Raptor and Songbird Surveys at Buckley Air Force Base, Aurora, Colorado

Colorado Natural Heritage Program

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Distribution of Winter Raptors and Abundance of Songbirds

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Cover photographs
Singing Western Meadowlark by Michael Menefee
Horned Lark by Michael Menefee
Note: None of the pictures from this report were taken on Buckley Air Force Base.

Summary: Distribution of Winter Raptors and Abundance of Songbirds at Buckley Air Force Base

The goals of this inventory were to better describe the spatial distribution of raptor activity in fall/winter 2012 and estimate the diversity and abundance of songbirds in spring 2013 at Buckley Air Force Base (Buckley AFB) in 2013. Colorado Natural Heritage Program (CNHP) biologists conducted winter raptor surveys at 6 overlook locations. Several of these observation locations were on the roofs of buildings or structures on the base. Each observations location was manned for 45-minute observation sessions 6 times from November 2012 to January 2013. Each overlook received 4.5 hours of observation during the fall/winter season producing 89 raptor observations. Red-tailed Hawks were the most abundant raptor on Buckley AFB, with frequent sightings of lone Bald Eagles. Each of 29 roadside sampling points was visited 4 times, and each visit consisted of 5-minute observations during which a biologist observed and listened for birds within a 200-m radius of the observation point. There were 1128 bird detections of 46 species. The birds most frequently detected were Western Meadowlarks (156), Mourning Doves (134), American Robins (99), Horned Larks (90), and Red-winged Blackbirds (86). Abundance estimation was conducted for only a handful of species that were detected with enough frequency and over an adequate diversity of distance categories to produce accurate estimates. The most abundant songbird species on Buckley AFB in spring 2013 were the Mourning Dove (3.7/ha), the American Robin (3.4/ha), the Red-winged Blackbird (1.2/ha), the Western Kingbird (1.1/ha), and the Western Meadowlark (0.8/ha). Estimates of abundance for the Western Meadowlark and the Red-winged Blackbird were the most precise (coefficients of variation < 17%).

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Background and Introduction

Ecological Setting: Buckley Air Force Base

Buckley AFB is a 3,280-acre installation (Figure 1) at the western edge of the Central Shortgrass Prairie Ecoregion. The shortgrass prairie is a broad ecoregion, which includes parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, Texas, and Wyoming. The portion of the central shortgrass prairie where Buckley AFB occurs is primarily a mix of shortgrass and midgrass prairie, with plains riparian systems and wetlands. Urban development is encroaching on the areas near Buckley AFB, and the area to the east is the only area not dominated by commercial or residential development.

Figure 1. Buckley Air Force Base, Aurora, Colorado.

Historically, much of Buckley AFB was mixed-grass and shortgrass prairies comprised of western wheatgrass (*Pascopyron smithii*), buffalo grass (*Buchloe dactyloides*), blue grama grasses (*Bouteloua* spp.), prickly pear cactus (*Opuntia macorhiza*), needle grasses (*Stipa* spp.), yucca (*Yucca glauca*), snakeweed (*Gutierrezia sarthrae*), sagebrush (*Artemesia* spp.), and rabbitbrush (*Chrysothamnus nauseosus*). Currently, Buckley AFB is comprised of native and non-native grasslands, with some shrub component, riparian areas and Williams Lake, and developed and landscaped areas. The most diverse vegetation communities at Buckley AFB are native midgrass prairies, dominated by blue grama and western wheatgrass, with some three awn (*Aristida* spp.), prickly pear, and snakeweed. The largest patches of midgrass prairie are found around the southern section of the runway and in the northeastern part of the base.

Riparian habitats at Buckley AFB include the wetland-associated vegetation in and around intermittent streams, such as East Toll Gate Creek and its un-named tributary. Another un-named drainage flows from Williams Lake to Sand Creek northeast of Buckley AFB. Shrub cover along East Toll Gate Creek is comprised of coyote willow (*Salix exigua*) and snowberry (*Symphoricarpos* spp.), with an overstory of peachleaf willow (*Salix amygdaloides*) and plains cottonwood (*Populus deltoides*). Bottomland meadows dominated by fringed brome (*Bromus ciliatus*) are found along the intermittent drainages at Buckley AFB.

Williams Lake, located in the northeastern part of Buckley AFB, is a man-made reservoir that was originally developed for recreational opportunities. The water level within the lake is maintained by a

well and supplemented by runoff from Buckley AFB. However, in the spring of 2010, Buckley AFB discontinued supplying water to Williams Lake in order to allow the area to return to its natural state. The average surface area of water on Williams Lake from 3 April 2013 to 17 June 2013 was 2606 yd^2. Until the early 1990s, Williams Lake was stocked with trout, but it was not a self-sustaining population and large numbers of fish were eaten by birds. In 2006, Williams Lake was stocked with bass, bluegill, and catfish, and a solar powered aerator was installed to help maintain the fishery. With access to food, water, and roosting structures (cottonwood trees), Williams Lake is an activity center for many bird species.

Throughout Buckley AFB, shelterbelts of trees and shrubs have been planted for wind protection and reduction of noise pollution. Trees and shrubs planted in the shelterbelts include lilac (*Syringa vulgaris*), American plum (*Prunus americana*), junipers and cedars (*Juniperus* sp.), hackberry (*Celtis reticulata*), and Ponderosa pine (*Pinus ponderosa*).

Management and Conservation of Birds at Buckley Air Force Base

Since Buckley AFB is within the Central Flyway migratory path for many birds, there is the potential to have up to 300 species that visit the base throughout the year. Many of these species have regulatory protection because of conservation concern, while others are significant management issues because of their potential for Bird Aircraft Strike Hazard (BASH) risk. Of the 9 management and conservation issues identified in the draft Buckley AFB Wildlife Management Plan (Buckley AFB Wildlife Management Plan Draft 2006), bird conservation issues are associated with at least 3, including: BASH; Threatened and Endangered Species; and Migratory Birds.

Bird/Aircraft Strike Hazard Management

The combination of ecozones on Buckley AFB provides habitat for a variety of birds, and many of these species pose some a threat to flight safety. One of the goals of BASH management is to manage habitats such that birds (and other wildlife) are attracted to areas outside the flight zone and are discouraged from using the areas near the airfield. Additionally, the Buckley AFB Wildlife Management Plan calls for reducing bird strike conflicts by improving recording keeping of strike frequency, severity, and geographic location. By documenting areas of high levels of bird use, Buckley AFB can identify areas of high BASH concern.

Conservation Legislation and Birds Conservation on Buckley AFB

Although there are hosts of wildlife management legislation that directs military installation actions for managing bird populations, there are only a few that are of direct relevance for Buckley AFB. The following legislation has direct relevance for bird populations at Buckley AFB and should be addressed when planning management activities:

Endangered Species Act (*ESA*). The ESA provides for conservation of Endangered and Threatened species and their habitats. Buckley AFB is required to consult with the U.S. Fish and Wildlife Service (USFWS) to ensure that actions authorized, undertaken, or funded by any federal agency do not jeopardize the continued existence of endangered/threatened species or result in destruction or adverse modification of habitat (unless exempted or permitted).

Bald and Golden Eagle Protection Act (BGEPA). The BGEPA prohibits taking, possession, and commerce of Bald Eagle (*Haliaeetus leucocephalus*) and Golden Eagle (*Aquila chryseatos*), and their parts, unless permitted or exempted by the Secretary of Interior.

Migratory Bird Treaty Act (*MBTA*). The MBTA protects migratory birds included in international conventions between the U.S. and Great Britain, Mexico, Japan, and Russia. The MBTA protects more than species that migrate, but all species of birds that are included on the List of Migratory Birds in 50 CFR 10.13. The MBTA prohibits taking, killing, or possessing birds or bird parts, nests, or eggs (unless permitted), and taking birds using bait.

There are only two rare birds found on Buckley AFB: the Bald Eagle and the Burrowing Owl (*Athene cunicularia*). In 2007, the Bald Eagle was removed from the list of federally threatened species. The Bald Eagle is considered uncommon or locally-common winter resident in Colorado's western valleys, mountain parks, and eastern plains. Habitat for the Bald Eagle is usually near reservoirs and rivers, and in the winter it may be found hunting over prairie dog towns. Bald Eagles have been documented on Buckley AFB, but do not breed here. The Burrowing Owl is a state-listed threatened species in Colorado because populations have been declining. This owl nests in prairie dog towns, and prefers sites with very low vegetation. However, they have been known to abandon areas where plague or poisoning has eliminated prairie dogs, or where the vegetation has grown tall from lack of grazing by rodents (Dechant et al. 2002). Nesting Burrowing Owls have been documented on Buckley AFB. Many birds that fall under the jurisdiction of the MBTA occur on Buckley AFB. The variety of ecotypes on Buckley AFB attract numerous bird species that use Buckley AFB for various habitat needs, including roosting, breeding, wintering, and feeding.

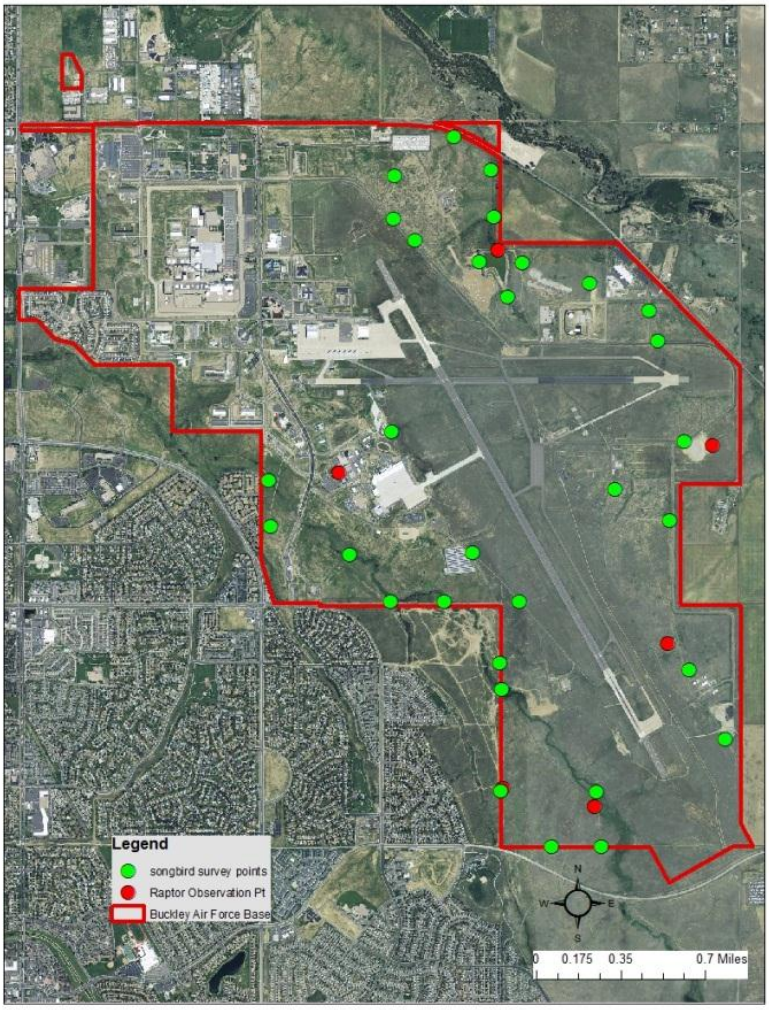

Figure 2. Bird observation points on Buckley Air Force Base, Aurora, Colorado.

Previous bird surveys on BUCKLEY AFB

Raptor Road Surveys:

Three road transect surveys were conducted during the winter of 1988–1989 as part of the 1989 Integrated Land Use Management Plan. The most common wintering raptor observed on Buckley AFB was the Ferruginous Hawk (*Buteo regalis*), with an estimated population of 30 to 40 individuals (Hunter Environmental Science and Engineering 1989). The Red-tailed Hawk (*Buteo jamaicensis*), Northern Harrier (*Circus cyaneus*), and Golden eagle were common winter birds on Buckley AFB, while Rough-legged Hawks (*Buteo lagopus*) were uncommon winter residents. During the breeding season, the Burrowing Owl, Red-tailed Hawk, Swainson's Hawk (*Buteo swainsoni*), American Kestrel (*Falco sparverius*), and Great Horned Owl (*Bubo virginianus*) use

habitats on Buckley AFB.

Songbird Surveys:
Prior songbird surveys assessed relative abundance of bird species by observations of individuals on Buckley AFB. The most abundant species in the area include the Horned Lark, Western Meadowlark, Black-billed Magpie, Grasshopper Sparrow, Western Kingbird, Eastern Kingbird, European Starling, House Sparrow, House Finch, and Rock Dove. Several species of blackbirds are also relatively common, especially in the improved areas of the installation, in riparian areas, and at Williams Lake. Appendix 2 of this document contains a list of bird species identified on and in the vicinity of Buckley AFB. This is not an exhaustive list since it was only from observations during fall of 2012 and spring of 2013.

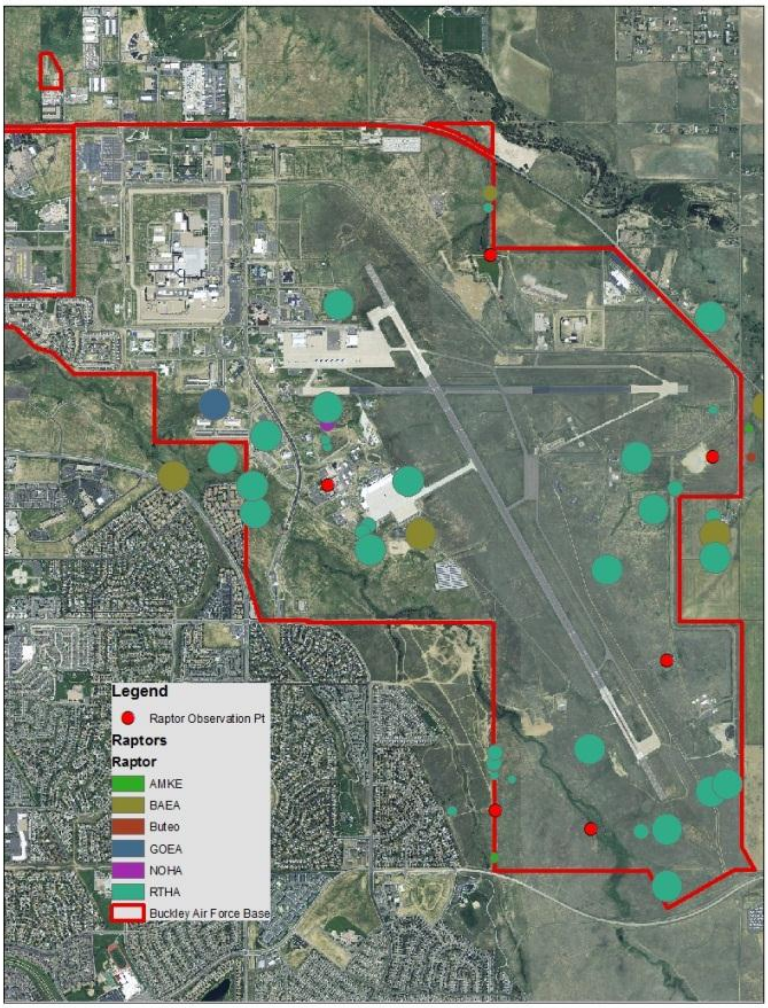

Figure 3. Raptor observations on Buckley Air Force Base in fall/winter 2012/2013. Size of circle reflects the estimated accuracy in location of observation.

Due to the changing landscape and expected growth of Buckley AFB, avian species diversity and abundance within the installation boundaries needed to be reassessed and resurveyed. This project was conducted over the 2012 fall/winter and 2013 spring migration/early-breeding season.

Methods and Results for 2012 Raptor Surveys and 2013 Songbird Surveys

Raptor survey methods:
Surveys for raptors consisted of 2 sampling methods: opportunistic observations and 45-minute observation points throughout Buckley AFB. Opportunistic observations of raptors were recorded as raptors were seen on Buckley AFB. The 45-minute observation points consisted of an observer spending 45 minutes at an elevated observation point where raptors could be more easily observed. Observers recorded birds to species, or genera if species identification was inhibited by distance or obscured by the habitat, approximate distance to bird location, and bird behavior. There were 6 raptor observation points (Figures 2, 3). Surveys were conducted from 13 November 2012 to 4 January 2013.

Songbird survey methods:
Songbird surveys were conducted at randomly-selected roadside locations on Buckley AFB. Ideally, sampling points should be random and away from roads. However, because of access limitations and safety concerns, random locations away from roads were prohibited. Point locations were selected randomly then moved to a point on the nearest accessible road. Thirty points were chosen, but only 29 were needed. Distance sampling methodology was used to assess songbird densities. Distance sampling uses the distances recorded for bird observations to estimate the probability of detecting birds at varying distances from the observer (Buckland et al. 2001). This probability then can be used to assess the likelihood of detecting birds based on distance, and, by extension, the likelihood there are birds that went undetected during surveys. At 29 locations (Figure 2) along roads in the three major habitat types (crested wheatgrass, midgrass prairie, and bottomland meadow/riparian) observers spent 5 minutes identifying birds based on song, and recording distance to bird observations. Midgrass prairie and crested wheatgrass (*Agropyron cristatum*) habitats were combined into one habitat type (midgrass prairie). Points were visited 4 times on separate days throughout spring 2013.

Raptor survey results:
Eighty-nine (89) raptors were observed during the timed-interval observations. Red-tailed Hawk, Bald Eagle, Northern Harrier, American Kestrel, and Golden Eagle were identified on Buckley AFB (Figure 3); however, the one observation of a Golden Eagle may have been a juvenile Bald Eagle. Along the eastern boundary, a juvenile Bald Eagle was observed in close proximity to an adult Bald Eagle. Red-tailed Hawks were observed most frequently (66 times), and were typically perching (62% of observations) or flying (soaring high or cruising low; 35% of observations). Northern Harriers and Bald Eagles were observed next most frequently (8 and 7 times, respectively). Bald Eagles were commonly flying low and, on one occasion, were observed feeding on prairie dogs on the western side of the base. It is believed that a majority of the Bald Eagle observations were of one adult that frequented the cottonwood trees near the prairie dog town on the western boundary. Northern Harriers were always seen cruising low, which is typical of this species' hunting behavior. American Kestrels were observed 5 times, typically perching. There were 3 observations of unidentifiable buteos, which were likely Red-tailed Hawks, but were too distant to make accurate species identification.

Western Meadowlark by Michael Menefee

Opportunistic observations identified Red-tailed Hawks and American Kestrels using cottonwood trees along the southern boundary, the interior developed areas in the western part of Buckley AFB, and near the northern entrance areas. One species known to occur on Buckley that was not detected during raptor survey sampling effort was the Burrowing Owl. Breeding populations were limited this year, but one individual was seen and one pair nested in the southeastern area of the base (pers. comm. K. Phillips).

Songbird survey results:
One-hundred sixteen (116) breeding bird surveys were conducted at sampling points with a total of 1128 bird detections of 46 species (Table 2). There were 639 detections in midgrass prairie habitats and 489 detections in riparian habitats. Considering the size of the midgrass prairie (midgrass and crested wheatgrass habitats) on Buckley AFB, there were considerably more bird detections per area in riparian systems. This is typical of most bird diversity profiles with greater species diversity and density in wetland habitats. The species most often detected along sampling points were Western Meadowlark (156), Mourning Dove (134), American Robin (99), Horned Lark (90), and Red-Winged Blackbird (86). In the riparian and bottomland meadow habitats Red-Winged Blackbird (69), Mourning Dove (56), and Cliff Swallow (49) were detected most frequently. In the midgrass prairie habitats Western Meadowlark (123), Horned Lark (90), Mourning Dove (78), American Robin (61), and Common Grackle (58) were detected most frequently. In addition to detection along breeding bird survey points, some species, such as Red-tailed Hawks, Common Grackles, Rock Doves, Mourning Doves, American Robins, House Finches, and House Sparrows were seen regularly in the developed parts of the Buckley AFB.

There were six species detected often enough and over a broad range of distance categories to make estimation of density and abundance tenable (Tables 2, 3). Those species were American Robin, Horned Lark, Mourning Dove, Red-winged Blackbird, Western Kingbird, and Western Meadowlark. Both the Cliff Swallow and the Common Grackle were detected frequently but they were not detected at varying distances from observation points to adequately estimate the species-specific detection function. This makes estimates unreliable because of the large variability in the estimate. For example, there are numerous Cliff Swallows at specific culverts and overpasses at Buckley AFB. Because this

Table 2. Bird species detected during breeding bird sampling effort and the number of detections by major habitat type at Buckley Air Force Base, Aurora, Colorado in May 2013. Twenty-nine survey points were visited 4 times each.

	Number of observations		
Species	Midgrass Prairie	Riparian/ Bottomland Meadow	Total
American Avocet	2	4	6
American Kestrel	2	0	2
American Robin	61	38	99
Bald Eagle	0	1	1
Barn Swallow	2	0	2
Black-billed Magpie	23	13	36
Brown-headed Cowbird	9	11	20
Brewer's Blackbird	0	10	10
Broad-tailed Hummingbird	1	0	1
Bullock's Oriole	6	11	17
Blue-winged Teal	2	8	10
Cassin's Finch	0	10	10
Chipping Sparrow	0	3	3
Cliff Swallow	15	49	64
Common Grackle	58	23	81
Eurasion Collared Dove	4	4	8
European Starling	9	33	42
Gray Catbird	0	1	1
Grasshopper Sparrow	1	0	1
House Finch	2	0	2
Horned Lark	90	0	90
House Sparrow	3	2	5
House Wren	0	5	5
Killdeer	19	15	34
Lark Bunting	7	0	7
Lark Sparrow	0	3	3
Loggerhead Shrike	6	0	6
Mourning Dove	78	56	134
Northern Flicker	3	5	8
Northern Mockingbird	1	0	1
Rock Dove	19	20	39
Red-tailed Hawk	11	6	17
Red-winged Blackbird	17	69	86
Say's Phoebe	1	0	1
Song Sparrow	1	3	4
Swainson's Hawk	4	1	5
Townsend's Solitaire	1	0	1
Vesper Sparrow	9	1	10
White-crowned Sparrow	4	0	4
Western Kingbird	38	33	71
Western Meadowlark	123	33	156
Western Tanager	0	1	1
Western Wood-Pewee	1	2	3
Yellow Warbler	1	11	12
Yellow-headed Blackbird	4	0	4
Yellow-rumped Warbler	1	4	5
Total	639	489	1128

species congregates in specific locations nearly all detections are at a fixed distance from the observation point. This lack of variation in the distances of detection creates problems for adequately estimation of the detection function for the species. Thus, I did not include the density or abundance estimates for these two species.

The species found in greatest density on Buckley AFB in spring 2013, was the Mourning Dove, followed by American Robin, Red-winged Blackbird, Western Kingbird, Western Meadowlark, and the Horned Lark. Mourning Doves and American Robins were most abundant on Buckley AFB, possibly numbering near 40,000. However, these estimates were the least precise. I believe this may be caused by the frequent detection of pairs of individuals. Because Mourning Doves and American Robins were commonly observed in pairs or groups, the variability in distance categories that were observed is low. For example, groups of individuals heard at 50 m from the observer make estimation of the detection function more problematic than the same number of individuals observed from 5 – 50 m. With that said, general observations on Buckley AFB suggest that the Mourning Doves and American Robins are some of the most abundant and widely-distributed species on the base. Western Meadowlarks were detected more frequently, but they were restricted to grassland habitats, whereas Mourning Doves and American Robins were found throughout Buckley AFB.

Estimates for Red-winged Blackbird and Western Meadowlark are likely the most reliable (low variability; Table 3). This precision is likely due to the ease of detecting both species at a variety of distance categories. Both species are loquacious, loud singers that tend to distribute themselves evenly over the landscape. For example, meadowlarks will perch atop roosts that are relatively evenly dispersed from the nearest neighbor. Yet this species can sing so loudly that detections of nearly 200 m away were possible. Similarly for the Red-winged Blackbird, individuals would space themselves evenly among the cattail marshes and riparian areas, making it easy to separate observations into distinct distance categories.

Table 3. Density and abundance of the most common bird species on Buckley Air Force Base, Aurora, Colorado in spring 2013. % CV is the percent coefficient of variation (standard error/mean) and reflects the precision of the estimate. Only those species with less than 40% CV are reported. Density is per hectare.

Species	Density Estimate (95% CI)	Abundance Estimate (95% CI)	%CV	Observations	Percentage of survey point visits in which species was detected (out of 116)
American Robin	3.4 (1.7, 6.8)	37,981 (19,213, 75,084)	35.4	97	51%
Horned Lark	0.7 (0.4, 1.2)	7995 (4732, 13,507)	26.8	85	53%
Mourning Dove	3.7 (2.0, 6.9)	41,535 (22,515, 76,620)	31.7	130	66%
Red-winged Blackbird	1.2 (0.9. 1.5)	13,243 (10,348, 16,949)	12.5	79	32%
Western Kingbird	1.1 (0.5, 2.2)	12,184 (6053, 24,528)	36.1	64	41%
Western Meadowlark	0.8 (0.6, 1.1)	8883 (6402, 12,326)	16.7	143	99%

Other species observed during the surveys were only seen during one occasion, suggesting that they were migrating through the area or simply rare. For example, a small flock of Cassin's Finches were seen along East Tollgate Creek but not seen on subsequent visits. A Townsend's Solitaire was seen along the eastern boundary at one survey point, which is outside its normal habitat preferences. One Gray

Catbird was detected along East Tollgate Creek. I believe this species was a resident but can be secretive, choosing to vocalize infrequently.

Although the breeding bird sampling points produced over 1000 bird detections, it should be noted that the species diversity and estimates of species abundance and diversity are based on visits during one season and one year. Species abundances and diversity can fluctuate annually based on a variety of changing conditions, such as climatic patterns, habitat quality, and local disturbances. Ideally, estimates of bird population should be conducted over multiple years to adequately depict the health of bird populations at a locale.

Considerations for future bird surveys at Buckley AFB

Buckley AFB has adequate needs (BASH, ESA) to monitor bird populations within its boundaries, and it may be advantageous to extend the monitoring effort to areas surrounding Buckley AFB. One of the greatest concerns on Buckley AFB is the threat of BASH incidents and the likelihood of increased BASH activity because of urban encroachment along Buckley AFB's boundaries. Flocks of large-bodied birds may pose a greater threat than lone, low-elevation raptors. For this reason, it may be advantageous for Buckley AFB to take an active role in sampling the densities, flight patterns, and population dynamics of waterfowl flocks that utilize the parks and urban areas around the base. Some of this sampling can be tailored to only track bird flock conditions along the landing and departure pathways. If BASH is the primary motivation for understanding bird populations and spatial distribution I recommend a thorough survey of Buckley AFB and the surrounding areas to map Canada Goose roosts and flight patterns.

The advantage of the bird sampling methodology used in this report is that it provides a basis for comparing changes in future raptor and songbird populations. The raptor sampling methodology is specific to locations of raptor activity and does not provide population-level data, but with the addition of rigorous territory mapping and nest monitoring may provide baseline data for on-base raptor populations. The songbird sampling can be reproduced in the future to compare changes in abundance of the more common songbirds and as a method of tracking trends in populations.

Citations

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Appendix 1. Bird survey locations on Buckley Air Force Base, Aurora, Colorado. UTMx is universal transverse mercator easting. UTMy is universal transmercador northing. All locations in North American Datum 1983.

Breeding Bird Survey Point	Number	Habitat	UTMx	UTMy
01-buckleysongbird	1	midgrass prairie	520410	4396977
02-buckleysongbird	2	midgrass prairie	520404	4396693
03-buckleysongbird	3	midgrass prairie	520546	4396547
04-Buckleysongbird	4	riparian/wetland	520977	4396402
05-Buckleysongbird	5	midgrass prairie	521168	4396169
06-buckleysongbird	6	midgrass prairie	521266	4396394
07-buckleysongbird	7	riparian/wetland	521075	4396701
08-buckleysongbird	8	riparian/wetland	521060	4397015
09-buckleysongbird	9	midgrass prairie	520808	4397239
10-buckleysongbird	10	midgrass prairie	521719	4396262
11-buckleysongbird	11	midgrass prairie	522118	4396074
12-buckleysongbird	12	midgrass prairie	522175	4395876
13-buckleysongbird	13	midgrass prairie	522348	4395200
15-buckleysongbird	15	midgrass prairie	522252	4394671
16b-buckleysongbird	16	midgrass prairie	522685	4393729
17-buckleysongbird	17	midgrass prairie	522626	4393209
18b-buckleysongbird	18	midgrass prairie	521224	4392502
19-buckleysongbird	19	riparian/wetland	521798	4392495
20-buckleysongbird	20	midgrass prairie	521465	4392497
21-buckleysongbird	21	midgrass prairie	521125	4392869
22-buckleysongbird	22	riparian/wetland	521131	4393543
23-buckleysongbird	23	midgrass prairie	521118	4393722
24-buckleysongbird	24	midgrass prairie	521245	4394129
25b-buckleysongbird	25	riparian/wetland	519147	4395323
26-buckleysongbird	26	riparian/wetland	520743	4394130
27-buckleysongbird	27	riparian/wetland	520386	4394131
29-buckleysongbird	29	midgrass prairie	519580	4394636
30-buckleysongbird	30	riparian/wetland	519570	4394944

Fall raptor survey point	Number	Habitat	UTMx	UTMy
Roof of Building 1005	1	midgrass prairie	520043	4394992
Southwest Perimeter Road	2	midgrass prairie	521134	4392884
South Perimiter Road	3	riparian/wetland	521749	4392764
Lake Williams Dam	4	riparian/wetland	521102	4396482
Fire Tower	5	midgrass prairie	522542	4395177
Roof of Building 1619	6	midgrass prairie	522242	4393852

Appendix 2. Common names and scientific names of birds observed at Buckley Air Force Base, Aurora, Colorado.

Species	Scientific Name
American Avocet	*Recurvirostra americana*
American Crow	*Corvus brachyrhychos*
American Kestrel	*Falco sparverius*
American Robin	*Turdus migratorius*
American White Pelican	*Pelecanus erythrorhynchos*
Bald Eagle	*Haliaeetus leucocephalus*
Barn Swallow	*Hirundo rustica*
Black-billed Magpie	*Pica hudsonia*
Blue-winged Teal	*Anas discors*
Brown-headed Cowbird	*Molothrus ater*
Brewer's Blackbird	*Euphagus cyanocephalus*
Broad-tailed Hummingbird	*Selasphorus platycercus*
Bullock's Oriole	*Icterus bullockii*
Canada Goose	*Branta canadensis*
Cassin's Finch	*Carpodacus cassinii*
Chipping Sparrow	*Spizella passerina*
Cliff Swallow	*Petrochelidon pyrrhonota*
Common Grackle	*Quiscalus quiscula*
Eurasion Collared Dove	*Streptopelia decaocto*
European Starling	*Sturnus vulgaris*
Golden Eagle	*Aquila chrysaetos*
Gray Catbird	*Dumetella carolinensis*
Grasshopper Sparrow	*Ammodramus savannarum*
Great Blue Heron	*Ardea herodias*
Gull	unknown
House Finch	*Carpodacus mexicanus*
Horned Lark	*Eremophila alpestris*
House Sparrow	*Passer domesticus*
House Wren	*Troglodytes aedon*
Killdeer	*Charadrius vociferus*
Lark Bunting	*Calamospiza melanocorys*
Lark Sparrow	*Chondestes grammacus*
Loggerhead Shrike	*Lanius ludovicianus*
Mallard	*Anas platyrhynchos*
Mourning Dove	*Zenaida macroura*
Northern Flicker	*Colaptes auratus*
Northern Harrier	*Circus cyaneus*
Northern Mockingbird	*Mimus polyglottos*
Rock Dove	*Columba livia*
Red-tailed Hawk	*Buteo jamaicensis*
Red-winged Blackbird	*Agelaius phoeniceus*
Say's Phoebe	*Sayornis saya*
Song Sparrow	*Melospiza melodia*
Swainson's Hawk	*Buteo swainsoni*
Townsend's Solitaire	*Myadestes townsendi*
Vesper Sparrow	*Pooecetes gramineus*
White-crowned Sparrow	*Zontrichia leuchophrys*
Western Kingbird	*Tyrannus vociferans*
Western Meadowlark	*Sturna neglecta*
Western Tanager	*Piranga ludoviciana*
Western Wood-Pewee	*Contopus sordidulus*
Yellow Warbler	*Dendroica petechia*
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*
Yellow-rumped Warbler	*Dendroica coronata*

Appendix 3. Map of Songbird and Raptor Sampling Points on Buckley Air Force Base, Aurora, Colorado.