

**The Effects of Off-Leash Dog Areas on Birds and Small Mammals in Cherry Creek
and Chatfield State Parks**

Submitted to:

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I. Introduction

The State of Colorado has 41 parks in Colorado that provide a wide variety of services to the public. The 12 million visitors to the state parks system enjoy boating, fishing, bicycling, hiking, camping, bird watching, winter sports (skiing, snowshoeing, etc.) and horseback riding (Colorado State Parks 2008).

Two of the larger parks, Cherry Creek and Chatfield State Parks, are within or near the Denver Metropolitan area and receive approximately 26% of the total visitor days recorded per annum in Colorado.

One activity that has become increasingly popular in recent years is walking dogs in off-leash areas. Several cities and towns in Colorado now have “dog parks.” Dog parks are typically fenced enclosures a few acres in size where dogs may roam unleashed within the confines of the park.

Both Cherry Creek and Chatfield Parks now have dog “off-leash” areas within the parks. These designated areas are not fenced and have boundary signs to guide dog owners where unleashed dogs may roam. Off-leash areas differ in several factors from dog parks. They are often larger; the Cherry Creek off-leash area is about 140 acres, and the Chatfield area is 114 acres. Both Cherry Creek and Chatfield have water play areas for dogs: dogs may roam in segments of the Cherry Creek riparian area, and at Chatfield there are a few ponds in the dog play area. Although the section of the South Platte River adjacent to the Chatfield dog area is off-limits to unleashed animals, dog owners rarely appear to comply.

Off-leash areas in both parks also have un-maintained vegetation, in contrast to the smaller dog parks, which may have planted and partially maintained vegetation communities. Both Cherry Creek and Chatfield Parks had riparian and upland grassland community types within their off-leash areas.

The off-leash areas also offer more recreational opportunities for dog owners; due to their larger size and unrestricted boundaries, dog owners may run with their dogs, are more likely to exercise multiple dogs, and train dogs in activities where running or unrestricted areas are helpful (e.g.; retrieving, obedience).

Cherry Creek initiated an off-leash dog area in 1971, and Chatfield in the early 1990s. The Cherry Creek area was first used as a hunting dog training area, with live birds and live ammunition. Over the years off-leash dog use increased and conflicts between dog owners and other users increased. The dog off-leash area was eventually reduced in size, and hunting dog training was eliminated. The Chatfield off-leash area began as a dog-training area and expanded into a multi-use off-leash area. Although visitor use figures for off-leash dog areas are not available, they appear to be very popular by the number of dogs and owners observed during the field portion of this study. Dog owners in both parks remarked that the off-leash areas had become more crowded in recent years, and there is likely a trend of increasing visitor use in these areas.

There are now observable effects from dog use in off-leash areas: high intensity use areas (primarily water play areas) have low vegetation cover or bare ground. Both the banks of Cherry Creek and Chatfield pond margins appear to have accelerated erosion.

There may be additional effects from dogs on natural communities that are not visually evident. Off-leash dog areas in both parks are home to a number of species of birds and small mammals.

Dogs may directly affect these fauna by flushing, chasing, trampling, killing, transmitting disease organisms, and reducing vegetation cover. Dogs may indirectly affect birds, small mammals and other fauna by reducing energy reserves, adding additional nutrients to affected ecosystems (primarily nitrogen from urine and feces), serving as seed vectors for invasive plants, and affecting wildlife behaviors through noise and scent marking.

This study had a primary objective of assessing the effects of off-leash dog use in Cherry Creek and Chatfield State Parks on bird and small mammal communities. A second objective was to determine if there were differences in bird and small mammal relative abundance in riparian and upland grassland community types.

II. Methods

Sample selection

Sample transects were randomly selected for bird and small mammal sampling within treatment (off-leash dog areas) and control areas (on-leash dog areas). Two treatment and two control areas were selected in each park, for a total of four treatment and four control transects. Additionally, transects were evenly divided among riparian and grassland community types.

For the grassland type, a numbered grid was placed over aerial photographs of this type in both parks for treatment and control areas. A random number was chosen from the range within the grid, and the center of that grid was the starting point of the transect. A random azimuth was chosen to complete the location of the transect such that it would fit within that community type and have a buffer area of approximately 30 meters (m) from adjacent community types.

For riparian transects, each potential treatment and control sample area was divided into 1-m segments along the stream, and a random segment was selected within the range of segments for the starting point of the transect. A coin was flipped to locate the transect upstream or downstream of the starting point. The treatment riparian transects are not officially within the dog off-leash areas. However, these areas were not fenced off from dog use and were being used actively enough to consider them part of the treatment areas.

Avian sampling transects were 300 m-long, and were measured in the field with a fiberglass tape. Small mammal transects were approximately 250 m-long and were located within the avian transects.

Transect starting locations were found on an electronic topographic map (Maptech software), and coordinates were entered to a Garmin GPSmap 60CSx global position satellite (GPS) unit and located in the field. Transect locations are given in Figures 1-3.

Avian Methods

Bird data was collected from 300 m-long transects that were previously located in the field. Beginning at the 0-end, two observers traveled down the transect and tallied all bird cues (song, call, and sight) and estimated the distance from the cue to the transect line, using the methods of (Emlen 1971, 1977). Birds flying overhead that were in the transect area were also tallied. Density estimates were not adjusted for undetected birds, so the subsequent density values are likely minimal estimates of birds present in the transect area. Data were collected from each transect for 30 minutes, at an average speed of 10 m/minute. Transects were run from 0530 hours (sunrise) to 0830 on the mornings of June 6 (Cherry Creek) and June 7 (Chatfield). Weather was warm and dry during these periods.

Raw bird data were transformed into estimated density values (birds/hectare) by summing individual observation “strips” within the transect for each species, and then summing individual species density data over the transect to yield total birds/hectare. Count data were also adjusted by removing obvious species that did not breed in that habitat. For grassland types, swallows, blackbird species, bluejay, brown-headed cowbird, and ducks were removed to obtain adjusted values. For riparian areas, the western kingbird and western meadowlark were removed.

Raw counts are typically adjusted for a particular lateral distance from the center of the transect beyond which the observer fails to detect bird cues (Emlen 1977). Although efforts were made to locate transects at least 30 meters from a different community type, this was difficult given that community patches were often small with many edge associated habitats. We often did not have 30 meters of community type on each side of the transect, and generally felt that we found most of the birds present in that community type. Therefore we did not adjust data to compensate for the inflexion point where bird detection would diminish.

Bird species diversity was calculated for each transect using the Shannon-Wiener diversity index on bird density values, and species richness (total number of species present) was also determined.

Bird data were analyzed with a two way completely randomized analysis of variance (ANOVA) model, with treatment (off-leash {treatment}, on-leash {control}) and community type (riparian, grassland) factors. Models were run with several independent variables including:

- Bird density (total birds/ha)
- Adjusted bird density (total birds/ha), with appropriate species removed from transects (see above);
- Species diversity;

- Adjusted species diversity;
- Species richness; and
- Adjusted species richness.

Models were also run using park location (Cherry Creek or Chatfield) as a covariate.

Small Mammal Methods

Fifty Sherman live-traps at approximate 5-meter intervals were placed on each transect. Each park had four transects, with 200 traps deployed at each park during the exercise. Traps were baited each day with sweet horse feed (omolene). Traps were deployed on the first day of the exercise in the evening from 1700-2030 hours. They were checked for captures each morning between 0600 and 0900 hours. The following data were collected from captured small mammals: species, sex, age, reproductive and recapture conditions. Each captured animal was hair clipped to determine recapture status.

Traps were located in very exposed areas in the off-leash (treatment) areas in both parks. At Cherry Creek, traps on the treatment grassland transect (1TG) were removed from the transect each morning following data collection and replaced in the evening. At Chatfield, riparian and grassland treatment transects (2TR and 2TG respectively) were removed and replaced each day.

The trapping session at Cherry Creek was run from June 8-June 11, 2008, and the session at Chatfield from June 11 to June 14. Trapping intensity was 600 trap nights (a trap night is the equivalent of deploying 1 trap for a single night) in each park.

At the end of each trapping exercise, soiled traps were cleaned and then rinsed in a bleach solution as a precaution to minimize exposure to hantavirus.

Small mammal data were summarized by transect and standardized to animals/100 trap nights, and Shannon-Wiener diversity determined for each transect. Data were analyzed in the same manner given for the bird analysis with a two way completely randomized ANOVA model.

Figure 1. Bird and Small Mammal Sampling Locations at Cherry Creek State Park, Arapahoe County, Colorado.

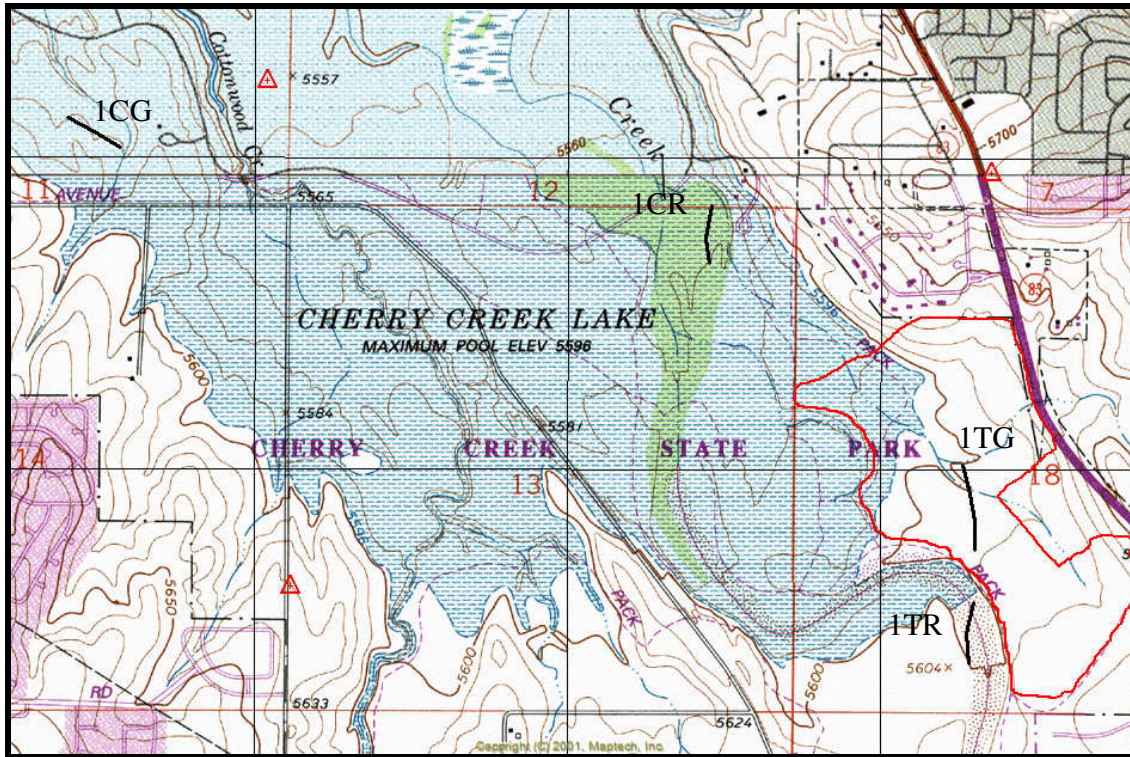


Figure 2. Bird and Small Mammal Sampling Locations at North Chatfield State Park, Arapahoe/Jefferson/Douglas Counties, Colorado.

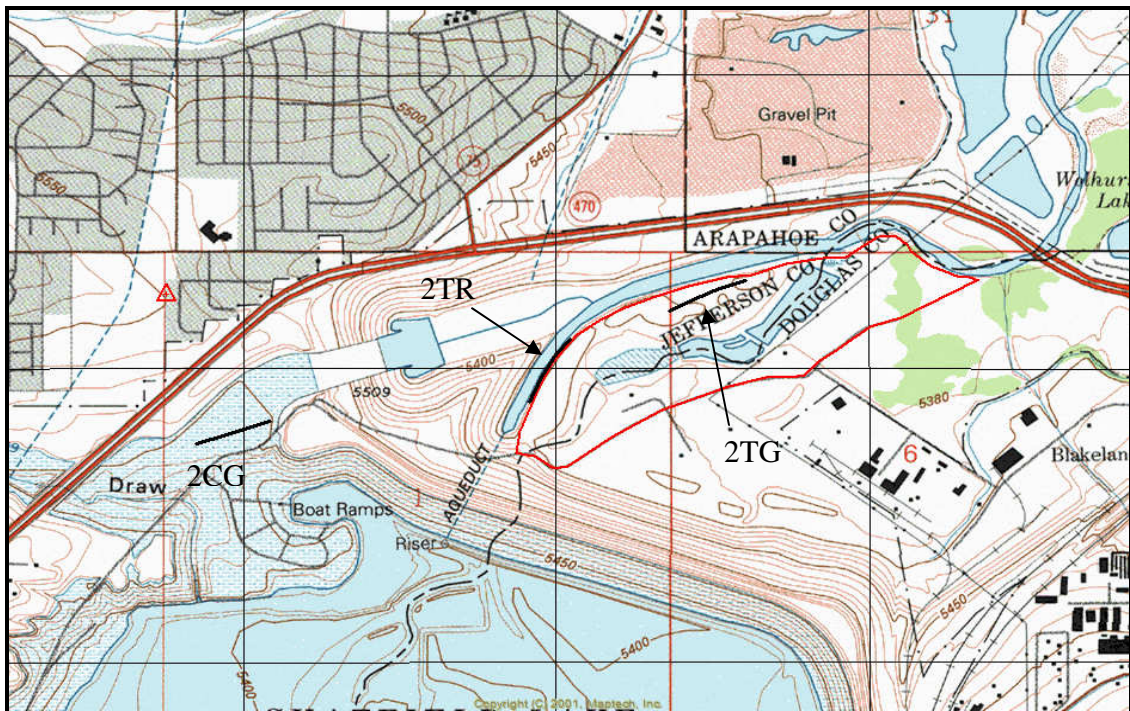
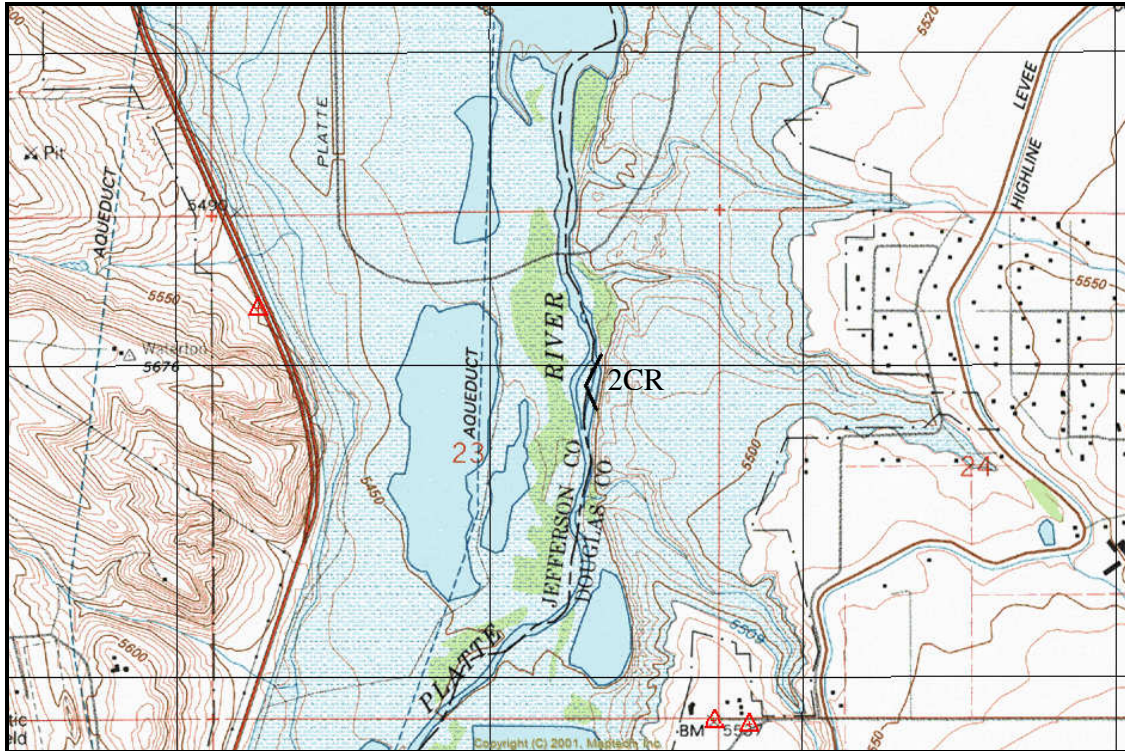


Figure 3. Bird and Small Mammal Sampling Locations at South Chatfield State Park, Douglas County, Colorado.



Legend

- 1CG Control grassland Cherry Creek State Park
- 1CR Control riparian Cherry Creek State Park
- 1TG Treatment grassland Cherry Creek State Park, dogs off-leash
- 1TR Treatment riparian Cherry Creek State Park, dogs off-leash

- 2CG Control grassland Chatfield State Park
- 2CR Control riparian Chatfield State Park
- 2TG Treatment grassland Chatfield State Park, dogs off-leash
- 2TR Treatment riparian Chatfield State Park, dogs off-leash

Red polygons in Figures 1 and 2 are dog off-leash areas.

III. Results

Transect Descriptions

A brief description is given for each transect.

Cherry Creek Control Grassland (1CG)

This transect was located just west of the model airplane field (Appendix 1, Photograph 1). It had approximately 98% graminoid cover, consisting of wheatgrass species (*Agropyron sp.*) and smooth brome (*Bromus inermis*). There was a hedge of plum shrubs (*Prunus americana*) along an intermittent stream 30-70 meters east of the transect. Residential homes are found about 0.5 mile to the west. It appeared that park visitors do not use this area often.

Cherry Creek Control Riparian (1CR)

This transect was located in a wide area (> 100 meters) of the Cherry Creek floodplain (Appendix 1, Photograph 2). Slight differences in surface topography led to small pools, saturated soils, and drier areas along the transect. Reed canary grass (*Phalaris arundinacea*) was on the edges and within standing water pools, and bulrush (*Scirpus pallidus*) and narrow-leaf cattail (*Typha angustifolia*) dominated areas with saturated soils. Approximately 80% of the area had an overstory dominated by plains cottonwood trees (*Populus deltoides*), with lesser coverage of peachleaf willow (*Salix amygdaloides*) and Russian-olive (*Elaeagnus angustifolia*). Much of the area had abundant understory plants, including patches of sandbar willow (*Salix exigua*). There were smaller openings of graminoids and forbs, including goldenrod (*Salidago sp.*) and leafy spurge (*Euphorbia esula*). Due to the wet nature of the area, lack of trails and abundant mosquitoes, visitor use here is probably very low.

Cherry Creek Treatment Grassland (1TG)

This area was heavily used by off-leash dogs and had a diversity of cover types (Appendix 1, Photograph 3). Although 90% of vegetation cover was graminoid and forb species, there were also patches of trees and shrubs. Graminoid species included thickspike wheatgrass (*Agropyron dasystachyum*), western wheatgrass (*Agropyron smithii*), crested wheatgrass (*Agropyron cristatum*), Kentucky bluegrass (*Poa praetensis*), green needlegrass (*Stipa viridula*), and cheatgrass (*Bromus tectorum*). Shrubs included snowberry (*Symphoricarpos occidentalis*), Wood's rose (*Rosa woodsii*), plum, and current (*Ribes sp.*). It was spanned by a web of dirt trails that were used by dogs/owners and horses.

Cherry Creek Treatment Riparian (1TR)

The Cherry Creek floodplain is narrower here than in the control area, with more consistent topography and more homogeneous soils. Soils here were well-drained sands with little organic matter accumulation and hardly any areas of standing water. The extensive overstory was dominated by plains cottonwood and peachleaf willow trees. Understory vegetation included willow stands with a graminoid ground layer. Creek banks were high in this area (1-2 m), with large areas of bare soil on the eastern bank where dog use had stripped the area bare (Appendix 1, Photograph 4). The north end of the transect is a popular water-play area for dogs.

Chatfield Control Grassland (2CG)

This area was probably a reseeded grassland, with vegetation cover dominated by crested wheatgrass and alfalfa (*Medicago sativa*) and yellow sweet-clover (*Melilotus officinalis*) on the edges (Appendix 1, Photograph 5). There was a small wetland surrounded by cattail on the east side of the community. This grassland was bounded on the south by the main park road, and on the north by Highway C-470. There are no trails here and no visitors were observed in this area.

Chatfield Control Riparian (2CR)

This community was located on a stretch of the South Platte River upstream of Chatfield Reservoir. A heavy canopy of mature plains cottonwood and narrowleaf cottonwood (*Populus angustifolia*) shaded much of the riverbank (Appendix 1, Photograph 6). Shrub stands of sandbar willow, snowberry, and alder were found in the understory, as well as large vine patches of grape (*Vitis sp.*), Virginia creeper (*Parthenocissus quinquefolia*), and poison ivy (*Toxicodendron rydbergii*). There were a few backwater pools created by beaver activity, and recently cut beaver trees were observed in a few locations. The community to the east was an upland grassland with large patches of rabbitbrush (*Chrysothamnus nauseosus*). Fishermen use a network of social trails on this section of the river, and there is also a paved handicapped trail just south of the main park road.

Chatfield Treatment Grassland (2TG)

This narrow strip of grassland was highly disturbed, with cheatgrass being the most prominent graminoid (Appendix 1, Photograph 7). Other herbaceous plants included bull thistle (*Carduus nutans*), morning glory (*Convolvulus arvensis*), alfalfa (*Medicago sativa*), and alyssum (*Alyssum minus*). Much of the off-leash dog area was in small grassland areas or more commonly, grasslands mixed with trees and shrubs. Although this area was highly disturbed, we observed most dog owners using the trails adjacent to the grassland.

Chatfield Treatment Riparian (2TR)

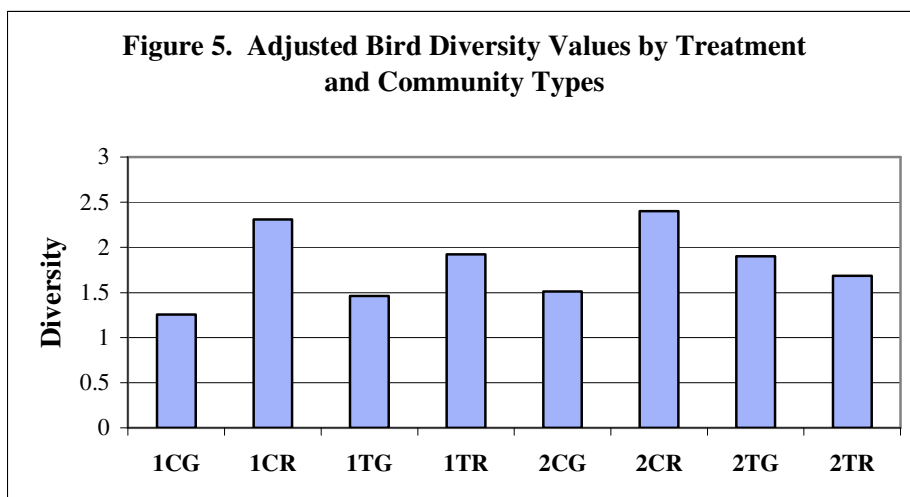
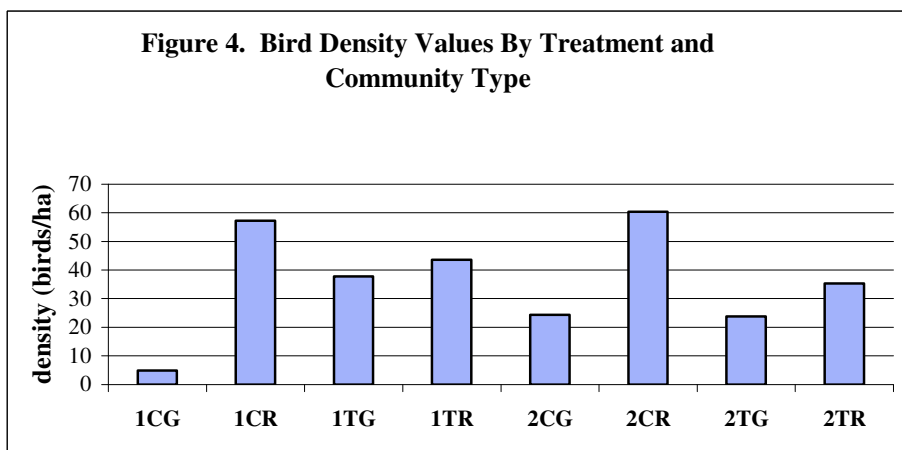
This transect was on the south side of the South Platte River after it had emerged through the Chatfield Reservoir Dam (Appendix 1, Photograph 8). The riparian zone was 20-30 m wide on the south side and about 8 m wide on the north, with a steep bank on the north side downslope from Highway C-470. Stream banks were lined with rip-rap and Russian-olive, Siberian elm (*Ulmus pumila*) and plains cottonwood trees. Understory vegetation included sandbar willow and sparse graminoids. A popular social trail used by dog and owners ran parallel to the stream.

Bird Survey Results

A total of 49 bird species were found at both parks (Appendix 2). During data collection at the transects, 27 species were found at Cherry Creek and 31 species at Chatfield Park respectively. An additional 5 other species were detected on or near the transects but not during the data collection exercises.

The most frequently occurring bird was the American robin (*Turdus migratorius*), which was found on all eight transects. The brown-headed cowbird (*Molothrus ater*) was found on six transects, and the yellow warbler (*Dendroica petechia*) and western meadowlark (*Sturnella neglecta*) were found on five transects. Twenty-one bird species were only detected on a single transect.

Total bird density ranged from a low of 4.9 birds/ha in the Cherry Creek Treatment grassland (1TG), to a high of 60.3 birds/ha in the Chatfield Control riparian area (2CR, see Figure 4).



Legend, Figures 4 and 5

1CG Control grassland Cherry Creek State Park, 1CR Control riparian Cherry Creek State Park, 1TG Treatment grassland Cherry Creek State Park, dogs off-leash, 1TR Treatment riparian Cherry Creek State Park, dogs off-leash

2CG Control grassland Chatfield State Park, 2CR Control riparian Chatfield State Park, 2TG Treatment grassland Chatfield State Park, dogs off-leash, 2TR Treatment riparian Chatfield State Park, dogs off-leash

Bird diversity values represent both the total species present and the number of individuals detected. The Cherry Creek Control Grassland had the lowest bird diversity with a value of 1.26. Three transects had very similar values for the high end of the diversity range: Cherry Creek Control Riparian (2.31), Chatfield Control Riparian (2.40) and Chatfield Treatment Grassland (2.38).

When the diversity values were adjusted by removing non-resident birds from the transect data (Figure 5), the riparian areas generally had the highest diversity values.

Bird density and diversity values (both unadjusted and adjusted) were analyzed in a two factor completely randomized ANOVA model. All models were tested at an alpha level of 0.5 ($\alpha = 0.5$). This tested both the treatment effect (off-leash dog area versus on-leash dog areas) and the community effect (are there differences in bird abundance in grassland and riparian areas).

Table 1 shows results for the model run with bird density. Community type was statistically significant (mean riparian density \neq mean grassland density), the treatment effect was not significant (mean dog off-leash area density = mean dog on-leash area density), and the interaction between treatment and community type was significant. In this case, a significant interaction term indicates that a different relationship exists among treatment and control means depending on whether you are looking at grassland or riparian communities. This result was typical for the various other independent variables that were analyzed (diversity, richness, etc.), where almost all models had a significant treatment x community interaction effects. The covariate of park (Cherry Creek/Chatfield) was not found to be significant in any model.

When the interaction term is significant, the model must be broken down into simple effects; the treatment effect must be evaluated separately for riparian and grassland communities, and the community effect must be evaluated separately for treatment and control areas. These comparisons were done with a series of t-tests, after the variances were tested for equality.

Bird density and diversity were significantly affected in dog-off leash areas, but only in riparian areas. Mean control riparian bird density was significantly greater (1.7x greater) than in dog-off leash areas (mean control riparian density was 58.78 birds/ha; mean dog-off area riparian density was 34.72 birds/ha), with a p-value of 0.0488. Control riparian bird diversity was also significantly greater than dog-off area riparian diversity (control riparian diversity = 2.357, dog-off riparian diversity = 1.948, $p = 0.0161$). There was not a significant treatment effect for grassland bird density or diversity.

There was also a community effect, but only in control areas. Bird density in control riparian areas was much greater than in control grassland areas (mean adjusted control riparian density = 58.78 birds/ha, and mean adjusted control grassland density = 13.5 birds/ha, $p = 0.354$). Although riparian treatment adjusted bird density (32.95 birds/ha) was greater than grassland treatment sites (21.0 birds/ha), the effect was not statistically significant.

Table 1. Two Factor Analysis of Variance of Bird Density by Treatment and Community Type.

Source		Degrees of freedom	Type III SS	Mean Square	F value	p-value
Main Effects						
	Treatment (dog-off, dog-on)	1	5.198263035	5.198263	0.0636801	0.8132
	Community Type (riparian, grassland)	1	1392.6391	1392.6391	17.060202	0.0145*
Interaction						
	Treatment x Community	1	632.0233899	632.02339	7.7424555	0.0497*
Error		4	326.5234865	81.630872		
Total		7	2356.384271			

* denotes statistical significance at $\alpha = 0.05$. The significant treatment x community interaction term here indicates that these factors must be analyzed by each factor level

Small Mammal Live-Trapping Results

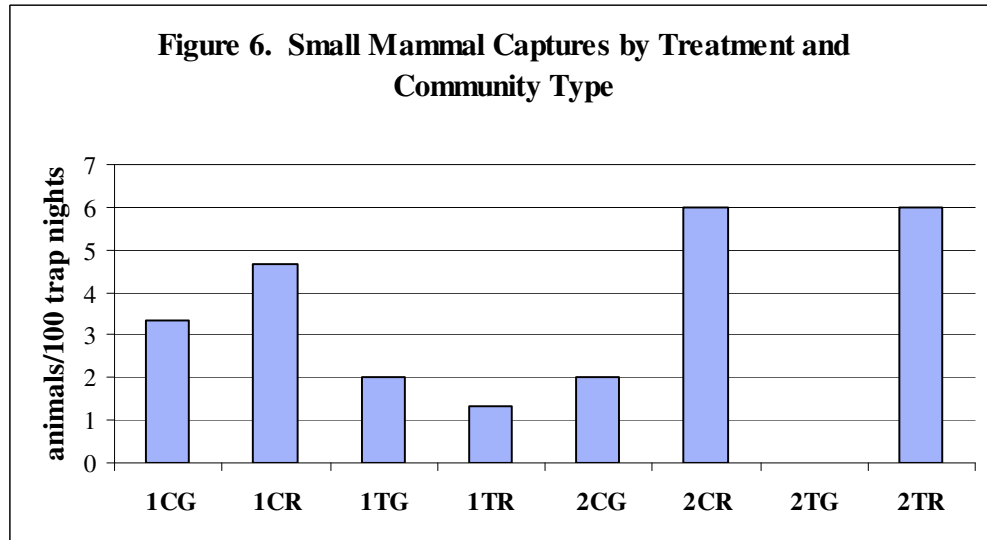
There was a total of 45 captures of 38 individual small mammals of five species captured in both parks during the survey period. The most frequently captured small mammal was the deer mouse (*Peromyscus maniculatus*, 42% of captures, recaptures not included), followed by the western harvest mouse (*Reithrodontomys megalotis*, 26.3%), Mexican wood rat (*Neotoma mexicana*, 13%), meadow vole (*Microtus pennsylvanicus*, 10.5%), and the prairie vole (*Microtus ochrogaster* 7.9%).

The overall capture rate was 3.75% (45 captures in 1200 trap-nights), which is very low for both grassland and riparian habitat in the Colorado Front Range.

Two transects had three species of small mammals captured, two transects had two species, three transects had one species, and one transect (Chatfield treatment grassland {2TG}) had no small mammal captures.

Small mammal abundance was standardized to captures/100 trap-nights; data analysis was performed on total minimum number of animals alive (recaptured animals excluded from data analysis). Shannon-Wiener diversity was determined for each transect. For transects with no captures or capture of a single species, the diversity value was 0.

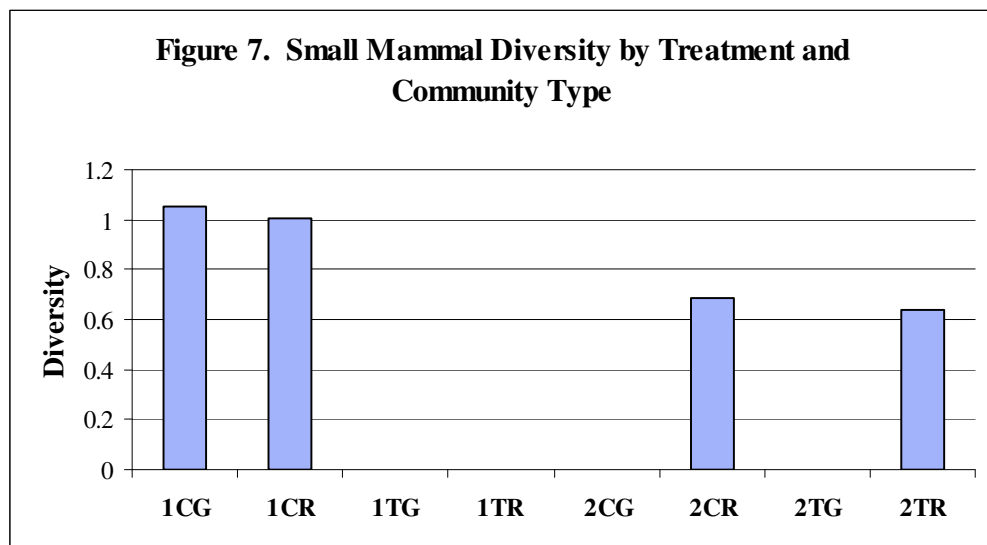
Both the treatment and control riparian community types in Chatfield Park had the highest capture rates of any transects (6 total captures/100 trap nights, Figure 6). The treatment grassland transect in Chatfield (2TG) had no small mammal captures. The control grassland and riparian transects at Cherry Creek had the highest diversity values, primarily because they had more species recorded (3) than the other sample transects.



Legend, Figures 6 and 7

1CG Control grassland Cherry Creek State Park, 1CR Control riparian Cherry Creek State Park, 1TG Treatment grassland Cherry Creek State Park, dogs off-leash, 1TR Treatment riparian Cherry Creek State Park, dogs off-leash

2CG Control grassland Chatfield State Park, 2CR Control riparian Chatfield State Park, 2TG Treatment grassland Chatfield State Park, dogs off-leash, 2TR Treatment riparian Chatfield State Park, dogs off-leash



Total small mammal captures and small mammal diversity were analyzed in a two factor completely randomized ANOVA model as before with bird data. All models were tested at an alpha level of 0.5 ($\alpha = 0.5$).

Mean total small mammal abundance was higher in on-leash (control) areas than off-leash areas (treatment); (Control 4.0 small mammals/100 trap nights, Treatment 2.3), but the difference was not statistically significant (Table 2). Riparian small mammal abundance was higher than in grassland communities (Riparian 4.5 small mammals/100

trap nights, Grassland 1.8), but again, the difference was not statistically significant (Table 2).

These same patterns were found for small mammal diversity (higher diversity for control and riparian effects) but these differences were also not statistically significant.

Table 2. Two-Factor Analysis of Variance of Small Mammal Abundance by Treatment and Community Type.

Source		Degrees of freedom	Type III SS	Mean Square	F value	p-value
Main Effects						
	Treatment (dog-off, dog-on)	1	5.551112	5.551112	1.5132491	0.2860
	Community Type (riparian, grassland)	1	14.231113	14.231113	3.8794423	0.1202
Interaction						
	Treatment x Community	1	1.25e-5	1.25e-5	3.4075e-6	0.9986
Error		4	14.673359	3.6683398		
Total		7	34.455596			

* denotes statistical significance at $\alpha = 0.05$

IV. Discussion

It is estimated that dogs are now found in 37% of U.S. households (AVMA, 2008). Using a general model by the American Veterinary Medical Association (2008) and population estimates for the Denver Metropolitan area (Denver, Arapahoe, Douglas, Jefferson and Broomfield Counties, U.S. Census Bureau, 2008), there are an estimated 295,000 dogs in the Denver Metropolitan area.

Dog use in parks and open space has become an increasingly important management issue for park managers. There is growing pressure to open new areas to dogs, and more dog owners are calling for off-leash areas where dogs can exercise, play, and be trained. At the same time, there has been increasing awareness that dogs have impacts on other human visitors and park wildlife.

Dog effects on wildlife were first studied in the 1950s, in areas where feral and free-roaming dog were thought to prey on white-tailed deer (*Odocoileus virginianus*, Sime, 1999). Dog effects on ungulates continued to be a major focus of this research. Sime

(1999) believes that generalized effects of human outdoor recreation on wildlife species can be extended to humans with dogs. In the case of ungulates, most species seem to be more affected by humans approaching on foot than in vehicles.

In more recent studies, dog effects on birds, disease transmission to wildlife, small mammals, carnivores and other receptors have been studied. Many of these investigations looked at target species in generalized recreation areas, but have not differentiated between off-leash and on-leash dogs.

Several more recent studies have looked at on-leash/off-leash differences in animal populations. Bekoff and Meaney (1997) examined the attitudes of people that use off-leash dog areas and found that about 50% of dog owners and non-dog owners generally agree that people cause more environmental impacts than do dogs. However, they did not look at specific wildlife or other impacts in their study area.

Lenth et al. (2006) looked at off-leash dog effects on mule deer (*Odocoileus hemionus*), rabbit (*Sylvilagus spp.*), black-tailed prairie dog (*Cynomys ludovicianus*), carnivore, and small mammal relative abundance along Boulder County Open Space trails in Colorado by examining scats/pellet counts, track plates, and remote triggered camera images. They found lower rabbit and deer activity within 100 m of the trail, and small mammal activity was lower from 5-50 m from the trail. They also found that dogs would wander up to 85 m off-trail.

Forrest and St. Clair (2006) examined direct counts of birds/small mammals and subsequent diversity indices in three off-leash and on-leash communities (coniferous forest, deciduous forest and meadow). They found that bird diversity differed by habitat, but not by dog on or off-leash area.

In this study, we examined direct counts of birds and small mammals in off and on-leash areas at two state parks. Our data were collected from a short period during the growing season (one day of bird sampling and three days of small mammals sampling at each park). Data were collected from grassland and riparian habitat types.

We did not find a common treatment effect for all habitats. Bird density and diversity were significantly lower only in riparian off-leash areas than in on-leash areas. But the reverse was found in grassland habitats: off-leash grasslands had more than 2x the bird density than on-leash grasslands, although differences in diversity were not so extensive. This suggests that off-leash dogs affect bird populations by varying mechanisms in different habitats.

Our observations were that although dogs and owners tend to stick to trails, they are more likely to disperse off-trail in grassland than in riparian habitats. We observed this tendency in both parks. Riparian habitats often have areas that make travel difficult for humans, including wet spots and areas with thick vegetation. At both parks, dog use in riparian habitats was concentrated within 10 m of the water line, with visual effects on vegetation cover (Appendix 1, Photograph 4), potentially explaining why the treatment

effect was only found in riparian habitats. This human/dog use concentration effect appeared to cause a reduction in riparian bird density.

Meaney et al. (2002) looked at trail effects on small mammals in Colorado and found that human and dog use in a riparian corridor was much higher on the trail side of a stream than the non-trail side (3958 human visitors, 619 dogs on trail side; 14 human visitors, 15 dogs on non-trail side).

Bird density and diversity may be affected by other mechanisms in grassland habitats that have off-leash dogs. Adjusted mean bird density in off-leash areas was higher than in on-leash areas (21.0 birds/ha off-leash areas, 13.5 birds/ha on-leash). These habitats were generally more disturbed than riparian sites and potentially had more niches for a greater variety of birds to occupy. Both off-leash grassland areas had considerable variation in baseline conditions: Cherry Creek off-leash grassland was larger than Chatfield, did not have uniform vegetation (more shrub and tree cover), was used by horseback riders with an adjacent stable (which attracts some bird species), and was generally farther from riparian off-leash areas.

Riparian habitats are generally thought to harbor the greatest density and diversity of birds in Colorado. Our data supported this trend, with riparian mean adjusted bird density greater than grassland in both control and treatment areas, although the effect was only statistically significant at control sites ($p=0.354$). These community differences are not as apparent at the treatment areas, possibly suggesting that grassland and riparian bird habitats are becoming more homogenized by off-leash dog use.

There were several notable results from the small mammal analysis.

- Small mammal relative abundance was unusually low, ranging from 0-6 animals/100 trap-nights for the eight transects, with a mean of 3.2 animals/100 trap-nights. In comparison, Meaney et al. (2002) sampled riparian transects for three years and averaged 10.9 animals/100 trap-nights in areas with or without trails. The 3.75% capture rate in this study suggests that both parks have very low numbers of small mammals in these habitats. Small mammal community abundance can be depressed by drought conditions over large areas, but we did not encounter this condition during the study;
- Voles (both prairie vole and meadow vole) are common small mammals in both grassland and riparian habitats in the Colorado Front Range. The capture of 7 voles in 1200 trap-nights is extremely low. No voles were captured at Chatfield, although they almost certainly reside there;
- Other small mammals that might be found at these parks but were not captured include the masked shrew (*Sorex cinereus*), hispid pocket mouse (*Chaetodipus hispidus*), northern pocket gopher (*Thomomys talpoides*), Ord's kangaroo rat (*Dipodomys ordii*), and long-tailed vole (*Microtus longicaudus*). The Preble's meadow jumping mouse (*Zapus hudsonius preblei*) was probably found in the Cherry Creek Park area before the dam and reservoir were built; it is still known from very small populations on Cherry Creek near the town of Parker. Preble's

meadow jumping mouse is known to reside in Chatfield on both the South Platte River and Plum Creek in very small numbers, but none were captured during this survey;

- The deer mouse, a habitat generalist, was the most frequently found small mammal, and this result is common in the Front Range. It was live-trapped in both riparian and grassland habitats and dominated the rip-rapped bank of the Chatfield riparian treatment transect;
- No exotic small mammals were captured at either park. This was somewhat of a surprise, given the disturbed nature of some of the transects and the proximity to residential structures, trash dumpsters, and a horse stable at Cherry Creek. I would not have been surprised if the introduced Norway rat (*Rattus norvegicus*) and/or the house mouse (*Mus musculus*) had been found; and
- The lack of small mammal captures in the treatment grassland at Chatfield Park was not surprising; grass height was generally < 15 centimeters (6 inches), and there was simply not enough cover for small mammals to survive here.

Small mammal relative abundance followed the patterns that were initially hypothesized: on-leash area mean abundance (4.0 small mammals/100 trap-nights) was greater than off-leash abundance (2.3 small mammals/100 trap-nights), and the riparian treatment mean (4.5 small mammals/100 trap-nights) was greater than the grassland mean (1.8 small mammals/100 trap-nights). However, none of these effects was statistically significant, primarily due to the high sampling variation associated with these means. Additional sampling would increase the power of the test and reduce the sampling variation.

Finally, this study should be viewed as an initial and minimal effort to evaluate effects from off-leash dogs on two community types. Initial information was provided on off-leash and on-leash dog areas and basic community types. Additional information on plant community structure and composition, floodplain characteristics, presence of nearby anthropogenic structures (e.g. roads and houses), and human and dog use visitation could help stratify sampling and reduce the variation among sample populations, allowing greater power to detect differences.

V. Recommendations

It appears that dog use in the off-leash areas is likely to increase, and increased impacts to off-leash area natural resources might be expected. A series of recommendations follows that are outcomes of the data presented here.

- If dog areas become an important management issue in the future, monitoring human/dog visitations and user needs and expectations may be in order. Knowledge of human/dog use intensity may help explain effects on natural communities.

- Grassland off-leash areas appear to be more resilient to effects of dogs than riparian off-leash areas, as measured by bird populations. If resources must be differentially allocated for mitigation measures, riparian areas should be treated first.
- There are several potential mitigation treatments for riparian areas. They include closing them to dogs, fencing sensitive areas, or providing controlled access with slope stability measures. Riparian play areas appeared to be very popular with both dogs and owners, and closing these areas would probably be unpopular. However seasonal closures, especially during the breeding bird period, could be considered. A combination of protective fencing, revegetation, seasonal closures or controlled access, and bank stabilization structures with permeable paving could provide more stability for these areas.
- Additional studies on bird and small mammal populations related to dog effects/mitigation could be warranted if more detailed information on this issue is required.
- General monitoring of park natural communities (e.g. small mammals and birds) can provide baseline ecological information. Future changes to these communities can then be compared to baseline conditions.

VI. Summary

Off-leash dog areas are very popular in Cherry Creek and Chatfield Parks. However, there is concern that this use may adversely affect park natural resources. We conducted a preliminary study to assess the potential effects of off-leash dog areas on bird and small mammal relative abundance in both parks. Bird and small mammal transects were randomly located in off-leash and on-leash dog areas in both riparian and grassland communities in both parks. Bird and small mammal relative abundance and diversity were assessed in these habitats in June 2008, and data were analyzed in a two-factor analysis of variance statistical model.

We found a statistically significant effect of lower riparian bird density/diversity in off-leash dog areas than in on-leash dog areas. Grassland habitats with off-leash dog areas had higher bird density than on-leash grassland areas, but this effect was not statistically significant.

We also found that riparian bird density/diversity was significantly higher than grassland bird density in on-leash areas as expected; it was also higher in riparian off-leash areas, but the effect was not statistically significant.

Small mammal captures were very low in both parks. Although we found the expected relationships of on-leash riparian areas having higher relative abundance values than off-

leash areas, and riparian areas having higher values than grassland areas, none of these effects were statistically significant.

We discuss reasons why riparian and grassland fauna may show different responses to off-leash dogs, and potential strategies that might be employed to mitigate adverse effects.

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Appendix 1. Photographs of Sample Transects at Cherry Creek and Chatfield State Parks.



Photograph 1. This control grassland in Cherry Creek SP had extensive graminoid cover and had residential homes and a model airplane field on its boundaries. 6/9/08.



Photograph 2. This control riparian community in Cherry Creek SP had a cottonwood tree canopy and variable soil conditions with pooled and ponded water. 6/9/08.



Photograph 3. This control treatment grassland had patches of alfalfa, snowberry, rose and cottonwood. It was heavily used by dogs and owners. 6/9/08.



Photograph 4. The Cherry Creek riparian treatment area had extensive areas of bare ground on the stream banks and edges. 6/9/08.



Photograph 5. This control grassland in Chatfield SP was probably seeded with alfalfa and crested wheatgrass. 6/13/08.



Photograph 6. This control riparian area in Chatfield SP borders the South Platte River and has a mature tree overstory and a shrub/graminoid understory. 6/13/08.



Photograph 7. This treatment grassland in Chatfield SP was highly disturbed with cheatgrass and other weed species prevalent. 6/13/08.



Photograph 8. This narrow riparian corridor in the Chatfield SP treatment area was lined with cottonwood and Russian-olive trees. 6/13/08.

Appendix 2. Bird Species Found on and Nearby Transects at Cherry Creek and Chatfield State Parks

Common Name	Scientific Name	Transect								Other
		1CG	1CR	1TG	1TR	2CG	2CR	2TG	2TR	
Sora	<i>Porzana carolina</i>									x
American White Pelican	<i>Pelecanus erythrorhynchos</i>									x
Double-crested cormorant	<i>Phalacrocorax auritus</i>						x		x	
Common Merganser	<i>Mergus merganser</i>								x	
Great Blue Heron	<i>Ardea herodias</i>				x		x			
Canada Goose	<i>Canada Goose</i>									
Green-Winged Teal	<i>Anas crecca</i>							x		
Mallard	<i>Anas platyrhynchos</i>		x					x	x	
Swainson's Hawk	<i>Buteo swainsoni</i>									x
Red Tailed Hawk	<i>Buteo jamaicensis</i>									x
Ring-necked Pheasant	<i>Phasianus colchicus</i>	x			x					
Killdeer	<i>Charadrius vociferus</i>	x				x				
Mourning Dove	<i>Zenaida macroura</i>	x	x					x	x	
Rock Dove, Common Pigeon	<i>Columba livia</i>									x
Great Horned Owl	<i>Bubo virginianus</i>				x					
Broad-tailed Hummingbird:	<i>Selasphorus platycercus</i>						x			
Hairy Woodpecker	<i>Picoides villosus</i>						x			
Northern Flicker	<i>Colaptes auratus</i>									x
Western Wood-Pewee	<i>Contopus sordidulus</i>		x		x		x			
Western Kingbird	<i>Tyrannus verticalis</i>	x		x					x	
Warbling vireo	<i>Vireo gilvus</i>						x			

Appendix 2 cont'd

Common Name	Scientific Name	Transect								Other
		1CG	1CR	1TG	1TR	2CG	2CR	2TG	2TR	
Blue Jay	<i>Cyanocitta cristata</i>			x						
Black-billed Magpie	<i>Pica hudsonia</i>	x					x			
American Crow	<i>Corvus brachyrhynchos</i>						x			
Northern Rough-winged Swallow	<i>Stelgidopteryx serripennis</i>						x			
Cliff Swallow	<i>Petrochelidon pyrrhonota</i>	x				x	x		x	
Barn Swallow	<i>Hirundo rustica</i>	x								
Tree Swallow	<i>Tachycineta bicolor</i>									x
Black-capped Chickadee	<i>Poecile atricapilla</i>		x				x			
House Wren	<i>Troglodytes aedon</i>		x		x		x			
Rock Wren	<i>Salpinctes obsoletus</i>									x
American Robin	<i>Turdus migratorious</i>	x	x	x	x	x	x	x	x	
Gray Catbird	<i>Dumetella carolinensis</i>									x
European Starling	<i>Sturnus vulgaris</i>	x			x			x		
Yellow Warbler	<i>Dendroica petechia</i>		x	x	x		x	x		
Yellow-rumped Warbler	<i>Dendroica coronata</i>						x			
Common Yellowthroat	<i>Geothlypis trichas</i>		x							
Yellow-breasted Chat	<i>Icteria virens</i>						x			
Grasshopper Sparrow	<i>Ammodramus savannarum</i>	x								
Song Sparrow	<i>Melospiza melodia</i>		x			x	x		x	
Bullock's Oriole	<i>Icterus bullockii</i>		x					x		
Western Meadowlark	<i>Sturnella neglecta</i>	x		x		x		x	x	
Red-winged Blackbird	<i>Agelaius phoeniceus</i>	x	x			x		x		
Yellow-headed Blackbird	<i>Xanthocephalus xanthocephalus</i>		x							

Appendix 2 cont'd

Common Name	Scientific Name	Transect								
		1CG	1CR	1TG	1TR	2CG	2CR	2TG	2TR	Other
Brewer's Blackbird	<i>Euphagus cyanocephalus</i>	x		x	x			x	x	
Common Grackle	<i>Quiscalus quiscula</i>								x	
Brown-headed Cowbird	<i>Molothrus ater</i>		x		x	x	x	x	x	
House Finch	<i>Carpodacus mexicanus</i>			x						
American Goldfinch	<i>Carduelis tristis</i>		x	x	x		x	x		

1CG Control grassland Cherry Creek State Park

1CR Control riparian Cherry Creek State Park

1TG Treatment grassland Cherry Creek State Park, dogs off-leash

1TR Treatment riparian Cherry Creek State Park, dogs off-leash

2CG Control grassland Chatfield State Park

2CR Control riparian Chatfield State Park

2TG Treatment grassland Chatfield State Park, dogs off-leash

2TR Treatment riparian Chatfield State Park, dogs off-leash

Other: indicates birds seen near or on transects but not during data collection