/km^2 and population estimate from 111.36 to 122.92 individuals. The confidence intervals do overlap substantially for the density and population between 2019 and 2022. This species is very well adapted to the suburban areas with open areas such as open spaces and found in highest densities around riparian areas (Arcese et al. 2020).

Yellow Warbler densities and population estimates dropped at an alarming rate from 2019 to 2022. The density in 2019 was 20.52 individuals/km^2 and decreased to 7.5 individuals/km^2 in 2022 (Table 1). Standard error decreased in 2022 despite a decrease in total number of points surveyed. A smaller standard error can mean a higher precision in the estimate. This most likely means a decreased sampling effort in 2022 is not likely a cause of the decline in Yellow Warblers because sample size is inversely related standard error. Possible causes of declines of Yellow Warbler have been attributed to cattle grazing and Brown-headed Cowbird parasitism(Lowther et al. 2020). Brown-headed Cowbird density and population estimates decreased in 2022; however, the confidence intervals did overlap indicating a possibly insignificant change. Brown-headed Cowbird management and control has seen significant increases in Yellow Warbler populations after treatment in some populations (Gallagher 1997). A Yellow Warbler population saw a six-fold increase in density three years after cattle grazing at a riparian site in Arizona stopped (Ohmart, 1994).

Common Yellowthroats did have a decline in density and population estimates from 2019 to 2022 in the study area. The density went from 10.31 to 6.72 individuals/km^2 (Table 1) and the population from 75.25 to 49.03 from 2019 to 2022. The 95% confidence intervals for density and population estimates do not overlap. This indicates a potential significant decline in Common Yellowthroats in the study area. Wetland draining and successional forest growths are possible causes of decline. Agricultural uses, flood control, and urban development are common causes of drained wetlands used by Common Yellowthroats for breeding (Guzy and Ritchison 2020). This species has been noted to benefit from forest clearing and removing canopy trees (Yahner 1993). However, Common Yellowthroats decline as vegetation is left to mature through succession on sites that had trees cleared (Yahner 1997). The City of Fort Collins has made efforts in recent years to remove invasive trees like crack willow (*Salix fragillis*) and Russian olive (*Elaeagnus angustifolia*) along the Cache la Poudre. The successional growth of these cleared areas back to forests may have caused a decline in local Common Yellowthroat populations.

Bullock's Orioles did have a decline in density and population estimates from 2019 to 2022 in the study area. The density went from 7.10 to 4.51 individuals/km^2 (Table 1) and the population estimates declined from 51.83 to 32.89 individuals on the study area from 2019 to 2022. The 95% confidence intervals for density and population estimates between years did overlap. This indicates the change in population is most likely not significant. The study area needs more monitoring in order to tell if this decline is a significant trend. In eastern Colorado, breeding habitat degraded for Bullock's Oriole as a result of groundwater extraction for irrigation and results in population declines (Flood et al 2020). Local populations can benefit from reducing development and agriculture on or near riparian habitat on the Cache la Poudre. Another threat is brood parasitism. Brown-headed Cowbirds have expanded their range in the past few decades due to land conversion to agriculture and cattle grazing (Lowther 1993)Bullock's Orioles do have nests parasitized by Brown-headed Cowbirds and this reduces reproductive success (Flood et al. 2020).

Management recommendations should be put into place to help thwart the focal species in decline such as Yellow Warblers, Bullock's Orioles, Common Yellowthroats, Northern Flickers. Yellow Warblers had the largest decline and could benefit from rotational grazing on natural areas or removal of cattle from natural areas. Allowing any overgrazed or disturbed areas to regrow may reduce Brown-headed Cowbirds in the area and restore previously degraded habitat for Yellow Warblers and Bullock's Orioles.

Starting this year, we have incorporated the City of Fort Collins Natural Areas Program (FCNAP) data into the analyses of our Integrated Monitoring in Bird Conservation Regions (IMBCR) bird data. Due to the way the data are structured in our database, we were only able to incorporate the 2019 and 2022 data into analyses. We plan to modify the data structure for previous years to allow the entire riparian data set to be analyzed next year. There are several advantages to this approach, including:

1. Efficiency – We analyze IMBCR data annually to produce density estimates. Incorporating the FCNAP data in with IMBCR data requires a small up-front time investment, but once the data sets are merged, there is little extra work involved to generate estimates for FCNAP projects.
2. Sample size – We are able to pool detections for each species across the entire IMBCR and FCNAP data sets. This results in larger sample sizes needed to generate density estimates, which means we are able to produce density estimates for more species within the Poudre River Natural Areas than we would if this were a stand-alone project.
4. Advanced Analytical Techniques – The IMBCR analysis uses state-of-the-art Bayesian analysis framework that produces estimates with a high level of precision and account for incomplete detection.
5. Trends – This year, we only incorporated the 2019 and 2022 field data into IMBCR analyses to test out feasibility. The test was a success and we plan to clean up and format historic data from FCNAP projects so they can be incorporated as well. Once this is accomplished, we will automatically generate trend estimates at the species level for FCNAP projects with enough detections and years of data collected.

By analyzing these data with the IMBCR analysis framework, we will have the added advantage of generating trend estimates across Soapstone Prairie. We currently have up to eight years of data on different pastures, which should provide ample data to generate trends that can be used to paint a fuller picture of the health of bird populations within the natural area. Bird Conservancy Research Scientists are also in the process of developing data integration analyses that bring together Breeding Bird Survey, eBird, and IMBCR data to produce spatially-explicit estimates of population density, trend, survival, and recruitment. These finer-resolution predictions across different biological levels (abundance, trend, recruitment, survival) are a major step towards our goal of understanding how and where future management actions can maximize conservation efforts for grassland birds. Within the next couple of years, these spatially-explicit estimates will allow us to develop decision support analyses that can help better target and spatially prioritize management actions to achieve conservation objectives. Finally, given our model includes data from three open-source and broad-scale monitoring programs, it can be leveraged across a larger geography, capturing a wider range of conditions in both space and time. We believe this effort can help to better target conservation actions that improve population levels and related outcomes both at the local scale of Soapstone Prairie Natural Area, and across the entire Great Plains.

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LITERATURE CITED

Arcese, P., M. K. Sogge, A. B. Marr, and M. A. Patten (2020). Song Sparrow (Melospiza melodia), version 1.0. In Birds of the World (A. F. Poole and F. B. Gill, Editors). Cornell Lab of Ornithology, Ithaca, NY, USA. https://doi.org/10.2173/bow.sonspa.01

Bemis, C. and J. D. Rising (2020). Western Wood-Pewee (Contopus sordidulus), version 1.0. In Birds of the World (A. F. Poole and F. B. Gill, Editors). Cornell Lab of Ornithology, Ithaca, NY, USA. https://doi.org/10.2173/bow.wewpew.01

Bowden, D. C., G. C. White, A. B. Franklin, and J. L. Ganey. 2003. Estimating population size with correlated sampling unit estimates. Journal of Wildlife Management 67:1–10.

Buckland, S. T., D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borchers, and L. Thomas. 2001. Introduction to distance sampling: estimating abundance of biological populations. Oxford University Press, Oxford, UK.

Buckland, S. T., S. J. Marsden, and R. E. Green. 2008. Estimating bird abundance: making methods work. Bird Conservation International 18:S91–S108.

Burkett, E. W. (1989). Differential roles of sexes in breeding Northern Flickers (Colaptes auratus). Ph.D. dissertation, University of Wisconsin, Milwaukee, WI, USA.

Burnham, K.P., and Anderson, D.R. 2002. Model Selection and Multimodel Inference: A Practical Information-Theoretic Approach, 2nd ed. Springer-Verlag, New York, New York, USA. Czech, B., Krausman, P.R. & Devers, P.K. (2000). Economic associations among causes of species endangerment in the United States. BioScience, 50, 593–601.

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

Flood, N. J., C. L. Schlueter, M. W. Reudink, P. Pyle, M. A. Patten, J. D. Rising, and P. L. Williams (2020). Bullock's Oriole (Icterus bullockii), version 1.0. In Birds of the World (P. G. Rodewald, Editor). Cornell Lab of Ornithology, Ithaca, NY, USA. https://doi.org/10.2173/bow.bulori.01

Gallagher, S. R. (1997). Atlas of Breeding Birds, Orange County, California. Sea and Sage Audubon Press, Irvine, CA, USA.

Guzy, M. J. and G. Ritchison (2020). Common Yellowthroat (Geothlypis trichas), version 1.0. In Birds of the World (P. G. Rodewald, Editor). Cornell Lab of Ornithology, Ithaca, NY, USA. https://doi.org/10.2173/bow.comyel.01

Harrison-Atlas, D., D. M. Theobald, B. G. Dickson, V. Landau, and I. Leinwand. 2017. Description of the approach, data, and analytical methods used to evaluate river systems in the western U.S. Conservation Science Partners, Truckee, CA.

Hobbs, N. T., & Hooten, M. B. (2015). Bayesian models: a statistical primer for ecologists. Princeton University Press, Princeton, New Jersey, USA.

Kellner, K. (2018). Package 'jagsUI'. https://cran.r-project.org/web/packages/jagsUI/jagsUI.pdf. Accessed 2 Jul 2019.

Lowther, P. E., C. Celada, N. K. Klein, C. C. Rimmer, and D. A. Spector (2020). Yellow Warbler (Setophaga petechia), version 1.0. In Birds of the World (A. F. Poole and F. B. Gill, Editors). Cornell Lab of Ornithology, Ithaca, NY, USA. https://doi.org/10.2173/bow.yelwar.01

Lowther, P. E. (1993). Brown-headed Cowbird (Molothrus ater). In The Birds of North America, No. 47 (A. Poole and F. Gill, Editors). Academy of Natural Sciences, Philadelphia, PA and American Ornithologists' Union, Washington, DC, USA.

Martin, K., K. E. H. Aitken, and K. L. Wiebe (2004). Nest sites and nest webs for cavity-nesting communities in interior British Columbia, Canada: Nest characteristics and niche partitioning. Condor 106(1):5–19.

Naiman, R., H. Decamps, and M. McCain, editors. 2005. Riparia: Ecology, Conservation, and Management of Streamside Communities. First edition. Elsevier Academic Press, New York. Partners in Flight Science Committee 2012. Species Assessment Database, version 2012. Available at http://rmbo.org/pifassessment. Accessed on 06/06/2013.

Ohmart, R. D. (1994). The effects of human-induced changes on the avifauna of western riparian habitats. Studies in Avian Biology 15:273-285.

Plummer, M. (2003). JAGS: a program for analysis of Bayesian graphical models using Gibbs sampling. Proceedings of the 3rd International Workshop on Distributed Statistical Computing DSC 2003, 20–22 March 2003, Vienna, Austria.

Plummer, M. (2017). JAGS version 4.3.0 user manual. https://sourceforge.net/projects/mcmc-jags/files/Manuals/4.x/jags_user_manual.pdf/download. Accessed 2 Jul 2019.

R Core Team. (2022). R: a language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing. Retrieved from www.R-project.org/

Raphael, M. G., and M. White (1984). Use of snags by cavity-nesting birds in the Sierra Nevada. Wildlife Monographs 86:1–66.

Royle, J. A. (2004) Generalized estimators of avian abundance from count survey data. Animal Biodiversity and Conservation 27, pp. 375–386. R Development Core Team (2013) R: A language and environment for statistical computing. R Foundation for Statistical Computing. Vienna, Austria. ISBN 3-900051-07-0,URL http://www.R-project.org/.

Scott, V. E., and J. L. Oldemeyer (1983). Cavity-nesting bird requirements and responses to snag cutting in ponderosa pine. In Snag Habitat Management: Proceedings of the Symposium (J. W. Davis, G. A. Goodwin, and R. A. Ockenfels, Editors), U.S. Forest Service General Technical Reports RM-99. pp. 19–23.

Sillett, T. S., Chandler, R. B., Royle, J. A., Kéry, M., & Morrison, S.A. (2012). HIerarchical distance-sampling models to estimate population size and habitat-specific abundance of an island endemic. Ecological Applications, 22(7), 1997-2006.

Skagen, Susan K.; Hazlewood, Rob; Scott, Michael L. 2005. The Importance and Future Condition of Western Riparian Ecosystems as Migratory Bird Habitat. In: Ralph, C. John; Rich, Terrell D., editors 2005. Bird Conservation Implementation and Integration in the Americas: Proceedings of the Third International Partners in Flight Conference. 2002 March 20-24; Asilomar, California, Volume 1

Gen. Tech. Rep. PSW-GTR-191. Albany, CA: U.S. Dept. of Agriculture, Forest Service, Pacific Southwest Research Station: p. 525-527

Thomas, L., Buckland, S. T., Rexstad, E. A., Laake, J. L., Strindberg, S., Hedley, S. L., … Burnham, K. P. (2010). Distance software: design and analysis of distance sampling surveys for estimating population size. Journal of Applied Ecology, 47, 5–14.

Watanabe, S. (2010). Asymptotic equivalence of Bayes cross validation and widely applicable information criterion in singular learning theory. Journal of Machine Learning Research, 2010(11), 3571-3594.

Wiebe, K. L. and W. S. Moore (2020). Northern Flicker (Colaptes auratus), version 1.0. In Birds of the World (P. G. Rodewald, Editor). Cornell Lab of Ornithology, Ithaca, NY, USA. https://doi.org/10.2173/bow.norfli.01

Yahner, R. H. (1993). Effects of long-term forest clear-cutting on wintering and breeding birds. Wilson Bulletin 105:239-255.

Yahner, R. H. (1997). Long-term dynamics of bird communities in a managed forested landscape. Wilson Bulletin 109 (4):595-613.

Youngberg, 2022. Bird Conservancy of the Rockies. Field protocol for bird point counts and vegetation surveys in the Front Range area of northern Colorado. Unpublished report. Bird Conservancy of the Rockies, Fort Collins, Colorado, USA.

APPENDIX A: SPECIES LIST. NUMBER OF DETECTIONS FOR SPECIES RECORDED IN THE CACHE LA POUDRE RIVER NATURAL AREAS IN 2022.

Species	ScientificName	Count	Conservation Status (CPW, USFWS or PIF)*
American Avocet	Recurvirostra americana	5	
American Crow	Corvus brachyrhynchos	1	
American Goldfinch	Spinus tristis	34	
American Kestrel	Falco sparverius	2	
American Robin	Turdus migratorius	74	
American White Pelican	Pelecanus erythrorhynchos	59	
Bald Eagle	Haliaeetus leucocephalus	2	Special concern (CPW)
Bank Swallow	Riparia riparia	179	
Barn Swallow	Hirundo rustica	31	
Belted Kingfisher	Megaceryle alcyon	2	
Black-billed Magpie	Pica hudsonia	25	
Black-capped Chickadee	Poecile atricapillus	52	
Blue Grosbeak	Passerina caerulea	4	
Blue Jay	Cyanocitta cristata	66	
Blue-winged Teal	Spatula discors	2	
Brewer's Blackbird	Euphagus cyanocephalus	13	
Broad-tailed Hummingbird	Selasphorus platycercus	1	Watch List-Yellow D (PIF)
Brown-headed Cowbird	Molothrus ater	54	
Bullock's Oriole	Icterus bullockii	17	
Canada Goose	Branta canadensis	196	

Chimney Swift	Chaetura pelagica	3	Watch List-Yellow-D (PIF)
Cliff Swallow	Petrochelidon pyrrhonota	273	
Common Grackle	Quiscalus quiscula	81	
Common Merganser	Mergus merganser	2	
Common Raven	Corvus corax	4	
Common Yellowthroat	Geothlypis trichas	39	
Cooper's Hawk	Accipiter cooperii	1	
Double-crested Cormorant	Nannopterum auritum	16	
Downy Woodpecker	Dryobates pubescens	2	
Eastern Kingbird	Tyrannus tyrannus	8	
Eurasian Collared-Dove	Streptopelia decaocto	19	
European Starling	Sturnus vulgaris	151	
Forster's Tern	Sterna forsteri	1	Regional Concern (PIF)
Gadwall	Mareca strepera	1	
Grasshopper Sparrow	Ammodramus savannarum	3	
Great Blue Heron	Ardea herodias	31	
Great Egret	Ardea alba	14	
Great Horned Owl	Bubo virginianus	1	
Great-tailed Grackle	Quiscalus mexicanus	14	
Green-tailed Towhee	Pipilo chlorurus	1	
Hairy Woodpecker	Dryobates villosus	1	
Hooded Merganser	Lophodytes cucullatus	1	
Horned Lark	Eremophila alpestris	7	
House Finch	Haemorhous mexicanus	47	
House Sparrow	Passer domesticus	1	
House Wren	Troglodytes aedon	159	

Killdeer	Charadrius vociferus	57	
Lark Sparrow	Chondestes grammacus	1	
Lazuli Bunting	Passerina amoena	11	
Mallard	Anas platyrhynchos	44	
Mourning Dove	Zenaida macroura	58	
Northern Flicker	Colaptes auratus	33	
Northern Harrier	Circus hudsonius	2	Regional Concern (PIF)
Northern Rough-winged Swallow	Stelgidopteryx serripennis	71	
Osprey	Pandion haliaetus	6	
Prairie Falcon	Falco mexicanus	1	
Red-tailed Hawk	Buteo jamaicensis	6	
Red-winged Blackbird	Agelaius phoeniceus	537	
Redhead	Aythya americana	2	
Snowy Egret	Egretta thula	3	
Song Sparrow	Melospiza melodia	63	
Spotted Sandpiper	Actitis macularius	10	
Swainson's Thrush	Catharus ustulatus	1	
Tree Swallow	Tachycineta bicolor	41	
Turkey Vulture	Cathartes aura	16	
Vesper Sparrow	Pooecetes gramineus	4	
Warbling Vireo	Vireo gilvus	8	
Western Grebe	Aechmophorus occidentalis	1	Watch List: Yellow-D (PIF)
Western Kingbird	Tyrannus verticalis	8	Regional Stewardship Species (PIF)

Western Meadowlark	Sturnella neglecta	47	Regional Concern (PIF)
Western Wood-Pewee	Contopus sordidulus	38	
Wild Turkey	Meleagris gallopavo	1	
Wood Duck	Aix sponsa	4	
Yellow Warbler	Setophaga petechia	25	
Yellow-headed Blackbird	Xanthocephalus xanthocephalus	1	
Yellow-rumped Warbler	Setophaga coronata	4	

*Watch list Yellow-D (steep declines and major threats), Regional Concern, and Regional Stewardship species are designations from the Avian Conservation and Assessment Database Scores for Bird Conservation Region 18 and North America (Partners in Flight)