

**EVALUATION OF
HISTORICAL CAPTURE SITES OF THE
PREBLE'S MEADOW JUMPING MOUSE
IN COLORADO**

FINAL REPORT

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INTRODUCTION

Preble's meadow jumping mouse (*Zapus hudsonius preblei*) is a subspecies which is apparently localized along the Colorado Front Range and Laramie Mountains in Central Colorado and adjacent Southeastern Wyoming. The population appears to have suffered a decline of its historic range in Colorado. The historic range was known from eight counties along Colorado's Front Range corridor. Today, four counties are known to contain populations of *Zapus hudsonius*. The decline in range is believed to be due to habitat destruction from real estate development, grazing, and water diversions. A petition to list this subspecies as threatened or endangered was submitted by the Biodiversity Legal Foundation to the U. S. Fish and Wildlife Service on August 9, 1994. The claim of growing habitat destruction came from this petition document.

This study evaluates the current condition of sites where *Z. hudsonius* had been captured along the Front Range corridor. The goal of this study was to evaluate the current status of *Z. hudsonius* at former capture locations in terms of current habitat condition and, where possible, species presence or absence. Additionally, comparisons were made to recent capture sites in the Rocky Flats Environmental Technology Site Buffer Zone and Boulder City Open Space.

The study is based on site descriptions of historical records from museum specimens, unpublished dissertations, or publications. Some type of site description was found with each historical record although the usefulness of descriptions varied greatly in precisely locating a former capture site.

This final report contains site descriptions, vegetation analysis, trapping results, and discussion. For detailed methods and assumptions, please refer to the proposal for the EVALUATION OF THE PREBLE'S MEADOW JUMPING MOUSE HISTORICAL CAPTURE SITES IN COLORADO, dated June, 1995. The study was made possible through a grant from the Colorado Division of Wildlife to the University of Colorado at Denver.

METHODS

Visits were made to natural history museums to become familiar with this jumping mouse and to record site descriptions from specimen tags. Museums visited were the Chicago Field Museum, the Denver Museum of Natural History, and the University of Colorado Museum. Literature searches and discussions with local experts were also conducted.

For purposes of this study, a Colorado historic site is defined as the location where a museum specimen was collected over five years ago, or where a well documented observation was recorded over five years ago (i.e., prior to 1990). The precision in locating a historic site depends entirely on the precision of the description from the historical record. Every effort was made to locate a historic site within a one square mile

area. If this was not possible, a decision was made whether to choose a study site representing probable habitat within the larger area of historic occurrence or to drop the record from further consideration. The precise location of some sites are difficult to determine, because the actual starting point is unknown (e.g., from the edge of town in 1954 or perhaps from the post office?). This is especially the case for descriptions starting from cities that have expanded in recent years (e.g., Fort Collins or Boulder). Site descriptions detail the precision acquired in locating the historic sites.

Site descriptions from historical records were outlined on U.S.G.S. quadrangle maps (7.5 minute topographic series). These areas were typically larger than one square mile. Any additional historic information including old soils maps and discussions with resource managers or local experts was used to further refine the area on the quadrangle maps. Once all descriptions were refined, any site (record) with a precision greater than 1 mi. was dropped from further study. In considering two sites, areas within the larger area of known historical occurrence, were chosen to represent probable *Z. hudsonius* habitat without meeting the square mile resolution criteria. Once historical sites were selected for study, a site visit was conducted to choose a location for the study site. This was determined by probable habitat found within the refined historic site. Typically, a stream or river was found within the refined area and this area became the study site. This selection process was based on research indicating the distribution of meadow jumping mice in relation to water (Quimby 1951, Whitaker 1972, DOE 1995).

For each successfully located historic site, the vegetation was described and quantified. The vegetation among historic sites was then compared in order to answer the question "What is the relative habitat quality found at each historic site, today?" Six of the sites were also trapped to determine presence or absence of the species. These six were the historic sites most precisely located.

Data from structural measures taken from historic sites were subjected to ANOVA tests using STATSGRAPHICS Plus for Windows, Version 1.0. Multivariate analysis was also conducted on these data using Minitab Principal Component Analysis. An ordination of dominant plant species composition was conducted using DECORANA, from the Cornell Ecology Laboratory Statistical Series.

SITE DESCRIPTIONS

Specimens at natural history museums, information from the Colorado Natural Heritage Program and the U.S. Fish and Wildlife Denver Field Office, and library searches revealed 22 historical capture sites or observations of *Zapus hudsonius* along the Front Range of Colorado. See the Literature Cited and List of Museum Specimens/Records Examined sections. From the information provided in the 22 historical descriptions, 18 site locations were determined. After refining locations, 15 sites were visited to provide a site description. A site description of each of the 15 sites follows in alphabetical order by county. Additionally, site descriptions for three recent capture sites are provided. The

descriptions are general for each site and follow descriptors suggested by the U.S. Fish and Wildlife Interim Guidelines for Preble's Meadow Jumping Mouse Surveys. Soil classifications were determined from the appropriate U.S.G.S. Soil Survey, county or quadrangle. Each site description ends with a discussion of the site relative to the surrounding land use. Table 1 provides site ownership information and the legal description for each site. Figure 1 presents Front Range counties and key locations relating to historic capture sites.

Adams County

Badding Reservoir

In 1936, Landberg captured a *Z.h. preblei* at Croke Lake. This site is located in Thornton, Colorado, and is now adjacent to Interstate 25. Given the historical record description, the precise site location is known to approximately one-half square mile. Two reservoirs are at this location now, Croke Lake and Badding Reservoir. In 1936, only one reservoir, Croke Lake, was present. Croke Lake was built in 1888 by the Farmer's Highline Lateral Company (Bob Krugmire - City of Thornton, pers. comm.). In the 1950s, Interstate 25 was built through Croke Lake, splitting the reservoir in two. Badding Reservoir was chosen for study due to its higher quality habitat and the fact that the natural drainage (the inlet and outlet) appears to still exist in this area. In other words, the construction of the interstate highway may have bisected the lake leaving the inlet and outlet on the west side of the highway. Given the topography of the surrounding landscape, this is the appearance given, but it is an assumption at best.

Badding Reservoir is located at 5380 ft elevation and is just north of Interstate 25 and west of Thornton Parkway. The reservoir provides municipal water for the City of Thornton. Badding Reservoir is a man-made earthen dam impoundment that is centered on the former drainage. The dam slope is a steep embankment (35%), with a northeastern aspect. The geomorphology of the site includes disturbed soils and man-made fill. The soil type is Ulm loam below the dam face and fill material on the dam face.

The vegetation is composed of a tree and shrub overstory including plains cottonwood (*Populus deltoides*), peach-leaved willow (*Salix amygdaloides*), Russian olive (*Elaeagnus angustifolia*), green ash (*Fraxinus pennsylvanica*), Chinese elm (*Ulmus pumila*), and coyote willow (*Salix exigua*). The coyote willow occur in small patches adjacent to cattails (*Typha* sp.) along the shoreline. Willows are also found along the outlet channel on the southwest side of the dam slope. The understory is comprised mostly of rehabilitation grasses (i.e., smooth brome (*Bromus inermis*), timothy (*Phleum pratense*), or crested wheatgrass (*Agropyron crisatum*)) and exotic forbs. Exotic and introduced plant species were plentiful including Russian olive, Canada thistle (*Cirsium arvense*), and smooth brome. The patch size of riparian vegetation is about 0.33 hectares, although more wetland/riparian vegetation occurred across the reservoir on the inlet side.

This site is an isolated parcel of wildlife habitat within an urban setting. Adjoining land uses include a six-lane metropolitan interstate highway, residential development, and an elementary school.

Boulder County

Dry Creek Trail

D.A. Andrews recorded two *Z.h. preblei* captures, one in 1912, 5 miles east of Boulder; and another in 1913, 3 miles east of Boulder. One site was chosen to represent both descriptions within a combined possible area of 4 square miles, centered around Arapahoe Road and 4 miles east of 28th street at Valmont Reservoir. This study area represents probable habitat within a larger area of known occurrence. Although the Dry Creek site is referred to as a historical site, this fact should be understood. The site chosen was the City of Boulder Open Space, Dry Creek Parcel. This parcel is located along Baseline Road and Dry Creek, approximately one-eighth of a mile east of Baseline Reservoir at an elevation of 5280 ft.

The transect is located on the south facing side of the creek in the flood plain with a relatively flat slope (1-2%). Geomorphology is influenced somewhat by flooding. The soil type is Calkins sandy loam, 1-3% slope.

The vegetation along Dry Creek is composed of an overstory of tall shrubs, mostly coyote willow and leadplant (*Amorpha fruticosa*), and the occasional green ash or Russian olive trees. The understory consists of some wetland species mixed with rehabilitation grasses and Canada thistle. The patch size where the vegetation transect was established is approximately 0.14 hectares.

Dry Creek Open Space is a parcel in a large expanse of open space along South Boulder Creek and the south side of Baseline Reservoir. Other open space parcels adjoin the Dry Creek parcel to the southwest. The parcel is bounded to the north by Baseline Road and to the east by agricultural land mixed with low density residential development. There are many suitable areas within this large expanse of open space east of Boulder to look for meadow jumping mice populations.

Elmer Johnson Ranch

The historical record from this area was a *Z.h. preblei* captured by L.E. Swenson in 1951. The capture took place along an irrigation ditch in a wild plum thicket on the Elmer Johnson Ranch. The location was described in relation to Boulder (i.e., 8 1/2 miles north and 3 1/4 east of Boulder). Given this information and information from the County Assessor regarding the Elmer Johnson Ranch, the historic site is known to the nearest square mile at an elevation between 5200 and 5340 ft.

The ownership of the property has changed over the years following the sale and subdivision of the Elmer Johnson Ranch. Two land owners were identified as Earl Carrey and Michelle Roth, both living on subdivided parcels. One land owner to the south was also identified as Richard W. Behrman.

The topography of this area varies widely from west to east. The western portion of the area is the east facing hillside of Table Mountain. From here the land slopes greatly, creating some small intermittent drainage. At this point, the Boulder Feeder Canal drains water away from the natural drainage and carries water south. Additionally, the Table Mountain ditch skirts Table Mountain at a slightly higher elevation, then flows northeasterly away from the base of the mountain. Down gradient, the intermittent streams never get established as stream channels, and the area remains quite mesic.

Vegetation along both ditches was comprised of tall shrubs and the occasional mature plains cottonwoods. No plum thickets were noted. Grazing and crop production are still the main land uses in this area, but subdivision and residential development has occurred and has therefore influenced the area.

Lagerman Reservoir

This location was chosen to represent the historical record description of "3 miles northwest of Niwot, Colorado." The specimen was collected by E.M. Johnson in 1935. The precision associated with this site is within one square mile at an elevation of approximately 5090 feet.

Both the inlet areas and the outlet drainage were observed surrounding the reservoir. The topography of the area in general slopes to the east (2-3%).

The vegetation around Lagerman Reservoir is either wetlands or disturbed. The inlet areas are pure stands of cattails (*Typha* sp.). No trees or shrubs are present. The three outlet drainage are moist meadows with some associated short marsh area. Additionally, large patches of annuals (mustards) and musk thistle (*Carduus nutans*) were observed between the outlet channels. No shrubs or trees were present. The area immediately surrounding the reservoir is either crested wheatgrass (*Agropyron cristatum*) or rip-rap.

Lagerman Reservoir is an agricultural water supply surrounded by agricultural parcels mostly used for pasture land. There is encroaching residential development, which threatens subdivision of the large agricultural parcels. Public notice for rezoning and subdivision was posted for the eastern portion of section 13 at the time of the site visit.

Left Hand Canyon

This historic record came from the work of John Cruzan, PhD. candidate at Colorado University in Boulder, who captured (and apparently released) two *Z.h. preblei* at the

"mouth of Left Hand Canyon" in 1966. The elevation from Cruzan's report was 5620 ft. (Cruzan 1968).

Permission was gained to trap on private land at the mouth of Left Hand Canyon at an elevation of 5600 ft. This property is owned by William Rubin and Karen Conduff and seems to match Cruzan's description. The property is part of the Crestview subdivision established in 1965. Given the fact that very few points in the vicinity of the canyon mouth have an elevation of 5620 ft., the precision in locating this historic site is known to the nearest quarter mile.

When Cruzan studied this area, the Crestview subdivision was zoned, but construction of houses had not begun. The Rubin/Conduff property was not developed until 1980. Therefore, residential development has disturbed the area of *Z. hudsonius* historic occurrence between the time of Cruzan's study and this study.

The trapping and vegetation measurements were conducted on the north side of Left Hand Creek, just below the Haldi Ditch inlet. The transect and trap line locations were within the flood plain, but about two meters above the main channel. The area sustained a large flood in the spring, 1995 which washed out the landowner's bridge. Evidence of high water was suggested by the accumulation of debris in the study area. The soils along this portion of Left Hand Creek are Niwot soils of 0 to 1 percent slopes and Nederland very cobbly sandy loam of 1 to 12 percent slopes.

The vegetation at this site created an overstory with almost complete canopy closure in a large part of the study area. The overstory species consisted of narrow-leaved cottonwood (*Populus angustifolia*) and black walnut (*Juglans nigra*) trees. Cruzan's description mentioned only narrow-leaved cottonwoods. The understory was composed of rehabilitation grass species.

The context of this site to surrounding land uses is one of a large tract residential subdivision. Additionally, the Left Hand Canyon road parallels the creek up the canyon. The study site fell between the road and Left Hand Creek.

Niwot Trail Open Space

This site was selected to represent probable habitat within the general area of historical occurrence at Niwot, Colorado. This specimen was captured by E.M. Johnson in 1930.

The town of Niwot has experienced extensive growth in the past five years, so it is difficult to pin-point an area, yet Niwot warrants an effort to locate remaining potential sites of the former mouse population. Given these thoughts, the Niwot site is precisely located to the nearest square mile. The likely habitat seemed to be in the southeastern quarter of this square mile, therefore the Niwot Trail Open Space Parcel was chosen at an elevation of 5250 ft.

The Niwot Trail Open Space Parcel is situated where two irrigation ditches pass through the area. Riparian vegetation has become established along these ditches which are called the Boulder/Left Hand Ditch and the Whiterock Ditch. The Niwot trail crosses the Boulder/Left Hand Ditch several times before the two ditches begin to run parallel to each other and then follow the same course.

The vegetation transect was located about 1300 m northeast from the trailhead on the north facing embankment of the Boulder/Left Hand Ditch. The slope of the embankment was quite steep (20%), then it leveled off before meeting the water line. This more leveled area, probably due to sloughing of the ditch banks, was where the vegetation transect was established. The geomorphology was disturbed due to the construction of the ditch. The soil type is Ascalon sandy loam of 1 to 3 percent slopes.

The vegetation at this site consisted of both mature and young plains cottonwoods as overstory. Russian olive trees were scattered throughout the area as well. Shrubby vegetation consisted of coyote willow along the ditch bank, but this was one of the few areas along the trail that had willow present. The understory vegetation consisted of smooth brome, horsetail (*Equisetum arvense*), and Canada thistle. Overall, the ditches around the Niwot Trail location have approximately 5 km of continuous riparian forest.

The context of this site is one of an open space parcel surrounded by agricultural land uses and encroaching residential development. The town of Niwot is expanding toward this area from the north and the east. To the northwest on the opposite side of the Boulder/Left Hand Ditch is the Wederquest Sheep Ranch. To the south and southeast are agricultural lands and Highway 52. The Dry Creek Open Space parcel (different than Dry Creek at Baseline Road) is found to the west on the opposite side of N 79th Road.

Sawhill Ponds

John Cruzan, PhD. candidate at Colorado University in Boulder, captured three *Z.h. preblei* along Boulder Creek in 1967. The historic capture site was at the Sawhill Ponds Open Space parcel "in a stand of narrow-leaved cottonwoods...along Boulder Creek" (Cruzan, 1968). The precision of locating Cruzan's site at Sawhill Ponds is plus or minus 1/2 km along Boulder Creek. A site was chosen that had narrow-leaved cottonwoods and had been trapped by the Boulder City and County research team. The elevation of the study site is 5140 ft.

Gravel mining occurred in the Sawhill Ponds parcel prior to 1976 according to the Colorado Division of Minerals and Geology. It is not known whether Cruzan trapped prior to the mining disturbance or possibly during mining. According to U.S.G.S. quadrangle mapping revisions, mining was conducted between 1967 and 1978 in the same quarter section as the study site.

This site was trapped by Armstrong et. al. (1995). The vegetation transect was located on the flood plain of Boulder Creek in the riparian zone where mammal trapping occurred. Much alluvial material was present adjacent to the stream channel. The beginning of the transect was located 12 m away from the stream channel on the west side of the creek. This northeast facing bank slopes about 3 to 4 percent downstream.

The vegetation is best described as riparian forest comprised of narrow-leaved cottonwoods and young plains cottonwoods. Patches of coyote willow and tall native grasses are found in the understory. The riparian vegetation patch including an unbroken line of trees and shrubs is approximately 0.75 hectares. The soil type along this portion of Boulder Creek is Niwot soils of 0 to 1 percent slope with large areas noted as gravel pits.

The context of this site in relation to the surrounding land uses is one of open space within a large tract of land rehabilitated for wildlife habitat. The Walden Ponds Habitat Area borders the Sawhill Ponds to the north. Small ranch parcels and tailings ponds make up land use to the south. Some industrial development is found to the west, while agricultural parcels are found to the east.

South Boulder Creek West Trail

The description for this historical record is simply "South of Boulder." The specimen was collected by D.M. Andrews in 1918. The precision in locating this historic site is quite low, but is probably near the location of Dawson's (1989) reported capture (D.M. Armstrong; pers. comm.).

The site chosen to represent this record is located south of Boulder along the South Boulder Creek West Trail, west of Highway 93 at an elevation of 5470 feet. As with Dry Creek and Niwot Trail parcels, this site represents probable habitat within a larger area of known historical occurrence. Access to the trailhead is possible by traveling one half mile north of the intersection of highways 93 and 128 and turning west to the parking lot. Starting at the South Boulder Creek West Trailhead, hike about one kilometer in a southwest direction to an inner gate. Approximately 15 meters south of this gate and 30 meters to the west of the Lafayette Water District property boundary is where the vegetation transect began and continued in a southerly direction.

The transect is in the flood plain of South Boulder Creek, on the toe of a gentle (0-2%) east facing slope. Geomorphology is influenced by flooding (alluvial flow). The soil type is Niwot of 0 to 1 percent slopes.

The vegetation at this site includes an overstory of mature plains cottonwood and narrow-leaved cottonwood. The riparian corridor continues unbroken for approximately 5 km. The shrub component consists of short shrub species including wild rose (*Rosa* sp.) and snowberry (*Symphoricarpos occidentalis*) and occasionally coyote willow. The quality of

the vegetation was good with few exotic plants noted. The riparian vegetation patch is approximately 8.50 hectares although willow patches are infrequent.

The site exists within a large parcel of open space. The area is dissected by several irrigation ditches supporting agricultural and municipal needs including the Lafayette Water District supply. Portions of the open space are open to grazing leases. High and low density residential development is found on the opposite side of South Boulder Creek, southeast of the transect.

Tracy Collins Open Space Parcel

In 1989, three *Z.h. prebleii* were captured by Dawson (1989), at the City of Boulder's Tracy Collins Open Space Parcel. The capture site is precisely known to the nearest 1/2 km in any direction at an approximate elevation of 5820 ft.

This site was trapped by Armstrong et. al. (1995). The vegetation transect was located on the west side of Coal Creek on a toe slope of approximately 4 percent. The transect was located adjacent to a wet meadow area resulting from a Coal Creek tributary. The soil type is Niwot of 0 to 1 percent slopes. A hogback ridge rises to the southeast of Coal Creek in this area creating a very rocky and rugged environment.

The vegetation consists of an overstory of young plains cottonwoods, narrow-leaved cottonwoods, and relatively tall coyote willow. The understory consists of patches of skunkbush (*Rhus aromatica*), native grasses, and some exotic species including Canada thistle and smooth brome. The patch of riparian vegetation is approximately 3 hectares.

Tracy Collins parcel is a lightly grazed open space area surrounded by other open space parcels to the north and northwest. Pasture land exists to the west and east, and industrial development exists to the south. The industrial development is a graveling operation run by Western Aggregate, Inc. Highway 93 borders the parcel to the west and Highway 128 bounds the parcel to the northeast. Approximately two km to the southeast is the Rocky Flats Buffer Zone, specifically the Rock Creek Drainage which supports a viable population of *Z.h. prebleii*. The two drainages, Coal Creek and Rock Creek, are separated by the hogback ridge and about 2 km of piedmont.

Van Fleet Parcel

This site, where meadow jumping mice were captured in 1994 and 1995, was used for comparison of current vegetation composition between historic sites and sites of recent occurrence. This parcel is owned by the City of Boulder and managed by the Open Space and Real Estate Department. The vegetation transect site was located along South Boulder Creek behind the Open Space Operations Center at 66 South Cherryvale Road. The site is at an elevation of 5340 ft.

The transect site was positioned to coincide with actual *Zapus hudsonius* captures along this section of South Boulder Creek (Martin Margulies, pers. comm.). The site was located within the flood plain in the riparian zone on a nearly flat west facing slope. One sampling location was located on an island created by a diversion ditch. The soil type along this portion of South Boulder Creek is Niwot soils of 0 to 1 percent slopes.

The vegetation overstory consisted of tall shrubs, coyote willow, with some mature cottonwoods. Immature plains cottonwood and alders were also present. The patch size for this overstory is approximately 1 hectare of riparian habitat, although more patches of similar habitat were found downstream. The understory consisted of annual grasses and native perennial grasses including *Poa compressa* and *Carex* sp. Also present were short shrub species, wild licorice (*Glycyrrhiza lepidota*) and some exotic species, including Canada thistle and musk thistle.

This site exists within a large complex of open space parcels along South Boulder Creek, which flows year-round. The site is bounded to the south by Highway 36 and to the east by the Open Space operations buildings. To the west and north are Open Space parcels.

El Paso County

Monument Valley Park

E.R. Warren's 1912 apparent observation of a "very young jumping mouse" (Warren 1942) in Monument Valley Park of Colorado Springs establishes this historic site. The park is located in the center of Colorado Springs near Colorado College along Monument Creek. Note that Warren included his observation with discussion of *Z. h. campestris*.

Monument Valley Park is 2 miles long and has a bicycle and hiking path on both sides of the creek. Given the length of the park, the precision in locating this historical site is 1 mile in either direction along the drainage.

The site chosen for the vegetation transect and trapping was in the northwest portion of the park. This portion was chosen because of its seclusion from park visitors. The elevation is 6050 ft. which made Monument Valley Park the site in this study with the highest elevation.

Monument Valley Park is the only historic site in the Arkansas River watershed, although near the headwaters of Monument Creek is a recent capture site, the Air Force Academy grounds. This population has been documented by the Colorado Natural Heritage Program (A.R. Ellingson, pers. comm.). Monument Creek flows year-round, and evidence of heavy spring flooding was found in the study site in the form of sand deposits and piles of debris. The transect and trapping site was located within the floodplain of the creek on the east facing slope of approximately 2 to 3 percent. The geomorphology of the site is disturbed due to the large retaining walls that were installed in the 1930's. The soil

type is loams Ustic Torrfluents.

The vegetation along the transect consisted of plains cottonwoods, Chinese elms (*Ulmus pumila*), and tall shrubs (coyote willow). The understory vegetation consisted of tall herbaceous material including rehabilitation grasses, poison hemlock (*Conium maculatum*), and some patches of short shrub species. Overall, the area was thickly vegetated.

The context of Monument Valley Park is one of an urban park corridor. During the mid 1930s, a Federal project was undertaken to channelize the Monument Creek banks in an effort to control flooding. This project substantially changed the riparian corridor by paving the embankments with flag stone and reseeding the remaining flood plains. Today, residential and commercial development borders the park on both the east and west banks. The Colorado College grounds and the surrounding homes have been established for over 90 years. Additionally, pedestrians and bicyclists constantly are present in the park during the day.

Jefferson County

Semper

Two captures in 1909 by R.B. Rockwell were from two locations by Semper, Colorado. Semper was a railroad siding at the current intersection of 88th Avenue and the Colorado and Southern railroad tracks. The two locations, Semper proper (Semper 1) and 1 1/4 miles west of Semper (Semper 2), are separated by 2.5 km (1 1/4 miles). Both locations are in Westminster, Colorado.

Semper 1

The Semper 1 site is located approximately 0.6 miles west of Highway 36. It was formerly a railroad siding, but is now the location for a Westminster water treatment facility called "Semper." For this reason, the location is precisely known within a quarter mile at an elevation of approximately 5460 ft.

Ownership in the area is checkerboard in nature. The City of Westminster owns the Water Plant, the Colorado and Southern Railroad owns the tracks and the adjacent rights-of-way, and the remaining tracts are owned by various developers. The area is zoned for commercial use and some development has taken place, such as the Westminster Mall to the northeast. Other areas, at the time of the site visit, were currently under construction. Very little vacant land is remaining immediately surrounding the Semper site.

The Allen Ditch carries water from Standley Lake through the area. It parallels the railroad tracks until it reaches the intersection of 88th Avenue, then it turns east. The

ditch is about two meters wide as it flows through the Semper area. It has the typical steep embankments (45%) associated with irrigation ditches. The banks alternate from being concrete-lined, to filled with broken asphalt, to dirt, then back to concrete. The topography adjacent to the ditch is relatively flat and has been reworked, therefore the geomorphology is disturbed and consists of man-made fill materials. The soil type is called Nunn-Urban land complex on 0 to 2 percent slopes. According to the soil survey, the Urban portion refers to man-made features including pavement and recontouring which have influenced the soils.

The vegetation at Semper 1 is best described by discussing portions of Allen Ditch, starting first on the north side. Beginning at 88th Avenue and traveling upstream, the first 150 meters are lined with shrub patches of coyote willow and greasewood (*Sarcobatus vermiculatus*) with an understory of wheatgrass and musk thistle. The next 100 meters contain a few plains cottonwoods and another small patch of coyote willow. The next 1400 meters are lined with rehabilitation grass species including timothy (*Phleum pratense*) and crested wheatgrass. The south side of the ditch is all exotic species including Canada thistle, musk thistle, smooth brome, with the occasional willow plant and a few cottonwood saplings. The south side of the ditch has sparse ground cover compared to the north side. Both sides are littered with trash, concrete slabs, and pieces of asphalt.

The Semper 1 site is a narrow strip of patchy riparian vegetation within a commercially developed area. The Westminster Mall and all associated development including mini-malls, restaurants, parking lots, and maintained lawns are established to the north and east of Allen Ditch. The Colorado and Southern Railroad, the Westminster Water Plant, and West 88th Avenue are to the south and west. Upstream about 2 km, Allen Ditch water is carried in aqueducts. Downstream, the ditch turns east, following West 88th Avenue, and has concrete lined banks adjacent to maintained lawns. Therefore, the narrow strip of willow and cottonwood is quite isolated.

Semper 2

The second site, which is 2.5 km (1 1/4 mi.) west of Semper, is in an area totally developed in recent years. At the point of 1 1/4 miles west of Semper, the north side of West 88th Avenue is the site of the Charles O. Moore Middle School. To the south side is the Pebble Brook condominium development.

The drainage associated with the historic capture is not apparent, indicating that the drainage may have been altered or eliminated since 1909. Existing drainages in the area are the unnamed ditch flowing through Nottingham Park to the south of 88th, and the Highline Canal to the north. The southern drainage is approximately 1/2 km from West 88th Avenue and the Highline canal is over 1 km to the north. Both drainages have maintained lawns adjacent to the banks of the ditch and both ditches are narrow, offering little opportunity for the establishment of riparian vegetation.

Rock Creek, Rocky Flats Buffer Zone

Rock Creek is located within the Rocky Flats Buffer Zone and is a drainage containing a viable population of *Z.h. preblei*. The study site was located at the confluence where three of the four Rock Creek tributaries converge at an elevation of 5775 ft. This confluence site will be used to compare to the historic capture sites. Meadow jumping mice have been captured here since 1991 with the most recent captures being in September of 1995.

Rock Creek is an intermittent stream. Its headwaters are in the western edge of the buffer zone and as the creek drops in elevation from the piedmont, steep embankments lined with tall upland shrubs define the vegetation. As the creek moves away from the piedmont edge, springs and seeps feed the drainage, so that portions of the main channel retain water year-round.

The vegetation transect is located at the confluence. This transect is within the flood plain of the creek, on the southeast facing slope (1-2%). Alluvial flow is evident and the geomorphology is heavily influenced by flood events. The soil type is Haverson loam along 0 to 3 percent slopes.

The vegetation is best described as a riparian shrub community consisting of coyote willow and leadplant, with scattered plains cottonwoods. The understory consists of native herbaceous plants with some exotics present including Canada thistle, Japanese brome (*Bromus japonicus*), and smooth brome. The riparian corridor patch size is approximately 0.1 hectares, although many patches occur both above and below the confluence.

The context of this confluence site in relation to adjoining land uses is of a native area recovering from past grazing within a large tract of similar land use. Except for the presence of Highway 128, this Rock Creek site is surrounded by open space in 2 km in any direction. Human activity is very limited in the area.

Walnut Creek, Rocky Flats Buffer Zone

The Walnut Creek site at Rocky Flats was used as another area to compare to historic sites. Recent captures of meadow jumping mice occurred at this location in 1992 (EG&G 1992) at an elevation of 5670 ft.

This site is owned by the Department of Energy and like Rock Creek, is zoned as a Federal holding. The ownership may change in the near future, however. Possible owners include Jefferson County Open Space.

The vegetation transect was located at the confluence of upper and lower Walnut Creek branches and the stream flow of this portion of the creek is affected periodically by

discharges of effluent from the upstream holding ponds. The flow of Walnut Creek is therefore heavily influenced by the upstream pond management. The transect was located on both sides of the stream to coincide with capture locations. The sampling plots were all located within the flood plain of the creek with three plots on the north facing slope and two on the south facing slope. Geomorphology is influenced by flood events and alluvial material is present. The soil type is Englewood clay loam on 0 to 2 percent slopes.

The vegetation at the Walnut Creek transect site consists of an overstory of tall shrubs, predominantly coyote willow and immature plains cottonwoods. The understory is composed of short shrub species and dense herbaceous material. The short shrubs are snowberry, and wild rose. Herbaceous plants include Canada bluegrass (*Poa compressa*), Japanese brome, Canada thistle, and wild licorice. Adjacent to the riparian area is a large expanse of upland mesic grassland intermixed with snowberry and Canada thistle. The patch size of riparian vegetation is approximately 0.15 hectares.

This recent capture site exists within the greater Rocky Flats Buffer Zone, approximately 14 sections of former pasture land. The Buffer Zone property is undeveloped land and has few human visitors. The site is surrounded by at least 2 km of Buffer Zone property in any direction. The pond management areas are approximately 2 km upstream along the lower (southern) drainage and Indiana Avenue is 2 km west of the study site.

Larimer County

River Bend Open Space Parcel

The historic site from the Fort Collins area is described as 2.5 miles southeast of town. This description is from a 1954 capture by an anonymous biologist. The specimen is a part of the Colorado State University mammal collection. The precise location of the site is difficult to determine, because the actual starting point is unknown (e.g., from the edge of town in 1954 or from the post office?). For this reason, the historic site is known only in a general way. Many sites exist as possibilities for current suitable habitat, including Arapahoe Bend, Archery Range, Spring Creek, and River Bend Open Space Parcels. All these properties are owned by the City of Fort Collins and are managed by the City's Natural Resources Department.

Upon reviewing the Fort Collins area 1930 vintage soils maps which were overlaid on topomaps, the south east edge of town was about one mile west and north of where it is today. A likely looking parcel for jumping mouse habitat was in the southern half of section 17 or in section 20. Both areas are along the Cache la Poudre River. Additionally, the southern half of section 17 had a large area detailed as wetland/alkali lands. Today this site is the River Bend Open Space Parcel at 4895 ft. elevation. This area in section 17 was chosen to represent an area of possible historic occurrence.

Trapping and vegetation measurements took place on the west bank of the Cache la Poudre River although some traps were also placed on the opposite shore. The location of the study site was within the flood plain and the riparian zone of the river. Alluvial flow in the form of gravel bars and large mats of debris was evident. The geomorphology therefore is heavily influenced by flood events. The substrate is alluvium as the area has been mined for gravel on both sides of the river. The river wash type appears above and below the gravel pit polygon on soils map indicating that this was probably the conditions prior to graveling.

The vegetation along the transect is best described as a riparian forest complex. The overstory consisted of large mature plains cottonwoods and other smaller tree species including American elm (*Ulmus americana*), green ash, mountain maple (*Acer glabrum*), Russian olive, and peach-leaved willow. An underlying shrub component consisted mostly of coyote willow. The herbaceous understory consisted of mostly graminoid species, especially orchard grass.

This study site is a riparian area adjacent to a large open space parcel managed for wildlife and controlled recreation. A bike path and industrial development border the area to the west, while residential development borders the area to the north and east. Prospect Avenue bounds the parcel to the south, but the Cache la Poudre River provides a connection to downstream open space parcels.

Weld County

Fort St. Vrain

The historical records from the Fort St. Vrain Nuclear Generating Station property are from a report prepared by the Thorne Ecological Institute and Dr. Bruce Wunder of Colorado State University. Three individuals of *Z.h. preblei* were captured, one each year in 1972, 1976, and 1977. The precise location of the site was pin-pointed for this project (Dr. Bruce A. Wunder, pers. comm.).

The vegetation transect site and trapping site are at an elevation of 4750 ft. The land is owned by Public Service Company of Colorado and is zoned for agriculture. This area north of the generation station is currently leased to ranchers and farmers for grazing and crop production.

The trapping and vegetation transect sites are located together along an irrigation ditch which flows northeast from the generating station to a farm pond (reservoir). The site is within the river bottom of the South Platte River and is relatively flat in relation to slope and aspect. The exception to this topography was the irrigation ditch embankment which slopes at 10% and faces east. The vegetation transect was located along this embankment due to the fact that this was where the *Z.h. preblei* historic captures took place. The geomorphology of this area is disturbed river bottom deposits. The soil type

is Bankard sandy loam on 0 to 3 percent slopes.

The vegetation consisted of a few mature plains cottonwoods, tall bunch grasses and dense stands of herbaceous plants. Some small patches of snowberry were also present.

This historic site is located within a river bottom agricultural area. Grazing and crop production are adjacent land uses to the west and south. A large farm pond is located to the north of the site. To the east is more river bottom habitat with mature cottonwoods and an annual grass and forb understory. Northwest of the site approximately 2 km, is the confluence of the St. Vrain Creek and the South Platte River.

Hudson

The historical capture as recorded by D.V. Cunningham in 1956, gives a site description of "6 miles east of Hudson, Colorado." From this description, the capture site is precisely located within one square mile. Starting from the railroad tracks in Hudson, there is an irrigation canal, the Denver/Hudson Canal, exactly 6 miles east of town on Highway 52. The precision is possible because Hudson is such a small community and therefore the starting point is easily determined. The site is two miles east of the Colorado Division of Wildlife's Banner Lake Wildlife Area. Banner Lakes is clearly not the historic site. The site chosen is a private parcel, with an elevation of 5020 ft. The owners of the property are James and Georgene Brnak of Keenesburg and the land is zoned for agricultural use.

The study site is located on a north-facing slope of the Denver/Hudson Canal, where seepage from the canal has promoted wetland and shrub growth. A portion of the site is in the old intermittent drainage that ran northeastward prior to the canal construction according to 1927 vintage soil surveys. The slope of the site was approximately 10 to 12 percent. The seepage area is widest adjacent to the canal embankment and becomes narrower approaching the northern portion of the parcel. This northern portion of the parcel becomes quite dry and a prairie dog town has become established.

Overall, the vegetation is a shrubby riparian plant community with mature plains cottonwoods, peach-leaved willow, and cattails established. Moving away from the canal, the area becomes more mesic with grasses and short marsh predominating. Finally, dry channels are present with annual grasses and forbs surrounded by the prairie dog town.

The context of the site in relation to adjacent land uses is one of near isolation. The site is bordered by Highway 52 to the north, to the south and west by crop fields of predominately wheat, and to the east by a farm house and eventually the Keenesburg High School. The only corridor for animal movement would be along the canal which eventually drains into Prospect Reservoir, approximately 6.5 km to the south. Additionally, this site has been occasionally grazed.

RESULTS

Of the 15 historic sites visited, 11 were chosen to conduct vegetation analysis. Sites were omitted from the analysis based on lack of suitable vegetation (e.g., Semper) or lack of land owner permission to access a parcel (e.g., Elmer Johnson Ranch). The 11 sites chosen were:

- Badding Reservoir, Adams County
- Dry Creek Open Space, Boulder County
- Left Hand Canyon/Crestview Subdivision, Boulder County
- Niwot Trail Open Space, Boulder County
- Sawhill Ponds Open Space, Boulder County
- South Boulder Creek Trailhead West Parcel, Boulder County
- Tracy Collins Open Space, Boulder County
- Monument Valley Park, El Paso County
- River Bend Open Space, Larimer County
- Fort St. Vrain, Weld County
- Hudson, Weld County

From the 11 sites chosen for vegetation analysis, six were chosen for trapping. Selection was based on the ability to precisely locate the historic site and the knowledge of Boulder City and County Open Space research team's intentions to trap on Boulder City and County Parcels. The sites chosen for trapping were:

- Badding Reservoir, Adams County
- Left Hand Canyon/Crestview Subdivision, Boulder County
- Monument Valley Park, El Paso County
- River Bend Open Space, Larimer County
- Fort St. Vrain, Weld County
- Hudson, Weld County

Trapping results in Boulder Open Space parcels of historical significance are included in this report courtesy of Dr. David Armstrong.

In addition to these historic sites, four sites of recently documented *Zapus hudsonius* occurrence were visited and vegetation analysis was conducted at three of these sites. The three sites were:

- Van Fleet Open Space, Boulder County
- Rock Creek, Rocky Flats Buffer Zone, Jefferson County
- Walnut Creek, Rocky Flats Buffer Zone, Jefferson County

The fourth site is East Plum Creek in Douglas County. Results have been provided

courtesy of Dr. Fred Harrington. All the recent sites have had *Z. hudsonius* captures this year with the exception of Walnut Creek where captures occurred in 1992 (EG&G 1993). Numerous captures have occurred in Walnut Creek at upstream locations, just not at this location this year.

Vegetation Transect Results Historic Capture Sites

The 11 sites visited for vegetation measurements encompassed 10 sites in the South Platte River drainage and one site in the Arkansas River drainage. One-way ANOVA statistical tests at the 95 percent confidence interval were run for each measurement across all sites. Each site is discussed here in terms of notable vegetation transect measurements making it stand out from the other historic sites (Table 2 and 3).

Badding Reservoir, Adams County

The vegetational structure along the transect established at Badding Reservoir included trees, shrubs, and herbaceous vegetation. The canopy cover developed from trees and shrubs was average (Table 3) compared to all historic sites although significantly less than canopy cover at the River Bend Open Space Site and Sawhill Ponds. Tree height was significantly greater at other historical sites with the exception of the Left Hand Canyon site and the Fort St. Vrain site. These three sites had mature trees within the vegetation plots.

The tall (large) shrub component, consisting mainly of *Salix exigua*, is average in terms of shrub height and shrub corridor width, but low in the number of shrubs per hectare compared to all other historic sites. Shrub height was significantly less at the Fort St. Vrain and the Left Hand Canyon sites when compared to Badding Reservoir. Both the large shrub height and the shrub corridor width were significantly less at Badding Reservoir compared to Sawhill Ponds. Small shrub species such as *Symphoricarpos occidentalis* or wild rose were not present at this site.

Herbaceous vegetation consisted mostly of graminoids including smooth brome (Table 2). The herbaceous vegetation was relatively low in height although dense when compared to other historic sites. Litter depth was the greatest at this site due to the combination of dead smooth brome and willow material. Ground cover consisted mostly of litter and grass. The percentage of grass cover was significantly higher than at seven other sites.

The continuous riparian vegetation corridor measured approximately 400 meters. This was considerably less than some sites, especially those located along rivers, yet four sites were shorter in corridor length than Badding Reservoir.

Dry Creek Trail, Boulder County

The vegetation along Dry Creek contained trees, shrubs, and herbaceous plants. The canopy cover was mostly from shrubs, coyote willow and leadplant. Canopy cover was quite variable ranging from 9 percent to 88 percent. On average, the canopy cover measured at this site was typical of that measured at other historic sites.

The number of trees along the transect were few, one green ash and one Russian olive. The tree heights were average at Dry Creek compared to other historic sites.

Height of tall shrubs (i.e., willow and leadplant) were more variable than at other sites, ranging from no shrubs to 2.44 m. The number of shrubs, including tall and short shrubs, averaged 16.4 per plot. This number was a median value among all historic sites. The width of the shrub corridor was not significantly different than at any other historic site except Fort St. Vrain, where shrubs were scarce.

Herbaceous vegetation was composed of both graminoids and forbs (Table 2). The herbaceous plant density was the most variable among historic sites, and the herbaceous height was relatively shorter. The only site with herbaceous plant heights shorter than Dry Creek were South Boulder Creek West and Tracy Collins.

Ground cover at Dry Creek Open Space consisted mostly of litter and soil. Noteworthy was the relatively high forb and rock components to ground cover compared to other sites (Table 3).

Land form measurements (see Methods) were noteworthy at Dry Creek. The meandering channel ratio was the highest measured at 1.3 meters per meter on a straight line. This means that Dry Creek meanders more than other transect locations. The distance to the nearest confluence was only 30 m. All these land form factors helped to create the varied habitats along this section of the creek.

Left Hand Canyon, Boulder County

Left Hand Canyon has a different vegetation composition and structure than any other site. The canopy cover was provided exclusively from trees except at the far end of the study area. Tall trees including narrow-leaved cottonwood and black walnut provided 70 percent canopy cover on average over the vegetation transect. At the last plot, coyote willow contributed to canopy cover. Willows combined with narrow-leaved cottonwoods provided 28 percent canopy cover at the last plot.

Tall and short shrubs were absent until the last plot on the transect. At this point, the shrub height was 1.54 m and the number of shrubs per plot was eight. The shrub corridor was 6 m wide which is relatively narrow. Shrub measurements describing the entire transect were much less, of course, due to averaging with plots that had no shrubs.

Herbaceous vegetation was present but sparse. Graminoids present were smooth brome and orchard grass. Forbs included *Conium maculatum* and *Ambrosia psilostachya*. Herbaceous vegetation density was not distinguishable from density at many sites, although densities at Left Hand Canyon were significantly lower than four of the 11 historic sites. Herbaceous vegetation height was quite tall at 1.92 m on average (Table 3). Six historic sites had heights significantly lower than at Left Hand Canyon.

Litter depth averaged lower than at other sites. Although litter depth was low, ground cover was composed primarily of litter. This measurement was higher than the litter component of ground cover at eight other sites.

The riparian vegetation corridor was measured as the longest continuous corridor at any of the historic sites. This site is located at the mouth of a canyon, so the corridor continues upstream adding considerable length. The nearest confluence was 400 m from the study area.

Niwot Trail Open Space, Boulder County

The Niwot Trail Open Space Parcel has mature and young plains cottonwoods, but very few shrub patches. The vegetation transect was placed in one such coyote willow patch. The canopy cover derived from both trees and shrubs measured significantly lower than four other sites (River Bend Open Space, Sawhill Ponds, South Boulder Creek West, and Left Hand Canyon). Although no trees fell within the sampling plots, canopy cover was provided by young plains cottonwoods and Russian olive trees.

The height of the only tall shrub present, coyote willow (Table 2), was not distinguishable from tall shrub height measurements at other historic sites. The exception to this was Left Hand Canyon which had few shrubs and Sawhill Ponds where shrubs were relatively tall. Short shrub species were not present along the transect. The shrub width was narrower than at other historic sites, being significantly less than at Sawhill Ponds, South Boulder Creek West, Monument Valley Park, and Hudson.

Herbaceous plants included both graminoids and forbs (Table 2). Herbaceous plant height at 1.5 m on average was relatively tall, significantly higher than at five other historic sites. Vegetation density, also was significantly greater than at five other historic sites. South Boulder Creek West, Dry Creek Open Space, and Tracy Collins Open Space had both herbaceous plant height and density that was less than the same measurements at Niwot Trail.

Ground cover at this site was composed mostly of litter. This corresponds to the high litter depth found throughout the transect area. Tall, dense stands of grass and forbs year after year were responsible for the large amounts of litter material. Also noteworthy, was grass cover at an average of 14 percent, relatively high compared to other sites.

The Niwot Trail Parcel had one of the longest continuous corridors of riparian vegetation found at any historic site. This corridor was comprised of the many cottonwoods established along the irrigation ditches.

Sawhill Ponds, Boulder County

This site along Boulder Creek had vegetation best described as lush riparian forest. Tree species included many narrow-leaved and plains cottonwoods (Table 3). Numerous small patches of willow were present as was dense herbaceous ground cover.

The canopy cover at Sawhill Ponds was the highest measured (82%) among all the historic sites (Table 3). Trees were present in approximately every other plot, and were about 2.8 m in height. Shrubs, mostly coyote willow, were relatively tall compared to other sites. Both trees and shrubs contributed to the canopy cover.

No short shrub species were noted. The shrub corridor width was patchy, but quite wide where present. The width was significantly greater than at Fort St. Vrain, Left Hand Canyon, Niwot Trail, and Badding Reservoir.

Herbaceous plants included orchard grass, smooth brome, and Canada thistle. Vegetation density on average was surpassed by only one site, Monument Valley Park. Seven sites had densities significantly less than at Sawhill Ponds. Herbaceous plant height was the tallest of any historic sites. This was due to the orchard grass present along the transect. Correspondingly, litter also was relatively deep.

Ground cover was comprised mostly of bare soil and litter cover. The soil value was surprisingly high given the amount of herbaceous material and the litter depth. This suggests that litter was not evenly distributed across the transect area probably due to flooding.

The riparian corridor was approximately 350 m long. Seven sites had longer stretches of riparian vegetation and this fact corresponds to the type of watercourse associated with the site. Larger rivers have long corridors, whereas smaller creeks tend to have shorter corridors. The nearest confluence was approximately 850 m from the transect location.

South Boulder Creek West Trail, Boulder County

South Boulder Creek West has a strong tree component in the vegetation. Mature plains cottonwoods are present along with many narrow-leaved cottonwoods of lesser height. The overall tree height at the site averaged 3.0 meters (Table 3). Not many willow patches were present, so the majority of the canopy cover came from trees. Additionally, the number of trees per plot was the highest among historic sites.

Two species of short shrubs, *Rosa* sp. and snowberry, were present in the understory.

The number of these shrubs per plot was relatively low. The shrub corridor width was quite variable due to the patchy nature of the shrubs.

Herbaceous vegetation density and height were the lowest at any historic site. This area is grazed from time to time, although no cattle were present during the survey.

Ground cover was composed of litter and soil. The soil cover was significantly higher than three sites. Grass ground cover was also relatively high at an average of 17 percent. This level was significantly higher than at six other historic sites.

The riparian vegetation corridor length is quite large due to the many mature plains cottonwoods. The nearest confluence was approximately 1710 meters from the transect location, although two irrigation ditches cross the parcel in close proximity to each other.

Tracy Collins Open Space Parcel, Boulder County

Canopy cover at Tracy Collins included both trees and tall shrubs and was typical of measurements at other historic sites. Tree height along the transect was relatively short compared to other sites, although tall shrub species measured relatively tall, 2.4 m on average.

Short shrubs were abundant along the transect. Two species, rose and snowberry, contributed to heights relatively tall compared to other historic sites. The heights of short shrubs at Tracy Collins were significantly taller than at six of the eleven sites visited. Due to the abundance of short shrubs and the presence of many young tall shrub plants, the number of shrubs per plot was significantly higher than at any other historic site visited. This is probably due in part to the shrubs recovering from the flood event in the spring of 1995 and to the limited grazing that occurs on this parcel. Overall, the shrub corridor width was within the range of measurements at most other historic sites.

Herbaceous vegetation was relatively sparse and short at Tracy Collins. Vegetation density measurements were significantly less than at nine other sites and heights were significantly less than six other sites. Correspondingly, litter depth was relatively shallow. The scarcity of herbaceous vegetation could be an effect from grazing, but could also be an indication of the rocky substrate found at this site.

Ground cover was composed mostly of litter and soil. Rock cover, a relatively small portion of the total ground cover, was a relatively high proportion compared to other sites. This is probably a reflection of this site's location along the Colorado Piedmont and of the spring flood event. Of note, was the shrub ground cover measurement of 5 percent. This was the significantly highest measure of this type of ground cover. This value can be explained by the abundance of young willow and short shrubs present at the site.

The riparian vegetation corridor length was approximately 1800 m. This was one of the

longest corridors. The meandering ratio was 1.2 m/m (see Methods). The nearest confluence to the vegetation transect was only 40 m. These two landform features help to create the diversity of vegetation along the corridor overall. The diversity of habitats along the corridor includes short marsh, willow patches, cattails, cut banks, rocky braided channels and areas of silt deposits.

Monument Valley Park, El Paso County

The Monument Valley Park vegetation transect was the only transect studied in the Arkansas River drainage. All other sites were in the South Platte drainage.

Canopy cover was exclusively from coyote willow (Table 2). Values were quite variable, ranging from no canopy to 76 percent. The shrub height was within the normal average range of historic sites. Short shrubs were also present along the transect (Table 2 and 3) and the heights of these shrubs were the tallest recorded. All other historic sites had short shrub heights less than Monument Valley Park (Table 3). Note also that the species of shrubs were those typically present at sites in the South Platte drainage (Table 2). The number of shrubs per plot were relatively high with five other sites having significantly less shrubs per plot. Average shrub width was approximately 18 m. Three sites, Fort St. Vrain, Left Hand Canyon, and Niwot Trail had widths significantly narrower than Monument Valley Park.

Herbaceous vegetation density was the highest of any site. Only two other sites (Sawhill Ponds and Niwot Trail) had densities near this level. The density was due mostly to grasses at Monument Valley Park. Table 2 lists the dominant herbaceous plant species present. Herbaceous vegetation height was relatively tall at this site. Ground cover at Monument Valley Park was composed mostly of litter and soil cover as was typical at many of the other historic sites.

Landform measurements (i.e., riparian vegetation corridor length, meandering ratio, and distance to a confluence) were all within the typical range of historical sites (Table 3). Monument Valley Park has the highest elevation of all the historic sites.

River Bend Open Space Parcel, Larimer County

The vegetation transect at the River Bend Open Space Parcel was located at the Cache la Poudre River. The vegetation here is typical of riparian vegetation along large water courses along the Front Range of Colorado. Canopy cover along the transect was provided by trees and shrubs and the cover was significantly higher than at six other historic sites (Hudson, Monument Valley Park, Niwot Trail, Badding Reservoir, Fort St. Vrain, and Dry Creek). The trees encountered along the transect included plains cottonwoods, green ash, and mountain maple. Tree heights were relatively short, but statistically distinguishable from only two other sites.

The only shrubs encountered were coyote willow. These shrubs were significantly taller than those measured at five other historic sites. Additionally, the number of shrubs per plot at River Bend were significantly higher. Only one site, Tracy Collins, had more shrubs per plot. Shrub corridor width was well within the range found at all the historic sites.

Herbaceous plants included a mixture of graminoids and forbs (Table 2). The vegetation density from herbaceous plants was low, with six other sites measuring significantly higher densities. Height of the herbaceous vegetation was higher than five other sites at 1.51 meters on average, and only one other site, Sawhill Ponds, had taller herbaceous vegetation. Litter at the River Bend site was within the normal range at all sites. Ground cover within the study area approached an even partition of soil and litter. The soil ground cover measurement was relatively high for historic sites.

The riparian vegetation corridor was approximately 600 m long. The corridor area was highly divided and disturbed by gravel bars and sloughs. Corridor length and width created a patch size of 9 hectares were the vegetation measurements and the trapping was conducted. The meandering ratio was high compared to all sites, 1.2 m/m. This distinguishes the water course from a straight line situation as is found at ditch sites (e.g., Semper and Fort St. Vrain). The nearest confluence from the study area was with Spring Creek tributary, 550 m upstream.

Fort St. Vrain, Weld County

The Fort St. Vrain transect was established along a ditch precisely where meadow jumping mice were captured in the mid-1970s. The ditch was straight and narrow and these transect measurements are quite different than most of the other site transects. Along the vegetation transect, a few mature plains cottonwoods were present and tall shrubs were absent. Two trees were included in the transect measurements and the heights were 3.5 m. and 13 m. Fort St. Vrain was the only site where the transect did not have tall shrubs present; however, tall shrubs are present in the general area.

Snowberry was the only short shrub encountered. The height of these shrubs was well within the range observed at most sites. Only Monument Valley Park had greater height measurements. Average number of shrubs per plot at Fort St. Vrain was the lowest recorded for any site, and shrub corridor width was the narrowest.

Herbaceous vegetation (density and heights) on the other hand, was within the usual range of measurements at historic sites. Both graminoids and forbs were present along the transect (Table 2). Litter depth was moderate with four sites having depths significantly greater than Fort St. Vrain.

Ground cover at the Fort St. Vrain study site was composed mostly of litter and bare soil cover, although the litter component was significantly lower than at four other historic sites

(Table 3). The forb cover, an average of 14.4 percent, was one of the highest values recorded. This site and Dry Creek were significantly higher than all other sites for forb cover. Tree ground cover is also notable, but probably not important. One large tree fell within the last plot and this fact explains the rather high tree component for ground cover. Regardless, this value is still not distinguishable from tree ground cover at other sites.

The vegetation corridor was 300 m long. It would be incorrect to call this corridor riparian, although riparian habitat was found approximately 200 to 250 m away, along the South Platte River. The meandering ratio was 1.0 m/m, describing the straight line nature of the ditch where the transect was located.

Hudson, Weld County

Hudson contained mature cottonwoods, patches of tall willow and wetland area. Canopy cover was derived from trees and shrubs, although no trees fell within any of the transect plots. The canopy cover was relatively low with five other sites having significantly higher percentages.

The only shrub present (coyote willow - Table 2) is watered by seeps along the canal embankment. Shrub height was typical among historic sites. The number of shrubs per plot were relatively high, at an average of 25 per plot (Table 3). Five sites showed significantly lower values for the number of shrubs compared to Hudson. Shrub width was quite variable along the transect with values ranging from no shrubs to a width of 35 m. The average value (Table 3) was within the typical range of historic sites.

Herbaceous vegetation was composed of graminoids and forbs including wetland species such as cattails (Table 2). Vegetation density and herbaceous vegetation were median values compared to other sites. Litter depth was 49 mm on average which was significantly higher than that at Left Hand Canyon, Tracy Collins, South Boulder Creek West, and Fort St. Vrain. Ground cover was composed mostly of litter at Hudson. There was much matted vegetation from both cattails and rushes as well as some wind blown vegetation captured by the shrubs.

The continuous riparian vegetation length at Hudson was the lowest recorded. However, the willow areas were interspersed among wetland and dry upland areas. There were really five large patches of willow habitat, one of which the vegetation transect was placed. The size of this willow patch was 10 hectares. The nearest confluence was 450 m upstream.

Summary of Vegetation Transects for Historic Capture Sites

In summary, the following distinctions were noted in comparing vegetation measurements and species composition at historic sites. The Sawhill Ponds Open Space parcel contained the highest measurements for several vegetation components: highest tall shrub, canopy cover, and herbaceous vegetation height. Additionally, herbaceous vegetation density and litter depth were relatively high. One interesting note, the short shrub structural component is missing from this site, at least within the transect area. This absence should not be overemphasized. Sawhill ponds offers many areas of possible *Z. hudsonius* habitat and the transect data presented in this report represents only one such area. Five other sites also lacked a short shrub component in the vegetation structure (Badding Reservoir, Hudson, Left Hand Canyon, Niwot Trail Open Space, and River Bend Open Space). The Fort St. Vrain study area had poor representation of any shrub components. No tall shrub patches and very few snowberry patches distinguished this site from all others.

Although herbaceous vegetation measurements were low at Tracy Collins and South Boulder Creek West Open Space parcels, Tracy Collins had strong shrub components as part of the vegetation structure. Both tall and short shrub species were present indicating the presence of both tall and short shrub structural components. Additionally, the number of shrubs per plot and the shrub ground cover were significantly higher than the other historic sites. South Boulder Creek West parcel had the highest number of trees per plot. It is interesting to note that both of these parcels are grazed periodically.

Ground cover at all sites typically was mostly litter or bare soil cover. Sites that differ from this typical situation were Badding Reservoir with a high grass component, Fort St. Vrain and Dry Creek Open Space with high forb components, and Tracy Collins with high shrub and rock components.

All other measurements at the historic sites fell within an average range and were not particularly useful in distinguishing sites. The measurements were useful in understanding what values are typical at historic sites. This will be useful in comparisons with locations where *Z. hudsonius* is currently found.

Structure of vegetation is driven partly by species composition (Table 2). The absence of snowberry, for example, documented the lack of a short shrub component at a number of sites. All sites excluding Fort St. Vrain had coyote willow present. All sites had a combination of introduced, exotic, and native herbaceous plant species.

Recent Capture Sites

Rock Creek, Jefferson County

The vegetation at the Rock Creek confluence contained trees, shrubs, and herbaceous vegetation. Correspondingly, canopy cover was formed from both trees and shrubs. Canopy cover was quite variable ranging from 2 to 79 percent. On average, the canopy cover was typical of the three recent capture sites and the 11 historic sites (Tables 3 and 4). Although canopy cover was, in part, from trees, few trees were found at this site, mostly plains cottonwoods (Table 2). Tree heights were typical compared to both recent sites and historic sites.

Tall shrub species (i.e., willow and leadplant) height measurements were typical of all sites. The average height at Rock Creek was 1.84 m. Short shrub species heights were quite low (average 0.07 m). This was significantly lower than heights at four other sites; Dry Creek Open Space, Tracy Collins Open Space, Walnut Creek, and Monument Valley Park. The number of shrubs per plot was significantly higher than eight historic sites, but was not significantly higher than the other two recent capture sites, Walnut Creek and Van Fleet Open Space. The width of the shrub corridor at Rock Creek was relatively narrow (Tables 3 and 4).

Herbaceous vegetation comprised an abundance of graminoids and forbs (Table 2). Vegetation density was relatively low compared to both historic sites and other recent capture sites. Eleven sites measured significantly higher densities for herbaceous vegetation when compared to Rock Creek. Herbaceous vegetation height and litter depth were typical compared with most other sites (Tables 3 and 4).

Ground cover at Rock Creek was comprised mostly from litter and rock (Table 4). Although the soil ground cover portion was average compared to other sites, it was not a major portion of ground cover like other sites. Indeed, rock ground cover was significantly higher than that measured at any other site, historic or recent sites. Additionally, the percentage of litter as ground cover compared relatively low to the other sites.

Land form measurements were noteworthy at Rock Creek. The meandering ratio was the greatest at this site (1.4 meters per 1 meter - Table 4). The distance to the confluence was only 18 m. Other landform measurements, riparian vegetation corridor length and distance to an embankment were average compared to the other sites.

Walnut Creek, Jefferson County

The vegetation at Walnut Creek is best described as a thick patch of coyote willow and cottonwoods adjacent to a mixture of short shrubs and grassland. Canopy cover was from shrubs and trees, and was relatively consistent throughout the transect. The canopy

cover measure was typical, on average, of measurements taken at historic and recent capture sites, only much less variable. The only tree species present along the transect was the plains cottonwood (Table 2). The number of trees per plot were few and height measurements were relatively short.

Coyote willow, peach-leaved willow, and leadplant described the tall shrub species. Tall shrub heights were consistently tall along the transect and on average were significantly taller than three historic sites. Tall shrub species were taller than those at the other recent sites as well. The shrub corridor width was typical of corridors at other sites. Wild rose and snowberry comprised the short shrub species at Walnut creek. The height of these shrubs were significantly higher than all other recent and historic sites on average. The only exception to this was Monument Valley Park (Table 2 and 4) where the average was slightly higher, however not significantly higher in an ANOVA multiple range test.

Herbaceous vegetation was comprised of both graminoids and forbs, but with less diversity of species compared to Rock Creek (Table 2). Herbaceous vegetation density was average when considering all sites, but was the highest density measured for the three recent capture sites. Herbaceous vegetation height was typical compared to all other sites. Litter depth was the highest recorded at any site, but was only significantly higher than seven sites including Van Fleet.

Ground cover at Walnut Creek was comprised mostly of litter and soil. A noteworthy portion of the ground cover was the proportion of shrubs. Like the number of shrubs per plot, shrub ground cover was a significantly larger portion of ground cover compared to most other sites (Table 3 and 4). Only Niwot Trail, River Bend Open Space, and Tracy Collins Open Space parcels had comparable values for shrub ground cover.

Two landform measures were significant at Walnut Creek. The riparian vegetation corridor was relatively short compared to all other sites. Also, the distance to an embankment was the shortest distance recorded at 0.8 m (Table 4).

Van Fleet Open Space Parcel, Boulder County

The vegetation structure along the Van Fleet Open Space parcel contained trees, shrubs, and lush herbaceous vegetation. Both trees and shrubs contributed to canopy cover. The only species of tree observed along the vegetation transect was the plains cottonwood. Very few trees were recorded, but those measured were of average height compared to other sites (Table 3 and 4).

The dominant tall shrub was coyote willow and heights of this species were typical compared to tall shrubs at both historical and recent capture sites. Short shrub species dominated by snowberry and wild rose (Table 2) were relatively tall, but not as high as at Walnut Creek or Monument Valley Park. Overall, the number of shrubs per plot was relatively great, with eight site average measurements showing significantly fewer tallies.

The shrub corridor width was the widest recorded at all sites, but was significantly wider than only nine sites.

Herbaceous vegetation was comprised of graminoids and forbs having a relatively low density. Five sites were significantly higher in herbaceous vegetation density than Van Fleet. Vegetation height was quite variable, ranging from 0.58 to 1.6 m (Table 4). Litter depth was relatively low.

The largest proportion of ground cover was mostly litter and bare soil. Van Fleet had a higher than average forb component compared to other sites. Only the Fort St. Vrain site had a forb ground cover percentage significantly higher than Van Fleet.

Land form measurements were typical compared to other sites with the exception of the distance to a confluence. The ditch diversion area was considered a confluence area and was only 20 m from the transect area and the area of recent captures.

Summary for Vegetation Transects at Recent Capture Sites

Rock Creek had relatively high densities of both tall and short shrub species, although the shrub heights were average compared to all other sites. Ground cover components differed from other sites in that the rock component was much higher. Both exotic, introduced, and native herbaceous plants were present.

Walnut Creek had consistently tall and dense shrub components within a relatively short riparian corridor. Both native, exotic, and introduced herbaceous plants were present. The Van Fleet parcel shrub component was similar to Walnut Creek. Herbaceous vegetation cover and density was quite variable along the transect.

All recent capture sites had all four vegetation structural components present. All other structural measurements at these three sites were within the normal range at all sites, historic and recent (Table 5). All three historic sites had coyote willow, snowberry, wild rose, introduced and native grasses, and native and exotic forbs (Table 2).

Principal Component Analysis

Principal Components analysis allows multivariable comparisons of all sites, simultaneously. The principal components are those that contain the most variability in the data set. Expectations for graphing the PCA information were that the recent capture sites would group together and perhaps other sites of similar vegetation structure would be contained within the same grouping.

Principal Components analysis was conducted only on variables measured within the five study plots at each site. Therefore, landform variables such as distance to a confluence, vegetation corridor length and the like were not included in this analysis. With only 70

data points for each variable, the variables could not all be used and have a strong PCA test. Therefore, additional variables has to be eliminated from the PCA. The ANOVA results revealed that some variables varied greatly within a site thus causing difficulty in distinguishing between sites. Additionally, some variables revealed such similarity between sites that the variable was not helpful in distinguishing sites. Finally, ecological considerations regarding the Preble's meadow jumping mouse and the fact that ground cover categories influence each other, the list of 19 variables was narrowed to eight (tall shrub height, short shrub height, shrub corridor width, number of shrubs per plot, herbaceous vegetation height, herbaceous vegetation density, litter and forb ground cover components).

The PCA was run for all sites using the eight variables chosen. The first three principal components, described 65 percent of the variability between sites. Eigenanalysis of the matrix revealed that height of tall shrub species, the width of the shrub corridor, and the number of shrubs provided the most variability between sites in the first principal component. The height of herbaceous vegetation, herbaceous vegetation density, and ground cover from forbs and litter provided the most variability between sites in the second principal component. The height of short shrub species and litter ground cover provided the most variability between sites in the third principal component. Additional variables not originally included were inserted in place of original variables to see if the contributions by variables changed markedly. One example was exchanging grass ground cover with forb ground cover. No exchanges made marked changes to the output indicating that the variables chosen were strongly representative of variability between sites.

Next, these eight variables were used to construct a graph representing sites along the principal component axis. Site variables were first standardized, then averaged for each site. This average was multiplied by the corresponding eigenvector component. Then each site variable was summed, noting the sign, to get a point for the corresponding principal component. These site points were plotted onto two dimensional axis graphs for all PC combinations.

Figure 2 presents sites plotted using the first versus the second principal component and Figure 3 presents sites using the first versus the third principal component. Figure 4 uses the second versus the third principal components. Instead of simply looking for groupings within the graphs, an arbitrary distance was used on both axis. Using an arbitrary restriction for grouping sites; between five for PCA 1, between ten for PCA 2 and PCA 3, similarities of vegetation structure between some sites are observed.

For the first and second principal components (Figure 2), structural similarity is observed for Walnut Creek and Van Fleet Open Space. These two sites currently contain Preble's meadow jumping mouse populations. No other sites appear similar to these sites or Rock Creek (another recent capture site) using the first and second principal components. Other similarities include Monument Valley Park and Sawhill Pond which both have tall

shrub species of relatively great heights, and Left Hand Canyon and Niwot Trail.

In graphing the first principal component against the third, only two similar groups were observed. Again, the Left Hand Canyon site and the Niwot Trail Open Space parcel were of similar structure. Relatively tall herbaceous plants, the lack of a short shrub component, a relatively narrow shrub corridor and low forb ground cover are all similar structural measures between these two sites. Also, the Dry Creek Open Space parcel and the Sawhill Ponds were similar. The number of shrubs and litter ground cover were quite similar at these two sites.

Compared to the first two principal component graphs, Figure 4 presents a higher number of similar sites. This graph represents sites based on the second and third principal components. The variability attributed to these principal components de-emphasizes the tall shrub structural component and emphasizes litter ground cover and herbaceous vegetation. Also apparent in this graph is a correlation between PCA2 and PCA3, denoted by the diagonal line. This correlation may indicate redundancy in these two principal components attributed to the averaging done to get representative points for each site.

Figure 4 reveals two groupings of four sites each. The group in the middle of the graph shows similarity to the Van Fleet Open Space parcel. The three other sites in this grouping are the Dry Creek Open Space parcel, the Fort St. Vrain site, and the River Bend Open Space parcel. These sites all have similar herbaceous vegetation structure (height and density) and similar litter ground cover.

Overall, the principal component analysis indicated that the historic sites do not tend to resemble sites currently supporting Preble's meadow jumping mouse populations, especially in shrub structure. Additionally, Rock Creek does not resemble the other two recent capture sites, the Van Fleet parcel and Walnut Creek.

Ordination of Plant Species Composition

Dominant plant species composition was analyzed by using a Fortran ordination program, DECORANA, from the Cornell Ecology Laboratory Statistical Series. The expectations of the analysis were that recent sites would group together due to similarities in species composition. Historic sites may not group with recent sites given the disturbances these sites have received. Expectations, however, were not met. Plant species presence or absence for all eleven historic sites and three recent sites were used in the ordination analysis. The variability of species composition among sites was represented almost entirely by the first two ordination axes (98.8%). It follows that only the first two axes be graphed to observe similarities in species composition among sites (Figure 5).

Figure 5 presents a graph of the DECORANA ordination axes for species composition. Each square represents a site as coded in the legend. The overall distribution of the sites

along the two axes may be explained by water availability in the form of intermittent streams; permanent streams, rivers, reservoirs, or ditches. This is depicted in Figure 5 as a dotted line surrounding sites along intermittent streams. Sites outside of the dotted line (i.e., left side of graph) have year-round water flows.

Similar groupings of sites were determined using arbitrary designation of 40 units along axis one and axis two. Five groupings were observed as denoted by solid lines. Recent capture sites did not group together as expected, but Van Fleet Open Space and Walnut Creek did show similarities to some historic sites.

Although, similarities in overall species composition were suspected between some recent and historic sites, upon further consideration of Table 2, it was determined that individual species in common between sites of "similar" species composition (as determined by ordination) were very few. This indicated that the arbitrary designations to determine similarity in the ordination graph were too great. Therefore, no similarities were noted through ordination among any of the sites for dominant plant species composition.

Trapping Results

No meadow jumping mice were captured at any of the six sites trapped. This statement is inclusive of trapping efforts at Badding Reservoir, Adams County; Left Hand Canyon/Crestview Subdivision, Boulder County; Monument Valley Park, El Paso County, River Bend Open Space, Larimer County; Hudson and Fort St. Vrain, Weld County (Table 6). Additionally, the Boulder City and County Open Space research team captured no meadow jumping mice at Tracy Collins and Sawhill Ponds open space parcels, two other historic sites. Therefore, at eight historic sites where researchers were confident they were trapping close to the actual site of past captures, no *Zapus hudsonius* were captured in 1995.

Two interesting observations were made in the small mammal assemblage of historic sites. The first was the occurrence of house mice (*Mus musculus*) at some of the historic sites. The second was the observation of domestic cats (*Felis catus*) at Badding Reservoir, Left Hand Canyon, Monument Valley Park, and River Bend Open Space. These species are associated with human alterations to the landscape including dwellings and agriculture, and indicate a trend of anthropogenic influence upon some historic sites.

DISCUSSION

Comparison of historic and recent capture sites revealed vegetational structure differences. Structural components included the tree component (T1), the tall shrub component (S1), the short shrub component (S2), the herbaceous vegetation component (H1), and ground cover.

T1 and ground cover were not particularly useful in making comparisons. Ground cover was quite similar between recent and historic sites and the role of the T1 components in *Z. hudsonius* habitat was not apparent in this study.

S1, S2, and H1 components, in terms of height and density were useful in revealing structural differences between recent and historic sites as they relate to the amount of cover provided. Recent sites always had all three components present, although the height varied among the three sites. Historic sites often had components missing such as tall shrubs at Fort St. Vrain or short shrubs at Badding Reservoir.

East Plum Creek had all four structural components present, although trees were few (Harrington 1995). With this information, four of the five recent capture sites in Colorado had all five structural components represented. It is not known whether the presence of all vegetation structural components are necessary in a riparian area to support *Z. hudsonius*. What is known is that the recent capture sites had all components and many historic sites did not. The possibility exists that combinations of only two or three structural components in Front Range riparian areas could provide adequate cover for *Z. hudsonius*. Whitaker (1972) states of populations from the Northern and Eastern U.S., that *Z. hudsonius* was present in areas of adequate herbaceous cover and areas of herbaceous and shrubby vegetation.

One site that was lacking herbaceous cover compared to other sites was the Tracy Collins Open Space parcel. The reduction in the H1 component was revealed by comparisons with recent capture sites and comparisons to other ungrazed historic sites (Tables 3 and 4). Shrub components at Tracy Collins remain relatively tall and dense. One explanation for the lack of herbaceous cover is that grazing has removed this H1 structural component. Although grazing occurs only in early summer and only for short durations, enough disturbance may have occurred to cause the recent decline or disappearance of *Z. hudsonius* from this site. The disappearance of jumping mice from this site has not been thoroughly documented (D.M. Armstrong, pers. comm.) This explanation is purely speculative at this time, although the observation of vegetation structure at this site is worth noting. Another simple explanation for the lack of herbaceous cover could be that the topographic is so different than other sites that grasses and forbs cannot be supported. If this were the case, however, why are the shrub components so well represented? Regardless, what is needed is Tracy Collins vegetation structural information prior to 1990 to make a proper evaluation of grazing impacts.

The individual variable comparisons of descriptive statistics and ANOVAs were partially reinforced by the multivariate principal component analysis of structural measures. Two recent capture sites were similar to each other in terms of shrub component measurements. No historic sites were similar to any recent sites where shrub related variables were emphasized in the principal components. Similarities between recent and historic sites were seen, however, when herbaceous vegetation and litter variables were emphasized in the principal components. An important consideration at historic sites becomes the composition of herbaceous vegetation compared to recent sites.

Although species composition as a whole was not valuable in seeing similarities among sites, all three historic sites had coyote willow, snowberry, wild rose, introduced and native grasses, and native and exotic forbs. All historic sites, excluding Fort St. Vrain, also had coyote willow. Many historic sites had snowberry, and all had some mixture of introduced and native grasses, and native and exotic forbs. Historic sites may have relatively more introduced grasses and exotic forbs contributing to herbaceous cover than recent capture sites.

Dominant plant species composition did not play an important role in determining the presence of *Z. hudsonius* as revealed by this study. Perhaps moisture availability is a better indication of habitat suitability. Other studies have related general species composition with moisture availability. Whitaker (1963) concluded that particular species of plants did not determine distribution of *Z. hudsonius* and that the general habitat and overall floristic composition were probably more important. Grass dominated sites seemed to support more jumping mice in Whitaker's study. This study did not compare complete herbaceous composition among successful and non-successful sites. Quimby (1951) concluded that moisture availability is more important than vegetation type although vegetation type did play a lesser role in distribution.

Interestingly, three of the four recent captures sites, East Plum Creek, Rock Creek, and Walnut Creek, are along intermittent streams. If moisture availability is most important in determining distribution of *Zapus hudsonius*, other habitats adjacent to intermittent streams may be used during dry periods such as in late summer. Along streams of limited flow, wet meadows and seeps may be important habitats during dry periods. Harrington (1995) described wet meadow adjacent to East Plum Creek and the Rocky Flats drainages have numerous seeps and wet meadows.

Most historic sites currently do not have the diversity of habitats that would allow alternative areas away from the main riparian zone during dry periods. These habitats have probably been lost or altered as encroaching real estate development has narrowed riparian areas and rechannelized some waterways.

The 11 historic sites studied have suffered either direct disturbances or increasing isolation. Both may have affected vegetation structure and compositions from past conditions when populations of *Z. hudsonius* was present. Typically, areas that were

disturbed appeared to have been reseeded with introduced species of grasses, either smooth brome or cultivated species of wheat grasses (Table 2). Shrub components may or may not have returned after the disturbance. Riparian zones tend to work as corridors for plant movement as well as animal movement (Gregory et al. 1991). Sites that became increasingly isolated due to surrounding real estate development appeared to have been invaded by exotic species such as Canada thistle and Russian olive from disturbed upstream or upwind areas. Missing structural components may not provide enough cover and may leave individual jumping mice vulnerable to predation. Disturbances may also extirpate populations directly or cause emigration if the disturbed parcel is not already isolated.

Although native and non-native herbaceous plants were noted at all sites, there are some historic sites that had more introduced grasses than native species. This study only recorded overall species composition of dominant plants, so strong conclusions about "naiveness" are difficult. Yet, many historic sites appeared to have been reseeded after disturbance or are being invaded by exotic species due to increasing isolation as discussed above. Invasion of exotics and reseeded of non-native grasses after disturbances may have played a major role in degrading the suitability of *Z. hudsonius* historic sites. Based on the results of this study, however, this statements is speculation at best.

The fact that no *Z. hudsonius* were captured at any precisely located historic site is disturbing. Researchers employing much less trapping effort have documented species presence at other sites (Table 6). Outright alteration of historic sites by real estate development (Left Hand Canyon and Semper), highway construction (Croke Lake), stream alteration (Monument Valley Park) or perhaps grazing (Tracy Collins) have removed vegetational structure components and undoubtedly have altered species composition, although to what degree is uncertain. Mammalian assemblages at some historic sites reflect anthropogenic influence as well. Although some historic sites may not have been directly disturbed, such as Hudson or Sawhill Ponds, they may have become increasingly isolated to the point of unsuitability. In contrast, recent capture sites are all part of a larger, relatively native, and historically undisturbed parcel of land. Sites that become isolated may no longer be repopulated through immigration from adjacent populations of the same species (Harrison 1991).

For reasons of habitat loss and isolation which are reflected in structural changes and probably species composition in the riparian vegetation, these sites appear to have been lost. Three of the six sites trapped under this study were located along the eastern edge of *Z. hudsonius* historic range in Colorado (Armstrong 1972). Therefore, the current range of *Z. hudsonius* in Colorado seems to have decreased from the former range. This trend is especially true for the areas adjacent to or east of the Interstate 25 urban corridor.

Future Recommendations

Surveys should continue along the eastern portion of the historic range of *Z. hudsonius* to better understand the current distribution in the state. One location to begin this search would be the Banner Lakes parcel owned by the Colorado Division of Wildlife.

A detailed habitat description for *Z. hudsonius* in Colorado and Wyoming is needed. This description should be based on a 6 m radius circle around each specific capture location and more general site descriptions. Special attention should be given to the detailed composition of grass and forb communities. Qualities that make a site suitable for both summer foraging and cover and winter hibernation should be determined. One researcher should be charged with the task of compiling habitat parameters at all recent capture sites. This could be done by reviewing all current reports or revisiting all 1995 capture sites and record habitat parameters using the same method. The latter suggestion should be employed only if 1995 habitat information appears incompatible between sites (e.g., cannot subject the entire data set to statistical analysis).

The effects of grazing on jumping mice should be studied. As mentioned in the discussion, 1989 measurements could be used to identify what conditions were like when *Z. hudsonius* was present at Tracy Collins and compare them to today's condition.

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List of Specimens/Records Examined

Specimens Examined (25) - BOULDER COUNTY: Boulder, (16 FMNH); S of Boulder, 1 (CU); 3 mi. E Boulder, 1 (CU); 5 mi. E Boulder, 1 (CU); 8 1/2 mi. N, 3 1/4 mi. E Boulder, 1 (CU); 3 mi. NW Niwot, 1 (DMNH); Niwot, 1, (DMNH). ADAMS COUNTY: Croke Lake, 1 (DMNH). JEFFERSON COUNTY: Semper, 1 (DMNH); 1 1/4 mi. W Semper, 1 (DMNH).

Other Museum Records (5) - LARIMER COUNTY: 2 1/2 mi. SE Fort Collins, 1 (CSU); Loveland, 2 (USNM). WELD COUNTY: Greeley, 1 (WC); 6 mi E Hudson, 1 (CSU).

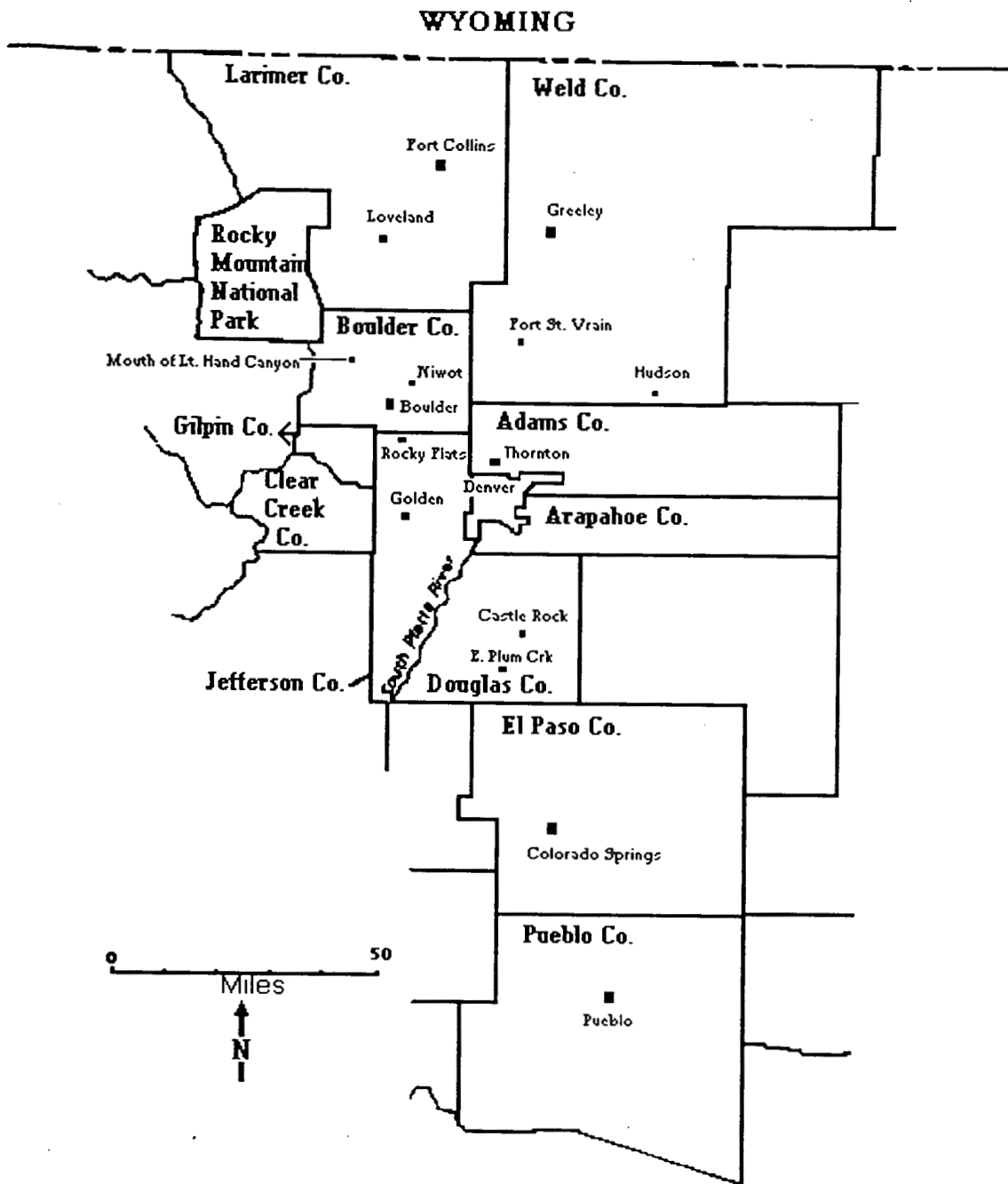


Figure 1. Counties and Important Locations Along the Colorado Front Range Corridor, 1995

Figure 2. Principal Component Analysis of Selected Structure Variables, PCA1 vs. PCA2, 1995

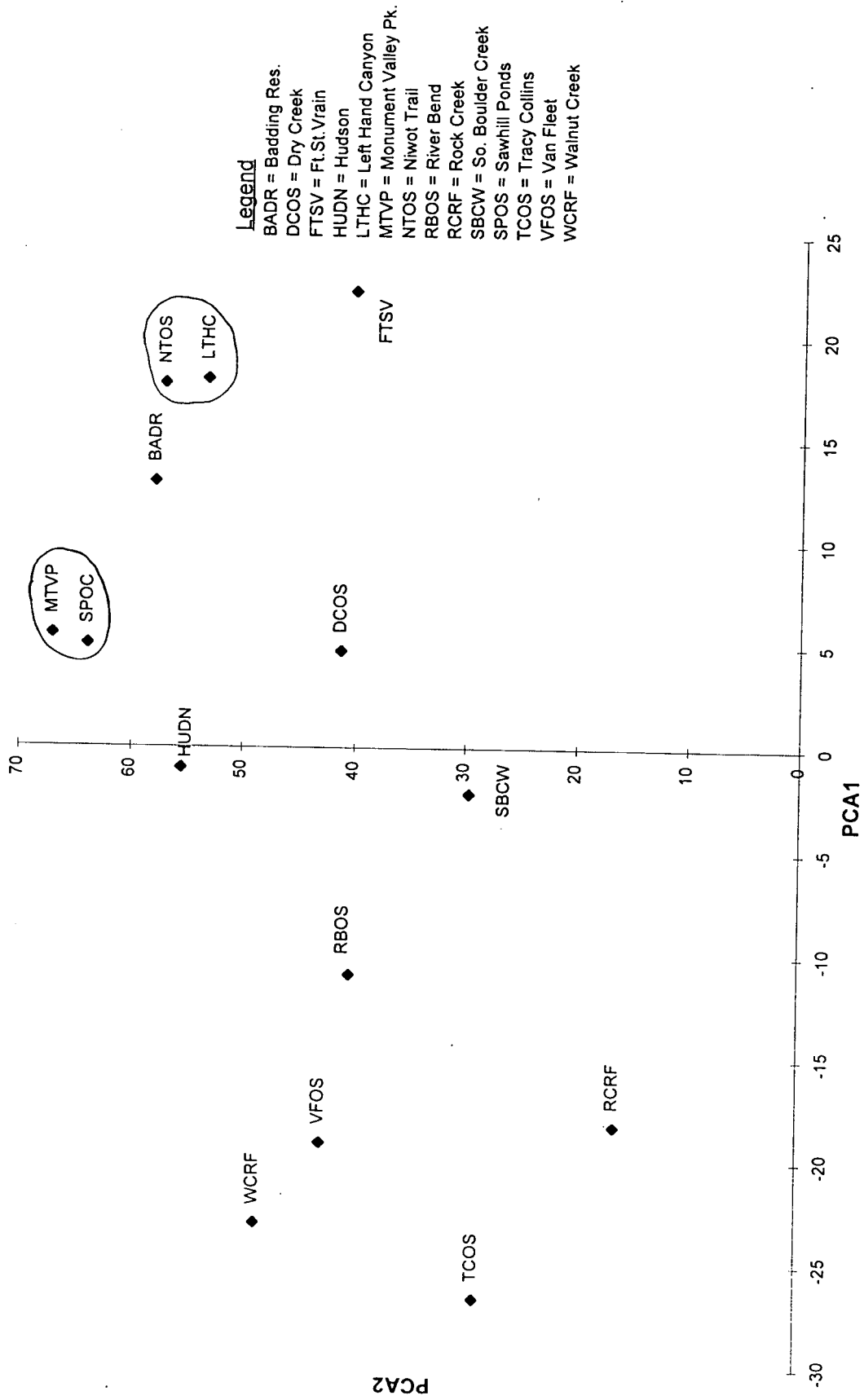


Figure 3. Principal Component Analysis of Selected Structure Variables, PCA1 vs. PCA3, 1995

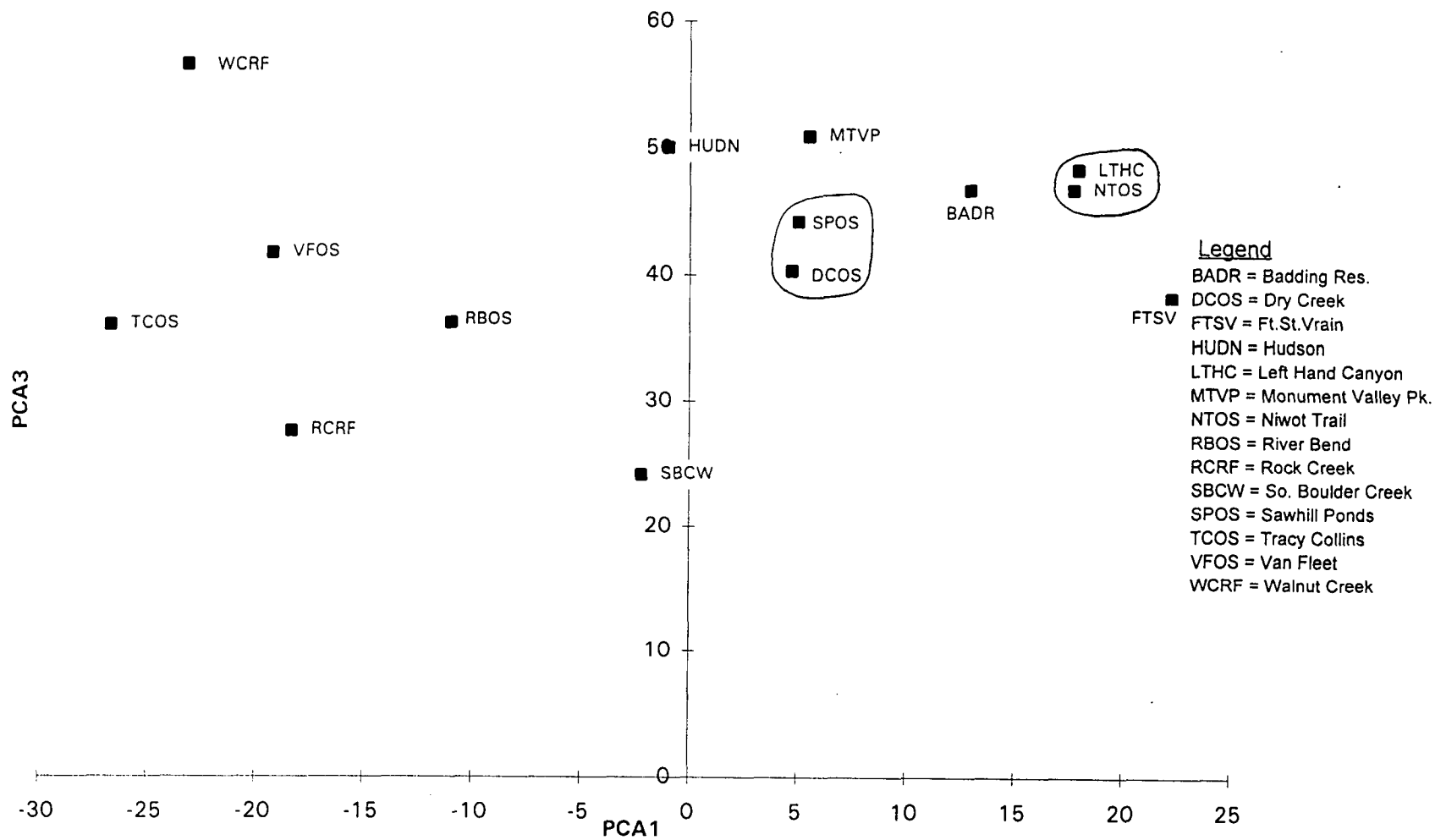


Figure 4. Principal Component Analysis of Selected Structure Variables, PCA2 vs. PCA3, 1995

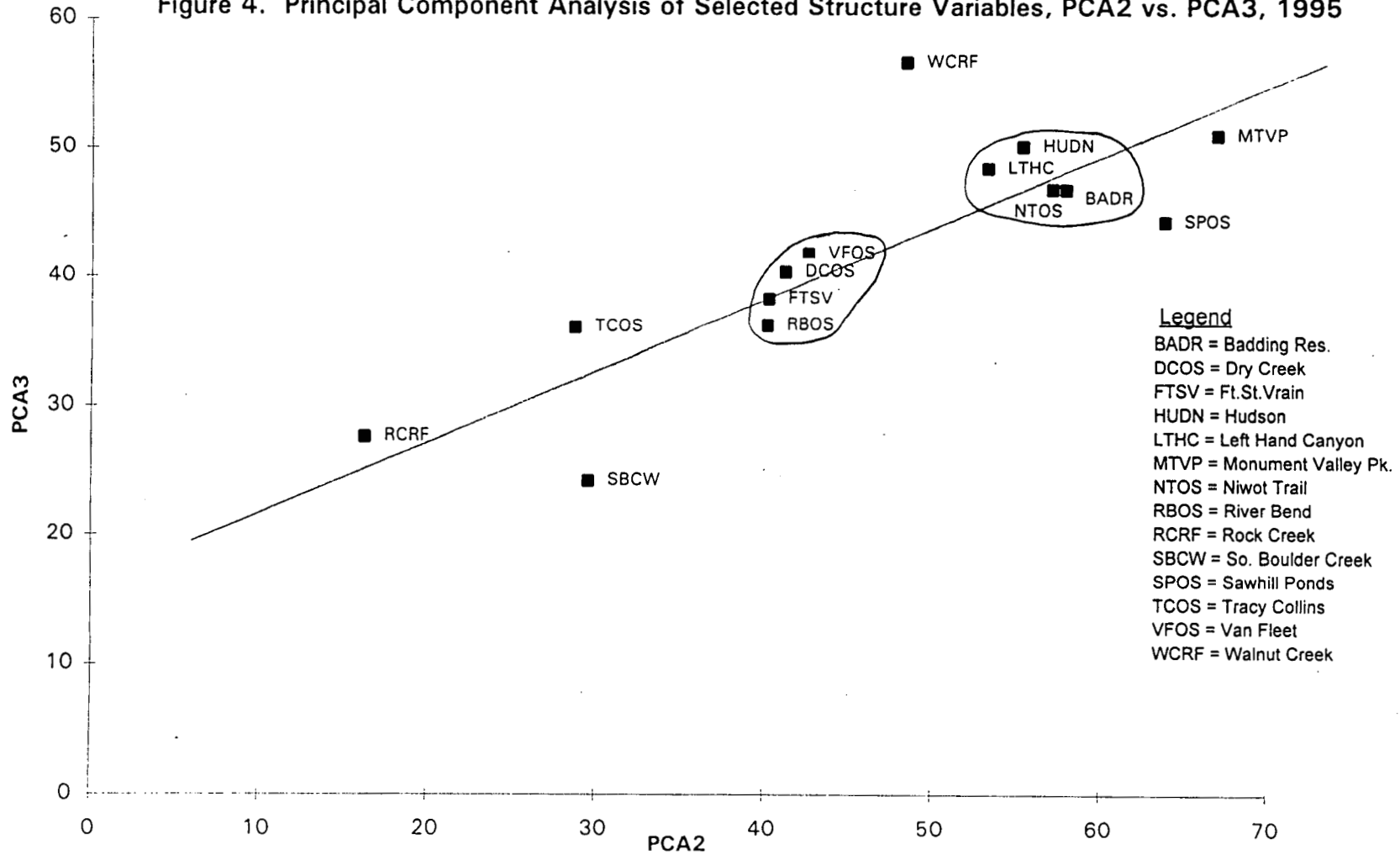


Figure 5. Ordination of Species Composition
at Historic and Recent Preble's Meadow Jumping Mouse Sites, 1995

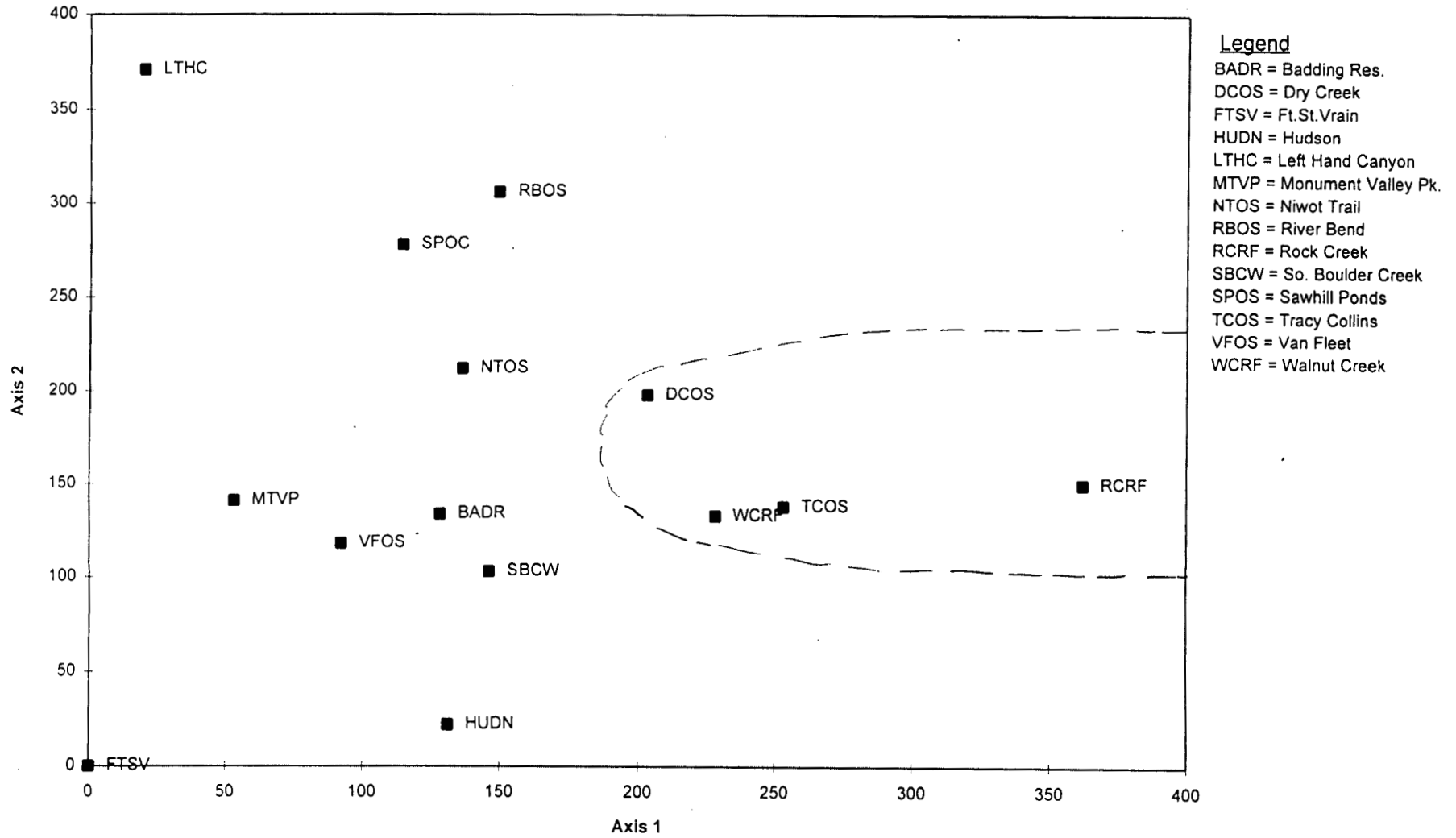


Table 1. Location and Ownership of the Historical Sites of the Preble's Meadow Jumping Mouse, 1995

General Locations	Legal Description	Quadrangle	Ownership/Management
<i>Adams County</i>			
Badding Reservoir (aka Croke Lake)	T2S, R68W, SE1/4, SW1/4, Sec 15	Commerce City	City of Thornton
<i>Boulder County</i>			
Dry Creek Open Space	T1S, R70W, NE1/4, NW1/4, Sec 2	Louisville	City of Boulder Open Space and Real Estate Department
Elmer Johnson Ranch	T2N, R70W, 1/2 E, Sec21 or T2N, R70W, 1/2 W, Sec22	Hygiene	Parcel No. 1317210-00-008,009 Earl Carrey or Michelle G. Roth
Lagerman Reservoir 3 mi NW of Niwot	T2N, R70W, SW1/4, Sec13 T2N, R70W, SE1/4, Sec14	Hygiene	Boulldr County Parks and Open Space Department
Left-hand Canyon (Mouth of Canyon)	T2N, R71W, SW1/4, SE1/4, Sec13	Lyons	Parcel #1319130-01-006 William S. Rubin & Karen S. Conduff
Niwot Trail Open Space	T2N, R69W, NW1/4, SW1/4, Sec31	Niwot	Boulldr County Parks and Open Space Department
Sawhill Ponds Open Space	T1N, R70W, NE1/4, NW1/4, Sec23	Niwot	City of Boulder, Boulder Mountain Parks Department
South Boulder Creek West Open Space	T1S, R70W, SE1/4, SW1/4, Sec16	Louisville	City of Boulder Open Space and Real Estate Department
Tracy Collins Open Space	T1S, R70W, NE1/4, SW1/4, Sec33	Louisville	City of Boulder Open Space and Real Estate Department
Van Fleet Open Space	T1S, R70W, SW1/4, NW1/4, Sec 10	Louisville	City of Boulder Open Space and Real Estate Department
<i>El Paso County</i>			
Monument Valley Park Colo. Springs/Colo. College	T14S, R66W, NW1/4, NW1/4, Sec7	Colorado Springs	City of Colorado Springs

Table 1. Location and Ownership of the Historical Sites of the Preble's Meadow Jumping Mouse, 1995

General Locations	Legal Description	Quadrangle	Ownership/Management
<i>Jefferson County</i>			
Semper Allen Ditch	T2S, R69W, S1/2, SW1/4, Sec24	Arvada	City of Westminster, CO & Southern RR, & Commercial Developers
1.25 W of Semper	T2S, R69W, SW1/4, SW1/4, Sec23 or T2S, R69W, NW1/4, SW1/4, Sec23	Arvada	Jefferson County Schools or City of Westminster
Rock Creek Confluence Rocky Flats	T2S, R70W, NE1/4, NW1/4, Sec2	Louisville	U.S. Department of Energy
Walnut Creek Confluence Rocky Flats	T2S, R70W, SE1/4, SW1/4, Sec1	Louisville	U.S. Department of Energy
<i>Larimer County</i>			
2.5 mi. SE of Ft. Collins	T7N, R68W, SE1/4, SW1/4, Sec17	Ft. Collins	Parcel No. 87192-00-909 City of Ft. Collins
<i>Weld County</i>			
Ft. St. Vrain	T3N, R67W, NE1/4, NE1/4, Sec3	Milliken	Public Service Company of Colorado
6 mi. E of Hudson	T1N, R64W, NW1/4, NW1/4, Sec11	Keenesburg	Parcel No. 1475-11-000003 Brnak, James J. & Georgene L. Brnak

TABLE 2. SPECIES PRESENT AT HISTORIC CAPTURE SITES OF PREBLE'S MEADOW JUMPING MICE

SPECIES	SITE NAMES							
	Badging Reservoir	Dry Creek Open Space	Left Hand Canyon	NiwoTrail Open Space	Sawhill Ponds Open Space	SoBlderCrkW Open Space	Tracy Collins Open Space	Van Fleet Open Space
TREES								
<i>Acer glabrum</i>			X					
<i>Alnus tenuifolia</i>				X				
<i>Elaeagnus angustifolia</i>	X	X						
<i>Fraxinus pennsylvanica</i>	*	X						
<i>Juglans nigra</i>			X					
<i>Populus angustifolia</i>			X		X	X	X	
<i>Populus deltoides</i>	X			X	X	X		X
<i>Ulmus pumila</i>	*							
SHRUBS								
<i>Amorpha fruticosa</i>		X					X	
<i>Artemisia ludoviciana</i>								X
<i>Crataegus erythropoda</i>							X	
<i>Grindelia squarrosa</i>								X
<i>Rhus aromatica</i>							.	
<i>Rosa sp.</i>						X	X	X
<i>Rubus deliciosus</i>						X	X	
<i>Salix amygdaloides</i>	.						X	
<i>Salix edguae</i>	X	X	X	X	X	.	X	X
<i>Symphoricarpos occidentalis</i>						X	X	X
GRASSES								
<i>Agropyron smithii</i>								
<i>Agropyron repens</i>								
<i>Agropyron sp. cultivare</i>								
<i>Agrostis stolonifera</i>							X	
<i>Bromus inermis</i>	X	X	X	X	X			.
<i>Bromus japonicus</i>	.							X
<i>Bromus tectorum</i>	.							
<i>Carex sp.</i>	X	X		X		X		X
<i>Dactylis glomerata</i>		X	X	X	X	X		
<i>Festuca pratensis</i>								
<i>Hordium jubadum</i>		X						
<i>Juncus balticus</i>		X						
<i>Juncus sp.</i>						X		
<i>Leucopoa kingii</i>						X	X	
<i>Poa compressa</i>								
<i>Poa pratensis</i>							X	X
<i>Stipa robusta</i>							X	
<i>Stipa viridula</i>	X						X	
FORBS								
<i>Achillea lanulosa</i>							X	
<i>Ambrosia psilostachya</i>			X					X
<i>Apocynum cannabinum</i>		X			X			
<i>Aposoum canabianum</i>								
<i>Asclepias sp.</i>								X
<i>Aster ericoides</i>								
<i>Aster sp.</i>								
<i>Barbarea orthoceras</i>								
<i>Cardaria draba</i>								X
<i>Carduus nutans</i>	X							.
<i>Centaurea diffusum</i>								
<i>Chenopodium album</i>						X		
<i>Cichorium intybus</i>								
<i>Cirsium arvense</i>		.		X	X	X	X	X
<i>Conium maculatum</i>			X					
<i>Convolvulus arvensis</i>				X				
<i>Cynoglossum officinale</i>	.			.			X	
<i>Dipsacus sylvestris</i>					X			
<i>Equisetum arvense</i>		X		X		X		
<i>Equisetum laevigatum</i>								
<i>Euphorbia esula</i>								
<i>Galium spurium</i>								X
<i>Geranium caespitosum</i>								
<i>Geranium sp.</i>								X
<i>Geum macrophyllum</i>		X						
<i>Glycyrrhiza lipidota</i>								X
<i>Helianthus annuus</i>								
<i>Hypericum perforatum</i>								
<i>Lactuca scariola</i>		X		X			X	
<i>Nasturtium officinale</i>							X	
<i>Oenothera biennis</i>		X						
<i>Plantago lanceolata</i>								
<i>Prunella vulgaris</i>								
<i>Pyrus sp.</i>		X						
<i>Ranunculus sp.</i>								
<i>Rumex crispus</i>							X	
<i>Salidago sp.</i>				X			X	
<i>Stachys palustris</i>								X
<i>Taraxacum officinale</i>	X						X	X
<i>Taraxacum sp.</i>						X	X	
<i>Thermopsis divaricarpa</i>								
<i>Thermopsis rhombifolia</i>								
<i>Toxicodendron rydbergii</i>								
<i>Tragopogon dubius</i>								X
<i>Typha angustifolia</i>	X							

X = species was recorded within a study plot
 * = species was observed within the study area

X = species was observed with a study plot
 . = species was observed within the study area

SPECIES		Monument	Valley Park	Rocky Creek	Rocky Flats	Rocky Flats	Open Space	St. Vrain	Hudson
SITE NAMES									
TREES	<i>Acer glabrum</i>								
	<i>Alnus tenuifolia</i>								
	<i>Elaeagnus angustifolia</i>								
	<i>Radiata pennsylvanica</i>								
	<i>Juglans nigra</i>								
	<i>Populus angustifolia</i>								
	<i>Populus deltoides</i>								
	<i>Ulmus pumila</i>								
SHRUBS	<i>Amorpha fruticosa</i>								
	<i>Artemisia ludoviciana</i>								
	<i>Crataegus erythropoda</i>								
	<i>Gnaphalium squarrosa</i>								
	<i>Rhus aromatica</i>								
	<i>Rosa sp.</i>								
	<i>Rubus deliciosus</i>								
	<i>Salix amygdaloides</i>								
	<i>Salix exigua</i>								
	<i>Symphoricarpos occidentalis</i>								
GRASSES	<i>Agropyron smithii</i>								
	<i>Agropyron repens</i>								
	<i>Agropyron sp. cultivare</i>								
	<i>Agrostis stolonifera</i>								
	<i>Bromus horneis</i>								
	<i>Bromus japonicus</i>								
	<i>Bromus tectorum</i>								
	<i>Carex sp.</i>								
	<i>Dactylis glomerata</i>								
	<i>Festuca pratensis</i>								
	<i>Horidium jubatum</i>								
	<i>Juncus balticus</i>								
	<i>Juncus sp.</i>								
	<i>Leucopoa kingii</i>								
	<i>Poa compressa</i>								
	<i>Poa pratensis</i>								
	<i>Stipa robusta</i>								
	<i>Stipa viridula</i>								
FORBS	<i>Achillea lanulosa</i>								
	<i>Aster erinoides</i>								
	<i>Aster sp.</i>								
	<i>Barbarea orthoceras</i>								
	<i>Cardata draba</i>								
	<i>Cardus nutans</i>								
	<i>Centaurea diffusa</i>								
	<i>Chenopodium album</i>								
	<i>Cichorium intybus</i>								
	<i>Cirsium arvense</i>								
	<i>Cirsium maculatum</i>								
	<i>Convolvulus arvensis</i>								
	<i>Cynoglossum officinale</i>								
	<i>Dipsacus sylvestris</i>								
	<i>Equisetum arvense</i>								
	<i>Equisetum laevigatum</i>								
	<i>Euphorbia esula</i>								
	<i>Galium spurium</i>								
	<i>Geranium caespitosum</i>								
	<i>Geranium sp.</i>								
	<i>Geum macrophyllum</i>								
	<i>Glycythiza lepidota</i>								
	<i>Helianthus annuus</i>								
	<i>Hypochaeris perforatum</i>								
	<i>Lactuca scariola</i>								
	<i>Nasturtium officinale</i>								
	<i>Oenothera biennis</i>								
	<i>Parnassia lancoolata</i>								
	<i>Pumila vulgaris</i>								
	<i>Pyrus sp.</i>								
	<i>Ranunculus sp.</i>								
	<i>Rumex crispus</i>								
	<i>Sedum sp.</i>								
	<i>Stachys palustris</i>								
	<i>Taraxacum officinale</i>								
	<i>Taraxacum sp.</i>								
	<i>Thermopsis divaricata</i>								
	<i>Thermopsis thomifolia</i>								
	<i>Toxocodon rydbergii</i>								
	<i>Trigonon dubius</i>								
	<i>Typa angustifolia</i>								

TABLE 2. SPECIES PRESENT AT HISTORIC CAPTURE SITES OF PEBBLE'S MEADOW JUMPING MICE

TABLE 3. DESCRIPTIVE STATISTICS OF VEGETATION AND LAND FORM MEASUREMENTS FOR ALL HISTORIC SITES

Vegetation Measurements	BADDING RESERVOIR			DRY CREEK OPEN SPACE			LEFT HAND CANYON			NIVOT TRAIL OPEN SPACE						
	Count	Average	Median	Count	Average	Median	Count	Average	Median	Count	Average	Median				
	Standard Deviation	Standard	Standard	Standard Deviation	Standard	Standard	Standard Deviation	Standard	Standard	Standard Deviation	Standard	Standard				
CanopyCover (%)	5	40.8	35	29.9	5	42.8	39	35	5	70.8	88	28.1	5	34.2	35	32.3
TREES																
Tree Height (m)	5	4.78	0	6.57	5	1.5	0	2.47	5	7.1	7.5	1.88	5	0	0	0
Number of Trees	5	1.2	0	1.6	5	0.4	0	0.5	5	1	1	0	5	0	0	0
SHRUBS																
Tall Shrub Height (m)	5	1.90	2.20	1.24	5	1.26	1.81	1.17	5	0.31	0.00	0.689	5	2.02	1.90	0.383
Short Shrub Height (m)	5	0	0	0	5	0.4	0	0.559	5	0	0	0	5	0	0	0
Number of Shrubs	5	8	5	7.8	5	16.4	19	10.2	5	1.6	0	3.58	5	5.8	7	2.77
Shrub Width (m)	5	8.4	10	4.83	5	11.2	15	7.26	5	1.2	0	2.68	5	5.2	5	1.92
HERBACEOUS VEGETATION																
Density (%)	5	66	72	21.5	5	48.4	31	31	5	45.2	52	14.8	5	73	80	20
Height (m)	5	1.01	0.86	0.256	5	0.89	0.94	0.203	5	1.92	1.75	0.725	5	1.58	1.52	0.213
Litter Depth (mm)	5	57	68	33.9	5	20.6	23	10.1	5	13.4	13	5.68	5	52.6	40	41.2
GROUND COVER (%)																
Soil	5	3.4	0	4.77	5	16.8	12	21.4	5	4.4	4	2.07	5	10.2	7	8.76
Litter	5	74.2	78	11.43	5	62.8	67	13.6	5	90	90	3.08	5	68.6	73	17.5
Rock	5	0	0	0	5	2	0	4.47	5	0.8	0	1.09	5	0	0	0
Forb	5	0.6	0	1.34	5	9.6	12	4.16	5	1.4	2	1.34	5	4.8	3	4.6
Grass	5	19.8	15	9.63	5	7.4	8	6.39	5	2.2	2	0.447	5	14	13	10.7
Shrub	5	1.6	2.0	1.52	5	1.8	2.0	2.05	5	1	0.0	2.24	5	2.4	2.0	1.82
Tree	5	4	0	8.94	5	0	0	0	5	0.4	0	0.894	5	0	0	0
LAND FORM MEASUREMENTS																
Riparian Vegetation																
Corridor Length (m)	1	4			1	0.61			1	60			1	51		
Patch Size (ha)	1	0.34			1	0.14			1	0.72			1	2.7		
Distance to Embankment (m)	5	5.4	4.0	2.97	5	3	3.0	1.58	5	15	15.0	0.707	5	1.2	1.0	0.447
Distance to Confluence (m)		NA			1	30			1	400				NA		
Stream Meandering Measure	1	1.0			1	1.3			1	1.2			1	1.1		
Elevation (ft)	1	5380			1	5280			1	5600			1	5250		

NA = not applicable

DESCSTAT.XLS

TABLE 3. DESCRIPTIVE STATISTICS OF VEGETATION AND LAND FORM MEASUREMENTS FOR ALL HISTORIC SITES

HISTORIC SITES

Vegetation Measurements	SAWHILL PONDS				Standard Deviation	SO. BOULDER CREEK W.				Standard Deviation	TRACY COLLINS OPEN SPACE				Standard Deviation	MONUMENT VALLEY PARK				Standard Deviation
	Count	Average	Median	Standard Deviation		Count	Average	Median	Standard Deviation		Count	Average	Median	Standard Deviation		Count	Average	Median	Standard Deviation	
CanopyCover (%)	5	82	85	9.66	5	71.8	89	30.4	5	61.2	67	28.2	5	27.4	6	33.8				
TREES																				
Tree Height (m)	5	2.8	3.9	2.61	5	3	3	3.48	5	0.59	0	1.32	5	0	0	0				
Number of Trees	5	0.6	1	0.5	5	2.4	3	2.3	5	0.6	0	1.3	5	0	0	0				
SHRUBS																				
Tall Shrub Height (m)	5	3.22	3.27	0.221	5	1.53	1.57	0.192	5	2.42	2.90	1.1	5	1.98	1.91	0.35				
Short Shrub Height (m)	5	0	0	0	5	0.15	0	0.204	5	0.43	0.42	0.132	5	0.82	0.81	0.071				
Number of Shrubs	5	15.8	16	3.96	5	7.2	6	3.96	5	42	78	15.5	5	21.6	18	12.4				
Shrub Width (m)	5	21.6	21	1.95	5	18.8	16	9.2	5	16.6	8	16.1	5	18.2	18	2.28				
HERBACEOUS VEGETATION																				
Density (%)	5	86	85	2.91	5	23.8	24	3.42	5	28	30	11.6	5	91	92	6.4				
Height (m)	5	2.02	2.05	0.11	5	0.76	0.77	0.128	5	0.74	0.7	0.19	5	1.59	1.74	0.257				
Litter Depth (mm)	5	53	50	19	5	13.8	12	7.66	5	13.4	12	4.22	5	36.2	25	25.7				
GROUND COVER (%)																				
Soil	5	35.6	28	25.8	5	29	27	20.3	5	23.8	20	12.3	5	25.6	22	15.6				
Litter	5	58.2	63	23.8	5	49.6	47	16.8	5	52	50	13.6	5	64.8	67	16.4				
Rock	5	0	0	0	5	0	0	0	5	4.2	3	4.6	5	0	0	0				
Forb	5	0.8	0	1.09	5	3	3	4.16	5	2.8	2	2.17	5	0.8	0	1.09				
Grass	5	3	3	2.12	5	17	15	6.04	5	12.2	10	8.56	5	7.4	8	2.61				
Shrub	5	2.2	3.0	1.3	5	1.4	2.0	1.34	5	5.4	5.0	2.3	5	1.4	2.0	1.34				
Tree	5	0	0	0	5	0.4	0	8.94	5	0	0	0	5	0	0	0				
LAND FORM MEASUREMENTS																				
Riparian Vegetation																				
Corridor Length (m)	1	3.5			1	42			1	18			1	4.5						
Patch Size (ha)	1	0.76			1	8.0			1	3.0			1	8.2						
Distance to Embankment (m)	5	32	30.0	8.37	5	10.6	10.0	5.77	5	5	1.0	5.52	5	6.2	7.0	1.09				
Distance to Confluence (m)	1	850			1	1710			1	40			1	800						
Stream Meandering Measure	1	1.1			1	1.0			1	1.2			1	1.1						
Elevation (ft)	1	5140			1	5470			1	5820			1	6050						

NA = not applicable

TABLE 3. DESCRIPTIVE STATISTICS OF VEGETATION AND LAND FORM MEASUREMENTS FOR ALL HISTORIC SITES

HISTORIC SITES

Vegetation Measurements	RIVER BEND OPEN SPACE				FORT ST. VRAIN				HUDSON			
	Count	Average	Median	Standard Deviation	Count	Average	Median	Standard Deviation	Count	Average	Median	Standard Deviation
CanopyCover (%)	5	82.8	90	15.8	5	42	43	41.9	5	15.8	15	10.5
TREES												
Tree Height (m)	5	0.57	0.65	0.344	5	3.3	0	5.63	5	0	0	0
Number of Trees	5	1.6	2	1.1	5	0.4	0	0.5	5	0	0	0
SHRUBS												
Tall Shrub Height (m)	5	2.83	3.40	1.79	5	0.00	0.00	0	5	1.52	1.72	0.908
Short Shrub Height (m)	5	0	0	0	5	0.2	0	0.438	5	0	0	0
Number of Shrubs	5	34.8	41	20	5	0.8	0	1.79	5	25.2	25	20.2
Shrub Width (m)	5	15	18	8.77	5	0.4	0	0.89	5	18	20	15.2
HERBACEOUS VEGETATION												
Density (%)	5	46.8	48	10.1	5	65	66	8.37	5	55	55	21.5
Height (m)	5	1.51	1.52	0.167	5	1.08	1.06	0.284	5	1.38	1.27	0.557
Litter Depth (mm)	5	38.4	20	40	5	14.6	15	3.21	5	49	50	12.6
GROUND COVER (%)												
Soil	5	40.8	28	21.3	5	20.4	20	12.8	5	3	0	4.12
Litter	5	52	63	18.8	5	49	53	11.9	5	82.8	83	3.77
Rock	5	0	0	0	5	0	0	0	5	0	0	0
Forb	5	0.6	0	1.34	5	14.4	18	13.3	5	4.6	5	2.51
Grass	5	4	5	4.18	5	10.2	7	10.6	5	7.6	8	7.8
Shrub	5	2.4	2.0	1.82	5	0.4	0.0	0.894	5	2.2	3.0	2.17
Tree	5	0	0	0	5	5.6	0	12.5	5	0	0	0
LAND FORM MEASUREMENTS												
Riparian Vegetation												
Corridor Length (m)	1	6			1	3			1	0.55		
Patch Size (ha)	1	0.9			1	0.012			1	0.099		
Distance to Embankment (m)	5	21.6	19.0	4.1	5	6.4	6.0	2.51	5	9.6	12.0	6.31
Distance to Confluence (m)	1	550			1	800			1	450		
Stream Meandering Measure	1	1.2			1	1.0			1	1.1		
Elevation (ft)	1	4895			1	4750			1	5020		

NA = not applicable

TABLE 4. DESCRIPTIVE STATISTICS OF VEGETATION AND LAND FORM MEASUREMENTS FOR ALL RECENT CAPTURE SITES

RECENT SITES

Vegetation Measurements	ROCK CREEK				Standard Deviation	WALNUT CREEK				Standard Deviation	VAN FLEET OPEN SPACE				Standard Deviation
	Count	Average	Median	Standard Deviation		Count	Average	Median	Standard Deviation		Count	Average	Median	Standard Deviation	
CanopyCover (%)	5	37	26	33.1		5	57	66	23.4		5	35	39	18.0	
TREES															
Tree Height (m)	5	1.9	0	2.6		5	0.4	0	0.89		5	2.6	0	5.9	
Number of Trees	5	0.4	0	0.55		5	0.2	0	0.45		5	0.2	0	0.45	
SHRUBS															
Tall Shrub Height (m)	5	1.8	1.7	0.61		5	2.6	2.7	0.46		5	2.3	2.2	0.8	
Short Shrub Height (m)	5	0.07	0	0.15		5	0.8	0.9	0.47		5	0.4	0.3	0.39	
Number of Shrubs	5	45	54	23.6		5	68	65	34.6		5	42	40	17.3	
Shrub Width (m)	5	5.6	5.0	4.88		5	9.6	8.0	3.21		5	27	25	6.73	
HERBACEOUS VEGETATION															
Density (%)	5	15	12	12.6		5	48	55	26.1		5	40	34	13.2	
Height (m)	5	1.0	0.9	0.41		5	1.1	1.0	0.22		5	1.1	1.1	0.48	
Litter Depth (mm)	5	63	17	102		5	115	38	193		5	19	25	11.3	
GROUND COVER (%)															
Soil	5	16	20	12.6		5	10	10	9.6		5	12.5	8	8.0	
Litter	5	41	43	20.8		5	81	82	9.4		5	67.5	67	12.6	
Rock	5	32.5	25	31.8		5	0.3	0	0.9		5	6.2	5	8.2	
Forb	5	4.7	2	4.8		5	0.3	0	0.9		5	5	5	3.1	
Grass	5	3.4	2	5.0		5	3.8	3	4.4		5	7	5	6.3	
Shrub	5	1.4	0	2.2		5	4.6	5.0	2.5		5	1.8	2.0	1.1	
Tree	5	1.0	0	1.4		5	0	0	0.0		5	0	0	0.0	
LAND FORM MEASUREMENTS															
Riparian Vegetation	100					100					100				
Corridor Length (m)	1	170				1	160				1	400			
Patch Size (ha)	1	0.09				1	0.15				1	1.1			
Distance to Embankment (m)	5	12	10	4.7		5	0.8	1.0	0.84		5	6.0	3.0	6.5	
Distance to Confluence (m)	1	18				1	40				1	20			
Stream Meandering Measure	1	1.4				1	1.2				1	1.1			
Elevation (ft)	1	5775				1	5670				1	5340			

TABLE 6. TRAPPING RESULTS FOR HISTORIC AND RECENT SITES FOR THE MEADOW JUMPING MOUSE

	Historic Sites								Recent Sites				
	Badding Reservoir	Fort St. Vrain	Monument Valley Park ¹	Left Hand Canyon ²	Tracy Collins Open Space ³	Sawhill Ponds ³	Hudson	River Bend Open Space ⁴	Rock Creek	Walnut Creek	Van Fleet Open Space ³	E. Plum Creek ⁵	
Trap Nights	625	720	600	500	1200	1200	600	585	400	100	1200	375	
Available Traps ⁶	579	430	536	378	ND	ND	407	469	256	ND	ND	ND	
Species Richness	3	5	3	6	4	4	3	5	5	3	5	3	
Species Captured:													
<i>Sorex cinereus</i>	NC	NC	NC	1	NC	NC	NC	NC	NC	NC	NC	NC	
<i>Reithrodontomys montanus</i>	NC	NC	NC	NC	NC	NC	5	NC	NC	NC	NC	NC	
<i>Reithrodontomys megalotis</i>	NC	5	NC	1	NC	NC	NC	3	NC	NC	NC	NC	
<i>Reithrodontomys sp.</i>	NR	NR	8	NR	NR	NR	NR	NR	NR	NR	NR	NR	
<i>Peromyscus maniculatus</i>	16	57	NC	17	41	53	108	6	64	17	89	66	
<i>Neotoma mexicana</i>	NC	NC	NC	14	NC	NC	NC	NC	11	NC	NC	NC	
<i>Microtus pennsylvanicus</i>	7	17	11	14	5	23	75	5	22	NR	4	17	
<i>Microtus ochrogaster</i>	NC	2	NC	2	3	5	NC	6	26	NR	2	NC	
<i>Microtus sp.</i>	NR	NR	NR	NR	NR	NR	NR	NR	NR	10	4	NR	
<i>Mus musculus</i>	5	5	10	NC	NC	9	NC	37	NC	NC	2	NC	
<i>Chaetodipus hispidus</i>	NC	NC	NC	NC	2	NC	NC	NC	NC	NC	NC	NC	
<i>Zapus hudsonius</i>	NC	NC	NC	NC	NC	NC	NC	NC	2	6	10	8	

1 = Observed two house cats (*Felis catus*) in the study area

2 = Captured a rock squirrel (*Spermophilus variegatus*) in "Hava-a-hart" trap

3 = Preliminary data from Status of the Meadow Jumping Mouse (*Zapus hudsonius preblei*) on Boulder City and County Open Space Lands, Interim Report. September 1995.

Tallies do not include recaptures.

4 = Captured a house cat (*Felis catus*) in hava-a-hart trap

5 = Trapping results from Harrington, F.A. 1995 Survey for Preble's Meadow Jumping Mouse at the Highway 18 Bridge on East Plum Creek, Douglas County, Colorado. For DOT.

6 = Available traps are those remaining open and baited after one trap-night (untripped traps)

ND = No Data

NC = Not Captured

NR = Not Recorded