OCCASIONAL PAPERS

Museum of Texas Tech University

Number 221 19 May 2003

HABITAT USE BY BIRDS AND MAMMALS ALONG THE URBAN SOUTH PLATTE RIVER IN DENVER, COLORADO

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INTRODUCTION

Fewer studies of vertebrates have been conducted in urban areas than on sites in more natural conditions. One urban area that has received little scientific attention is the stretch of the South Platte River passing through Denver, Denver County, Colorado. The South Platte played a key role in American history because it is located in the arid shortgrass steppe of the western United States. In this steppe characterized by extremes in temperature and precipitation, the South Platte has have long provided water, shelter, food, and travel corridors for people and for wildlife.

The South Platte rivershed covers more than 8,878 km^2 (23,000 mi^2), of which 79% is in Colorado (U.S. EPA, 1999). Ute, Comanche, Arapaho, and Cheyenne used this watershed long before the arrival of settlers from Mexico and the United States. The first European settlements included fur-trading posts and forts (U.S. EPA, 1999). The earliest known European-Mexican settlement in the Denver area was the short-lived Mexican Diggings, established in 1857. Modern Denver grew from the small towns of Saint Charles and Auraria, founded in 1858 near the confluence of the South Platte and Cherry Creek (Jones and Forrest, 1973; Noel, 1980; Kirkpatrick, 1998). Anthropogenic changes accompanying European settlement included the construction of canals, producing a system that presently delivers water to 29 cities and towns, 120 ditch companies, 60 reservoir companies, and 620,000 acres of irrigated farmland (U.S. EPA, 1999). As in most cities, water also provided avenues for transportation and waste disposal, leading to the establishment of railyards and industry along the river. Floods have occurred periodically, including major events in Denver in 1864 and 1965 (Meister, 1965; Brenneman, 1973; Jones and Forrest, 1973; U.S. EPA, 1999; Chapman, 2001). Human and economic losses resulting from these floods led to the establishment of reservoirs such as Chatfield (H. E. Kingery, pers. comm., 2001) and water-management projects, which have greatly altered the water flow and biotic communities of the South Platte (Johnson, 1994).

Denver County lies within the Front Range of Colorado, an area in which the human population has expanded from 2,694,000 in 1990 to 3,512,779 in 2000 (Colorado State Demographer, 2000 Census, www.dlg.oem2.state.co.us). Approximately 16 km of the South Platte pass through modern Denver, where it remains a center of activity, serving as a major focus of economic and residential development. Additionally, the river and its associated urban parks are important recreational resources for bikers, walkers, kayakers, and others (e.g., Muntz and Wuth, 1983; Hekkers, 1987; Cooper et al., 1990; Kirkpatrick, 1998; Moorhead, 1992).

In recognition of the river's importance to local residents and wildlife, Mayor William McNichols created the Platte River Development Commission in the late 1970s (Chapman, 2001). Mayor Wellington Webb assembled the South Platte River Working Group in 1994 to address improvements to the urban corridor as a major issue during his tenure (Mayor's South Platte River Commission, 1995; Instream Issues Task Force, 1996; City and County of Denver, 2000). Subsequent improvements of recreational trails (40 km, or 25 miles, along the Platte, Cherry Creek, Bear Creek, Highline Canal, and Sand Creek) resulted in one of the best greenway systems in the United States (Shuster, 1996; Anonymous, 1998; U.S. EPA, 1999). Clean-up programs, economic development, and other activities received public recognition in various publications (e.g., Miller, 1996; Anonymous, 1997, 1998; Walker, 1997; Brovsky, 1999), the 1997 American Rivers Gold Medal for Urban River Partnership, and the 1999 National Wildlife Federation Conservation Achievement Award (Alston, 1999).

However, most resource analyses of the urban corridor have concentrated on fish, hydrology, and water quality (Instream Issues Task Force, 1996; Kimbrough and Litke, 1996). Some surveys of wildlife have been conducted within the metropolitan area, but the most detailed studies of birds and mammals associated with the South Platte River have been conducted in rural Colorado (Mitchell, 1972; Fitzgerald, 1978; Olson and Knopf, 1988). Thus the potential of the urban South Platte as wildlife habitat has remained largely unexplored.

Some of the surveys along the urban South Platte include Audubon bird counts and the Urban Denver Christmas Bird Count conducted since 1988 (H. E. Kingery, pers. comm., 1999). On 1 January 2000, for the 1999-2000 Christmas Bird Count period, 56 species and 8,896 individuals were recorded along the river. Of that total, 25% were Canada geese and 25% were starlings (Kingery, 2000; please see Appendix A for taxa reported in our study), and three new species (the ruddy duck [*Oxyura jamaicensis*], mew gull [*Larus canus*], and red-shouldered hawk [*Buteo lineatus*]) were added. Thompson (1994) monitored wildlife on a 16-acre wetland-mitigation area adjacent to the river. Thirty-four avian species were reported, 70% of which were red-winged blackbirds (*Agelaius phoeniceus*), barn swallows (*Hirundo rustica*), black-billed magpies (*Pica pica*), common grackles (*Quiscalus quiscula*), mallards (*Anas platyrhynchos*), starlings, and Canada geese.

Several short-term, local surveys of mammals also were conducted. Brittan (1992) briefly surveyed small mammals in South Platte Park, capturing deer mice (*Peromyscus maniculatus*) and meadow voles (*Microtus pennsylvanicus*). Erickson (1982) documented 11 species of mammals along the South Platte Greenway: the eastern cottontail (*Sylvilagus floridanus*), fox squirrel (*Sciurus niger*), American beaver (*Castor canadensis*), western harvest mouse (*Reithrodontomys megalotis*), Norway rat (*Rattus norvegicus*), house mouse (*Mus musculus*), meadow vole (*M. pennsylvanicus*), muskrat (*Ondatra zibethicus*), meadow jumping mouse (*Zapus hudsonicus sic*), domestic dog (*Canis*), and domestic cat (*Felis*). Grimes and Beane (1984) assessed damage caused by beavers. Thompson (1994) caught house mice, western harvest mice, meadow voles, and fox squirrels in 240 trapnights (house mice represented 83% of the individuals captured), and also saw cottontails, muskrats, and beavers.

The purpose of our study was to document the presence and habitat use of birds and mammals in the first year-round, systematic survey of the South Platte urban corridor. We assessed how avian and mammalian species composition differed among different plant communities and compared the faunas with those re-

ported from other urban sites in the Denver area. We selected six permanent study areas in order to establish benchmarks for long-term study, to facilitate repeatable surveys in the future, and to allow establishment of "living laboratories" where citizens can learn about riparian ecology. Results will allow optimization of human use of the river while minimizing negative impacts on wildlife.

MATERIALS AND METHODS

Major plant communities along the Platte consist primarily of cottonwood (*Populus deltoides*), elms (*Ulmus americanus* and *U. pumilus*), native grasses (including areas reseeded to native species), exotic grasses (mostly Kentucky bluegrass, *Poa pratensis*), weeds, and "other," all in patches of various sizes (Instream Issues Task Force, 1996). General predictions can be made regarding the importance of some of these communities to wildlife (e.g., Bottorff, 1974). We chose not to sample the fauna in proportion to the representation of the various plant communities, which are being changed through restoration and other activities. It was difficult to find sites sufficiently large and continuous for sampling, due to the fragmentation of both native and non-native vegetation resulting from channelization, bank stabilization with riprap, and other extensive alterations. We chose six sites (Figure 1) so as to have two transects per site, with each site representing one of six community types (mesic, restored mesic, riparian woodland, non-native grassland, semi-native grassland, and urban pond):

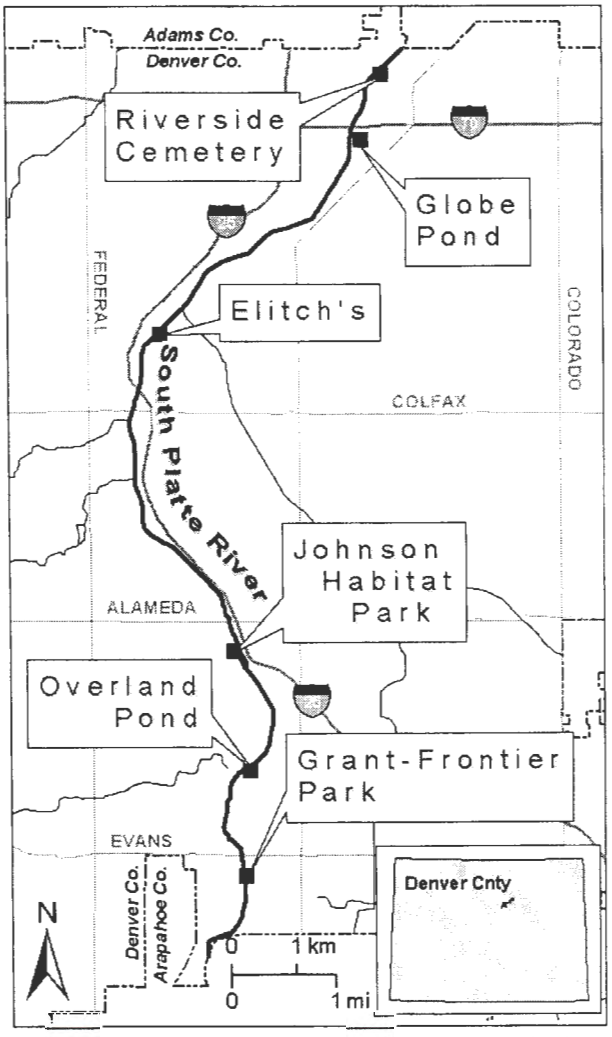

Figure 1. The six study sites along the urban South Platte River in Denver County, Colorado. Map by Adrian Kropp.

Mesic community type, Riverside Cemetery: Our study site in mesic lowland is located downhill from a 145-acre cemetery that was established in 1876 (Kirkpatrick, 1998); the opposite bank is occupied by industry. The study site, partially coinciding with that used by Thompson (1994), is dominated by sandbar willow (*Salix exigua*), smooth brome (*Bromus inermis*), and sand dropseed (*Sporobolus cryptandrus*). Various trees include hawthorn (*Crataegus erythropoda*), Siberian elm, and cottonwoods. Most of the herbaceous vegetation is the result of a wetland restoration project conducted in 1993 (Thompson, 1994).

Restored mesic community type, Elitch Gardens: This site is an urban park adjacent to Six Flags Elitch Gardens Amusement Park, upstream of where Auraria was founded in 1858 (Jones and Forrest, 1973; Kirkpatrick, 1998). The community includes sandbar willow, mustards (*Brassica* sp.), and dandelions (*Taraxacum officinale*), dominated by smooth brome (*B. inermis*) and other grasses. Saplings (*Populus* and

Ulmus) were planted at this site; there are no large trees, unlike the mesic community at Riverside Cemetery.

Riparian woodland community type, Grant-Frontier Park: An urban park (primarily planted to *P. pratensis*), a residential area, and industrial sites surround this small woodland. Most trees represent Siberian elm, with other conspicuous species including American elm, box elder (*Acer negundo*), wild rose (*Rosa woodsii*), and snowberry (*Symphoriocarpus occidentalis*). The site is steeply sloped and thickly covered with grass, primarily *Bromus*; fallen logs, branches, and human litter also provide groundcover.

Non-native grassland community type, Johnson Habitat Park: This six-acre park, surrounded by industry, was formerly a city dump "slated to become an outdoor classroom amidst a number of restored natural environments" (Shoemaker, 1981:5). We conducted our research on an area including native blue grama (*Bouteloua gracilis*) but dominated by non-native cheatgrass, crested wheatgrass (*Agropyron cristatum*), diffuse knapweed (*Centaurea diffusa*), and white sweetclover (*Melilotus alba*). This field includes five small junipers (*Juniperus* cf. *scopulorum*) and virtually no vertical structure other than these trees; the field was mowed at least twice during our study.

Semi-native grassland community type, Overland Pond: This site is surrounded by an urban park and a golf driving range (Shoemaker 1981; Kirkpatrick, 1998). Two ponds were developed from an old gravel quarry, and the surrounding area was replanted with indigenous species such as rabbitbrush (*Chrysothamnus nauseosus*) in 1986. The plant community includes cheatgrass, blue grama, smooth brome, mullein (*Verbascum thapsus*), goldenpea (*Thermopsis rhombifolia*), sandbar willow, Siberian elm, and blue spruce (*Picea pungens*). Transects were located in grassland above the edge of the steep river escarpment, above the upper edge of the riparian woodland.

Urban pond, Globe Pond: Globe Pond is located near the northern county limit of Denver in the community of Globeville. Dominant vegetation includes cottonwoods (*Populus*), Siberian elm, cattails (*Typha*), cheatgrass (*Bromus tectorum*), and weedy forbs such as *Kochia scoparia*, *Cirsium*, and pigweed (*Amaranthus* spp.). This was the most insular of our sites, with construction occurring outside of two of its boundaries during our study.

We used a combination of live-traps, scent stations, and transects to document the presence of as many birds and mammals as possible. We conducted sweep surveys of birds on each site following recommendations by Dawson (1981) and Ryder (1986). Permanent 300-meter line transects were established and marked with a permanent stake and geo-referenced using a global positioning system (GPS). All observers were experienced in identifying birds by both sight and sound. One person (Beane) walked the transect counting and identifying all birds observed or heard within 50 meters of the line. Two other observers conducted a sweep transect over each study area and counted all birds observed. Data were standardized by recording number of birds observed per linear transect and the amount of time per unit area. Surveys were conducted bimonthly over a 12-month period in 1998-99 (August, October, December, February, April, and June). Counts were conducted in the first five hours following sunrise. Each survey consisted of two counts on two consecutive days, with the order of the survey reversed on the second day.

We live-trapped small mammals using 7.5 x 7.5 x 22.5 cm (3"x3"x9") Sherman traps at 10 pace intervals, set in two transects per site with 15 traps per transect. We opened traps and baited them with oatmeal and peanut butter at or near sunset and checked traps at sunrise. We used Monel ear tags on rats and marked mice by toe-clipping (Nietfeld et al., 1996). We recorded identification, sex, and weight, with additional comments regarding reproductive condition. Traps were run for three consecutive nights in each of seven months (July, September, and November 1998, and January, March, May, and July 1999). Trapping effort was measured in trapnights (i.e., as the number of traps opened per night). Two Hav-a-hart traps also were employed at selected sites where the cover of vegetation sufficed to camouflage the traps.

One scent station was set up on open sand at each site to detect the presence of larger mammals. Each station consisted of a $1m^2$ area of clear sand with predator scent left as bait in the middle of the sand. Stations were set up in the morning and checked 24 hours later.

Results.—Scientific names of vertebrates we identified are listed in Appendix A. We documented 65 species of birds (Table 1), including both migrants (such as the horned grebe, lesser yellowlegs, solitary sandpiper, western sandpiper) and winter residents (common goldeneye, herring gull, ring-billed gull, tree sparrow). The hooded merganser breeds in Colorado (Kingery, 1999) but was a winter resident on the South Platte. Of the 65 species, nine accounted for nearly 20% or more of the observations during each sampling season (Table 2).

Trapping effort totaled 1,890 trapnights consisting of 315 trapnights per site. The use of Sherman traps documented the presence of five species of rodents (*R. megalotis*, *P. maniculatus*, *M. pennsylvanicus*, *R. norvegicus*, and *M. musculus*). Animal sightings, scat, and tracks at scent stations revealed the presence of ten additional species (Table 3). Magpies (*P. pica*) were the only non-target captures in Sherman and Hav-a-hart traps. There were very few recaptures. Three incidental mortalities (rodents) were prepared as vouchers and deposited in the Denver Museum of Nature and Science.

Discussion.—The elimination of native shortgrass steppe and the establishment of various plant communities presumably changed the composition of

Table 1. Birds documented at Elitch's (E), Globe Pond (G), Grant Frontier (GR), Johnson Habitat Park (J), Overland Pond (O), and Riverside (R). Non-native species are marked with an asterisk.

	E (restored mesic)	G (urban pond)	GR (riparian)	J (disturbed grassland)	O (semi-native grassland)	R (mesic)
Horned grebe		x				
Pied-billed grebe		x	x			x
American white pelican		x				x
Double-crested cormorant	x	x	x	x	x	x
Great blue heron	x	x				x
Black-crowned night-heron		x	x	x		x
Green-backed heron						x
Domestic goose			x			
Canada goose	x	x	x	x	x	x
Gadwall		x	x	x	x	x
American wigeon		x	x		x	x
Mallard	x	x	x	x	x	x
Blue-winged teal			x		x	
Northern shoveler		x	x	x	x	x
Green-winged teal		x	x	x	x	x
Common goldeneye			x	x		
Hooded merganser			x			
Cooper's hawk					x	
Swainson's hawk			x			
Red-tailed hawk						x
American kestrel	x			x		x
American coot		x	x	x	x	
Killdeer	x	x		x	x	x
American avocet		x				x
Common snipe					x	
Lesser yellowlegs						x
Solitary sandpiper		x				
Western sandpiper		x				
Herring gull	x		x	x	x	
Ring-billed gull	x	x	x	x	x	x
Rock dove	x	x	x	x	x	x
Mourning dove		x	x	x		x
Great horned owl		x				
Belted kingfisher	x	x	x	x	x	x
Downy woodpecker			x	x		x

Table 1. (cont.)

	E (restored mesic)	G (urban pond)	GR (riparian)	J (disturbed grassland)	O (semi-native grassland)	R (mesic)
Northern flicker	x	x	x		x	x
Western wood-pewee		x	x			
Say's phoebe			x			
Loggerhead shrike						x
Plumbeous vireo			x			
Black-billed magpie	x	x	x	x	x	
American crow	x		x	x	x	x
Common raven	x		x	x	x	
Cliff swallow	x	x	x	x		x
Barn swallow	x	x	x	x	x	x
Black-capped chickadee		x	x	x	x	x
House wren					x	
American robin	x	x	x	x	x	x
Gray catbird		x				
European starling*	x	x	x	x	x	x
Yellow warbler		x	x		x	
Yellow-rumped warbler	x					
Lark sparrow		x		x		x
Song sparrow	x	x	x		x	x
White-crowned sparrow	x	x				x
Dark-eyed junco	x	x	x		x	
Red-winged blackbird	x	x	x	x	x	x
Brewer's blackbird			x		x	x
Common grackle	x	x	x	x	x	x
Bullock's oriole						x
House finch	x	x	x	x	x	x
American goldfinch		x				
American tree sparrow		x				x
House Sparrow*	x	x	x	x	x	x
Number of species/site:	23	46	37	32	34	41

the fauna along the South Platte. In rural Weld County, Colorado, Fitzgerald (1978) documented 109 species of birds and 24 species of mammals along the South Platte River, including prairie falcons (*Falco mexicanus*), horned larks (*Eremophila alpestris*), Ord's kangaroo rats (*Dipodomys ordii*), spotted ground squirrels (*Spermophilus spilosoma*), and other taxa associated with shortgrass steppe. We did not find these species or such large numbers of species. We found the fewest mammals on the non-native grassland and the fewest birds on the restored mesic site, both of which lack mature elms and cottonwoods (Tables 1, 3). The greatest number of species occurred on two sites with vegetation providing well-developed vertical structure (Globe Pond and the lowland mesic site at Riverside Cemetery).

We saw birds primarily on the river or in trees along riverbanks, and the species listed are typical of riparian communities. For example, birds such as the common goldeneye are typical of open water, whereas the green heron prefers riparian woods (Andrews and Righter, 1992). This region of the South Platte supports large numbers of ducks in winter; for example, for the 1999-2000 Christmas Bird Count period, 16 species of ducks were recorded, comprising 36.4% of the count results (H. E. Kingery, pers. comm., 2000). We detected all of the 13 avian species known to breed in lowland riparian ecosystems in Colorado (Preston and Kingery, 1998), except for western and eastern kingbirds (*Tyrannus verticalis* and *T. tyrannus*) and blue grosbeak (*Guiraca caerulea*). Of the 13 species found at all 6 sites (Table 1), the mallard, double-

Table 2. Dominant bird species observed by season and location.

	Grant Frontier	Overland Pond	Johnson Habitat	Elitches	Globe Pond	Riverside
Late Summer - August	None	Canada Goose	House Finch	None	Canada Goose	None
% of Observations		39.0%	28.8%		23%	
Fall - October	Mallard	None	Green-winged Teal	Canada Goose	House Finch	House Finch
% of Observations	40.7%		45.6%	42.1%	36%	29.1%
Winter - December	Canada Goose	Canada Goose	Ring-billed Gull	Ring-billed Gull	Ring-billed Gull	European Starling
% of Observations	48.1%	66.7%	48.6%	76.5%	32.8%	45.2%
Winter - February	Mallard	Gadwall	Ring-billed Gull	Common Grackle	European Starling	Canada Goose
% of Observations	23.8%	19.4%	26.2%	33.9%	19.6%	30.3%
Spring - April	Gadwall	Gadwall	Gadwall	Ring-billed Gull	Common Grackle	White Pelican
% of Observations	30.5%	26.4%	29.7%	32.7%	29.7%	29.9%
Summer - June	European Starling	Common Grackle	Canada Goose	Common Grackle	European Starling	Common Grackle
% of Observations	26.3%	32.4%	38.6%	18.2%	26.3%	28.3%

Table 3. Mammals documented at sites as indicated on Table 1. Non-native species are marked with an asterisk. Abundance codes are from the Colorado Natural Diversity Information Source (2000).

Site	E (restored mesic)	G (urban pond)	GR (riparian)	J (disturbed grassland)	O (semi-native grassland)	R (lowland mesic)	Abundance
Cottontail		x		x	x		fairly common
Eastern fox squirrel	x			x	x		common
American beaver			x		x	x	fairly common
Western harvest mouse		x				x	fairly common
Deer mouse		x				x	abundant
Meadow vole	x				x	x	common
Common muskrat		x					common
Norway rat *	x		x				common
House mouse*	x	x	x		x	x	abundant
Dog*	x	x	x	x	x	x	
Coyote		x					common
Red fox	x	x	x		x	x	abundant
Common raccoon	x		x		x	x	abundant
Cat*				x	x		
Deer						x	fairly common
Number of species detected:	7	8	7	4	8	9	
Number of captures of rodents:	61	40	16	0	17	72	

crested cormorant, belted kingfisher, and red-winged blackbird also indicate the presence of water. The remaining ten (Canada goose, ring-billed gull, rock dove, barn swallow, American robin, European starling, common grackle, house finch, and house sparrow) are widespread birds common to urban areas (e.g., Loeffler, 1990, Kingery, 1998b; Colorado NDIS, 2000). The rock dove, European starling, and house sparrow are exotics introduced into the United States in the 18th and 19th centuries; they now comprise up to 95% of some urban bird communities during winter (Adams, 1994).

The dominant birds also were primarily urban-adapted species (Table 2). Six of the nine dominant species (Canada goose, mallard, ring-billed gull, European starling, common grackle, and house finch) are common urban birds, whereas the remaining three are migrant waterfowl (green-winged teal, gadwall, and white pelican). Most observations of these waterfowl were recorded in spring, late winter, or fall. Canada geese and ring-billed gulls were the most common wintering species at all sites, whereas the most common summer species at four of the six sites was the common grackle (Table 2).

Raptors are important indicators of ecosystem health and especially popular among bird-watchers. A great horned owl, Cooper's hawks, Swainson's hawks, and red-tailed hawks all were present, and all are uncommon sights in Denver (Colorado NDIS, 2000). The American kestrel was the most widely-reported raptor (Table 1). Its apparent success along the South Platte River might be attributed to its small size (it maintains the smallest territories of all Colorado hawks) and versatile diet (Winn, 1998).

The mammalian community was similar to that reported for other local urban areas. Two cottontails (*S. audubonii* and *S. floridanus*) are fairly common, but difficult to identify without a specimen in hand (Fitzgerald et al., 1994; Colorado NDIS, 2000). We detected deer sign at only one site (Table 3); whitetails (*O. virginianus*) are more closely associated with riparian regions than mule deer (*O. hemionus*), but both species are fairly common (Colorado NDIS, 2000). Of the native rodents encountered, the American beaver and western harvest mouse are considered fairly common, the deer mouse abundant, and the meadow vole and muskrat common in Denver (Colorado NDIS, 2000). Western harvest mice occur in wetlands, weedy or grassy areas, and riparian woodlands throughout eastern Colorado (Fitzgerald et al., 1994). The deer mouse is the most ubiquitous of North American rodents, using a wide variety of habitats and adapting particularly well to disturbance (e.g., Fitzgerald et al., 1994; Handley, 1999). Meadow voles prefer mesic areas but tolerate patchy habitats and edges well (e.g., Harper et al., 1993; Fitzgerald et al., 1994). Beaver and muskrat occur throughout Colorado where there are permanent bodies of water (Fitzgerald et al., 1994).

We expected to find the three widespread, non-native rodents observed (Table 3). Fox squirrels were introduced in several places in Colorado and have become common watchable wildlife in Denver and many other cities (e.g., Loeffler, 1990; Adams, 1994; Flyger, 1999). The Old World Norway rat and house mouse are cosmopolitan. The only site at which we did not capture *Mus* was the disturbed grassland, which lacked significant ground cover.

Raccoons were documented at four locations, but probably occur at all sites. They are very common in both urban and riparian areas and appear to be increasing in numbers in this region (Fitzgerald et al., 1994; VanDruff et al., 1996). The most common wild carnivore was the red fox, the most widely distributed wild carnivore in the world (Seidensticker, 1999). We detected the coyote at only one site, but it is common in Denver (Table 3). We saw domestic dogs at all six sites, and at least some of these dogs were living in dens and appeared to be feral. We found evidence of house cats at two locations. Domestic dogs and cats both have been implicated in the decline and disappearance of native species, although their impacts on wildlife have been poorly studied (Atkinson, 1989; Adams, 1994; Clarke and Pacin, 2002).

No animals were captured in transects on the disturbed, non-native grassland, which reflected the lack of vertical structure due to frequent mowing. This site also had the lowest species richness. The greatest numbers of rodent captures occurred in the two mesic areas (Table 3). Harvest mice were the most frequently-captured rodents in true mesic lowland. *Mus musculus* was the only mouse caught in the restored mesic community until 9 July 1999, when three meadow voles

were trapped. The presence of voles might indicate community succession following restoration efforts less than three years old, or might indicate a change in interspecific competition; interactions between *Mus* and native species should be examined.

Meadow voles, house mice, deer mice, Norway rats, and western harvest mice have been reported from elsewhere in the metropolitan area (Jones, 1997; ERO Resources, 1998). The presence of additional species at other nearby urban sites suggested that the South Platte mammalian fauna was somewhat depauperate. Both the prairie vole (*M. ochrogaster*) and the Mexican wood rat (*Neotoma mexicana*) have been reported from elsewhere in Denver County (Beane and Powell, 1997; Jones, 1997).

The absence of *Zapus* was of special note. Its presence along the urban South Platte was documented by a capture in "waist-high forbs over moist ground" (Erickson, 1982) at a site that is now the location of a children's museum and urban park lacking the original multi-stratum plant community. The only subspecies of jumping mouse (*Z. hudsonius preblei*) occurring in the area was listed as federally threatened (U.S. Fish and Wildlife Service, 1998). Most records are from moist riparian areas with thick herbaceous vegetation (Jones, 1999, and citations therein). Its absence along the urban South Platte indicated the lack of extensive native vegetation along this stretch of river.

Urban river corridors are popular locales for recreation, including watching wildlife. In Colorado, outdoor activities are considered tremendously important, as evidenced by recent surveys regarding preferences regarding wildlife viewing (Manfredo et al., 1991) and use of nature trails (Cuciti, 2002), and by large numbers of volunteers assisting in projects such as the breeding bird atlas (Kingery, 1998a) and bat surveys (Navo et al., 2001). In the Denver metropolitan area, the history of the Rocky Mountain Arsenal and other sites demonstrates the high level of public interest in natural history, although local governments strongly support economic growth and development (Jones and Preston, 2000). The lowland riparian ecosystem offers unique opportunities for public education, in spite of representing only about 3% of Colorado's area. This ecosystem supports a relatively high number of mammalian species, more native birds than the shortgrass steppe, and is one of the most threatened of western ecosystems (Cooperrider, 1989; Fitzgerald et al., 1994; Ohmart, 1994; Preston and Kingery, 1998; Fleischner, 1999). Additionally, riparian corridors are thought to serve as avenues of dispersal, particularly for species from the east, although the historic influence on dispersal remains unknown (e.g., Fitzgerald et al., 1994; Kingery, 1998b). Other positive values connected with the presence of urban plants and animals include aesthetic, environmental (e.g., services such as clean water and noise abatement), economic, psychological, and sociological benefits (Adams and Dove, 1989; Loeffler, 1990; Moorhead, 1992; Schwarz, 1993; Botkin and Beveridge, 1997; Werner, 1999). We make the following recommendations for management of urban areas, particularly those in riparian zones:

Maintenance and Management

The appearance of most urban recreational areas is maintained in a manner considered appropriate by most citizens. For example, in 1999, efforts to maintain the aesthetic appearance of the South Platte corridor included the equivalent of 9.5 miles of tree trimming and 199 miles of trash and debris pickup and removal (Urbonas, 1999). However, litter in the form of fallen trees and branches should be left for species known to respond positively to vertical structure (Douglass and Reinert, 1982; Getz, 1985; Sears and Anderson, 1991; Adams, 1994; VanDruff et al., 1996). Stable rodent populations also are key determinants in the distribution of very popular raptors (e.g., Preston and Beane, 1996). Considerations for public safety must be balanced with the needs of wildlife. Education might help modify current aesthetic values.

Special efforts should be made to manage for wildlife on less disturbed areas than on more frequently visited sites. Traffic noise negatively affects densities of breeding birds (Reijnen et al., 1997). Starlings and other less-desired generalists adapt better to human disturbance than do specialists (Hallock, 1989; Sears and Anderson, 1991; VanDruff et al., 1996). Many species are impacted directly and indirectly by roads (Trombulak and Frissell, 2000).

The restoration of native vegetation should continue for both aesthetic and biological reasons. Botkin and Beveridge (1997) offered recommendations for

managing for the best mix of urban vegetation types related to water use, and it has been reported that native birds in the Rocky Mountain region use native trees more than non-native birds (Sears and Anderson, 1991).

Put in place a mechanism, such as a long-term management plan, to ensure that long-term restoration efforts survive changes in politics and personnel. For example, on one of our sites, the restoration of xeric plants has not resulted in establishment of a xeric ecosystem because of how the park was managed subsequently.

Education

Institutions managing parks should mandate ongoing educational efforts, including on-site signage and addresses of pertinent websites such as those of Ballenger (1996a, 1996b), to ensure that the public has ready access to up-to-date information.

The widespread distribution of alien species requires that these organisms be of special importance in education and research. Herein we have treated nonnatives as 'exotics'. However, Haspel and Calhoon (1991:27) stated that the study of urban cats "...is the study of a species in a unique ecosystem, one in which it has been reproductively successful for thousands of years." Such intriguing ideas should be investigated for development of research and educational programming. How do invasive species interact with native wildlife in urban areas? In any case, exotics need to be included in any educational programming.

Projects such as the development of the South Platte Greenway provide opportunities to provide participation by local residents. Including residents in planning and incorporating information about local culture and history will promote alliances between city planners, environmentalists, and advocates of social justice (Chapman, 2001).

Research

Encourage additional research and peer-reviewed publications regarding urban areas. Many valuable data lie buried in 'gray literature', as in the report by Thompson (1994) and other reports cited in this paper. Various projects have been conducted regarding environmental quality (for example, see Kimbrough and Litke, 1996; Saldiva and Böhm, 1998) but more ecological work needs to be done regarding the ecology unique to cities. People in urban ecosystems can weaken or enhance the natural forces affecting ecosystems (Pickett and McDonnell, 1993; Collins et al., 2000). Such human-induced effects in Colorado include the expansion of house sparrow populations to elevations exceeding 3,000 m or 10,000 ft (Kaempfer, 1998). Some popular articles have treated ecological subjects (e.g., Kerlinger, 1999; Jones, 2000), and various examples of technical publications regarding urban ecology include those by Hallock (1989), Hiebert (1990), Groom (1993), Lajeunesse et al. (1997), Reijnen et al. (1997), Fernández-Juricic (2000), and Grinder and Krausman (2001). However, results of a recent survey demonstrated that very few papers in ecological journals dealt with urban biology (Collins et al., 2000).

The relative paucity of ecological research in urban areas counters widespread needs for biological input in urban planning (Murphy, 1988; Botkin and Beveridge, 1997; Babbitt, 1999) and is being partially addressed through establishment of the US Long-Term Ecological Research network (Parlange, 1998; Grimm et al., 2000). The South Platte is one of those urban sites providing a unique opportunity in the study of biological events that differ, or occur on a different time scale, than those in less impacted areas. We know that dramatic changes in floras and faunas have occurred since European settlement. In most cities, we lack data regarding the flora and fauna present before urban development. However, surveys such as ours provide baseline data and the opportunity to document alterations in bird and mammal communities as future changes occur along urban river corridors and other urban sites.

ACKNOWLEDGMENTS

We thank volunteers L. M. Carpenter, J. Harting, and C. Stucheli, and an anonymous reviewer. A. Kropp provided the map, R. Brune shared unpublished vegetation data, H. E. Kingery assisted with bird records, and B. Chadwick served as our liaison with the city. This project was supported by the Mayor's South Platte River Commission and by the Denver Museum of Nature and Science.

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APPENDIX A

Scientific and vernacular names of birds and mammals reported in this study. Non-native species are marked with an asterisk.

Birds

Horned grebe	*Podiceps auritus*
Pied-billed grebe	*Podilymbus podiceps*
American white pelican	*Pelecanus erythrorhynchos*
Double-crested cormorant	*Phalacrocorax auritus*
Great blue heron	*Ardea herodias*
Black-crowned night-heron	*Nycticorax nycticorax*
Green-backed heron	*Butorides striatus*
Domestic goose	*Anser anser**
Canada goose	*Branta canadensis*
Gadwall	*Anas strepera*
American wigeon	*Anas americana*
Mallard	*Anas platyrhynchos*
Blue-winged teal	*Anas discors*
Northern shoveler	*Anas clypeata*
Green-winged teal	*Anas crecca*
Common goldeneye	*Bucephala clangula*
Hooded merganser	*Lophodytes cucullatus*
Cooper's hawk	*Accipiter cooperii*
Swainson's hawk	*Buteo swainsoni*
Red-tailed hawk	*Buteo jamaicensis*
American kestrel	*Falco sparverius*
American coot	*Fulica americana*
Killdeer	*Charadrius vociferus*
American avocet	*Recurvirostra americana*
Common snipe	*Gallinago gallinago*
Lesser yellowlegs	*Tringa flavipes*
Solitary sandpiper	*Tringa solitaria*
Western sandpiper	*Calidrus mauri*
Herring gull	*Larus argentatus*
Ring-billed gull	*Larus delawarensis*
Rock dove	*Columba livia**
Mourning dove	*Zenaida macroura*
Great horned owl	*Bubo virginianus*
Belted kingfisher	*Ceryle alcyon*
Downy woodpecker	*Picoides pubescens*
Northern flicker	*Colaptes auratus*
Western wood-pewee	*Contopus sordidulus*
Say's phoebe	*Sayornis saya*
Loggerhead shrike	*Lanius ludovicianus*
Plumbeous vireo	*Vireo solitarius*
Black-billed magpie	*Pica pica*
American crow	*Corvus brachyrhynchos*
Common raven	*Corvus corax*
Cliff swallow	*Petrochelidon pyrrhonota*
Barn swallow	*Hirundo rustica*
Black-capped chickadee	*Poecile atricapillus*
House wren	*Troglodytes aedon*
American robin	*Turdus migratorius*
Gray catbird	*Dumetella carolinensis*
European starling	*Sturnus vulgaris**
Yellow warbler	*Dendroica petechia*
Yellow-rumped warbler	*Dendroica coronata*
Lark sparrow	*Chondestes grammacus*
Song sparrow	*Melospiza melodia*
White-crowned sparrow	*Zonotrichia leucophrys*
Dark-eyed junco	*Junco hyemalis*
Red-winged blackbird	*Agelaius phoeniceus*
Brewer's blackbird	*Euphagus cyanocephalus*
Common grackle	*Quiscalus quiscula*
Bullock's oriole	*Icterus bullockii*
House finch	*Carpodacus mexicanus*
American goldfinch	*Carduelis tristis*
American tree sparrow	*Spizella arborea*
House sparrow	*Passer domesticus**

Mammals

Cottontail	*Sylvilagus*
Eastern fox squirrel	*Sciurus niger*
American beaver	*Castor canadensis*
Western harvest mouse	*Reithrodontomys megalotis*
Deer mouse	*Peromyscus maniculatus*
Meadow vole	*Microtus pennsylvanicus*
Common muskrat	*Ondatra zibethicus*
Norway rat	*Rattus norvegicus**
House mouse	*Mus musculus**
Dog	*Canis familiaris**
Coyote	*Canis latrans*
Red fox	*Vulpes vulpes*
Common raccoon	*Procyon lotor*
Cat	*Felis catus**
Deer	*Odocoileus*

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