Population Estimates and Aspects of Hibernation in Preble's Meadow Jumping Mice along South Boulder Creek

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POPULATION ESTIMATES AND ASPECTS OF HIBERNATION IN PREBLE'S MEADOW JUMPING MICE (*ZAPUS HUDSONIUS PREBLEI*) ALONG SOUTH BOULDER CREEK, BOULDER COUNTY, COLORADO

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ABSTRACT

Preble's meadow jumping mouse (*Zapus hudsonius preblei*) occurs along the Front Range of Colorado and in south-central Wyoming. The present study uses PIT-tagging to mark individual jumping mice and mark-recapture analyses for population estimates and survival rates along South Boulder Creek and a ditch fed by it in Boulder County, Colorado. There was total of 256 individuals and 586 captures of marked jumping mice. Population estimates ranged from 14.7 to 41.2 animals per km along South Boulder Creek, and from 28.1 to 63.1 animals per km along the ditch. Extrapolations were made to the boundaries of the South Boulder Creek State Natural Area. First emergence from hibernation was 19 May and males preceded females. Adults were seen in June with low post-hibernation weights (some as low as 14 and 14.5 g). Adults reached weights that would enable them to enter hibernation by the third week in August. After mid-September, animals captured were considered to be young born during the second litter. By mid-October no jumping mice were captured and we infer that they had all entered hibernation. The estimated annual survival rate was 13.7 percent.

KEYWORDS: meadow jumping mouse, hibernation, population estimate, mark/recapture

Preble's meadow jumping mouse (*Zapus hudsonius preblei*), a subspecies of the meadow jumping mouse, has a distribution that is limited to the Colorado Front Range and south-central Wyoming. Probably a Pleistocene relict, *Z. h. preblei* previously enjoyed a wider distribution in tallgrass prairie across the eastern plains of these two states (Fitzgerald et al. 1994). Development in and adjacent to riparian areas, destruction of wetlands, excessive grazing, gravel-mining, and predation by wild and domestic predators have all had a detrimental effect on local populations. As a consequence, this small mammal has become rare and the subspecies was listed as threatened under the Endangered Species Act by the U.S. Fish and Wildlife Service on May 12, 1998. While its distribution and status in Colorado are currently under investigation, *Z. h. preblei* has been found in Larimer, Weld, Boulder, Jefferson, Douglas, Elbert, and El Paso counties in the past five years. Elsewhere in North America, other subspecies of *Z. hudsonius* are broadly distributed (Hall 1981) and populations are not known to be threatened.

The preferred habitat of this mouse is moist lowlands with dense vegetation, such as grassy fields, thick vegetation along ponds, streams, and marshes, and the rank herbaceous vegetation of wooded areas. In Colorado, *Z. h. preblei* shows an affinity for complex riparian communities with well-developed shrub, tree, grass, and forb species (Ryon 1996). Willows (*Salix* sp.) seem to be particularly favored, but other vegetation communities are also used.

Population estimates and survival rates for this subspecies are a critical piece in our understanding of its conservation status. To this end, we undertook a mark/recapture study of these animals along South Boulder Creek, on City of Boulder Open Space. We selected a study area from which jumping mice were known and that also had a reasonable extent of suitable habitat.

Z. hudsonius is a deep hibernator and remains in hibernation for as long or longer than most mammals (Whitaker 1972). Some evidence suggests that adults enter hibernation prior to young of the year (Quimby 1951). Dates of immergence in New York are from mid-September to October 20 (Quimby 1951), although there are records of immergence into November (Whitaker 1972). Our interest was in following a marked population of *Z. h. preblei* to determine the dates of immergence and emergence, and to follow the pattern of weight gain prior to immergence. In particular, we were interested to clarify the differences in these patterns between young of the year and full adults.

STUDY AREA

South Boulder Creek heads in the mountains west of Boulder. Once in Boulder it forms a broad floodplain in the 3.7 km (2.3 mile) study area, with well-developed grasslands and dense forbs adjacent to a cottonwood and willow riparian corridor. Additionally there are numerous wetlands throughout and ditches that draw water from the creek for agricultural use through the wide adjacent lowland meadows (Figure 1). The U.S. Fish and Wildlife Service was concerned about possible detrimental effects of a bridge that was to be built across East Boulder Ditch, at the north end of the study area to accommodate a new bike trail. East Boulder Ditch is similar to the other ditches, and is used here to represent population estimates for all the ditches in the system.

The state of Colorado recently designated a 486 ha (1,200 acre) parcel of Boulder open space along South Boulder Creek a State Natural Area. The entire study area falls within its boundaries. This Natural Area is a mosaic of wetlands, meadows, grasslands, riparian forests, and tallgrass prairie. The boundaries of the Natural Area serve to define a larger area of optimal habitat for *Z. h. preblei*, containing a portion of South Boulder Creek and a number of irrigation ditches that are fed by it. We used this Natural Area for extrapolation of population estimates beyond our study area.

METHODS

Field Methods

Six study sites were randomly selected from all possible 100-meter sections of the 3.7 km (2.3 mile) reach of South Boulder Creek in the study area. Each site contained two trapping grids, one on each side of the creek. Only three grids were used in 1997 (each composed of three parallel transects of 25 traps each); they were superimposed or overlapped with the 1998-1999 grids and incorporated into the grid design. Grid locations were marked on aerial photographs and were recorded with a GPS (Geographic Positioning System) unit. Each grid contained 72 traps, laid out as eight trap stations along the creek and nine trap stations out perpendicular to the creek. Traps were placed 9 meters apart on both axes, thus forming a grid 63 meters along the creek by 72 meters out from the creek. A transect of 50 traps was placed along East Boulder Ditch all three years; during fall of 1998 it was expanded to 65 traps and returned to 50 traps for spring 1999.

We used Sherman live traps for small mammal trapping and followed guidelines of the Animal Care and Use Committee of the American Society of

Mammalogists (1998). Traps were baited with a sweet feed combination (molasses in rolled oats, corn, and barley) and a ball of polyester was placed inside each trap for insulation and bedding. We placed traps in a covered location under vegetation as much as possible, to prevent over-cooling and over-heating of animals during the trapping period.

These six sites were trapped twice during the field season, the first three weeks of June and August in 1998 and 1999. We ran two sites (288 traps) per week the first two weeks. The third week in each month we added East Boulder Ditch with an additional 50 traps. This represents a 7,312 trap night effort for the summer season. In 1997 we trapped only Sites 2 and 3 during one week in July and one week in August. Traps were set out on Monday afternoons, checked and closed early each morning, reopened late each afternoon, and picked up Friday mornings. Traps were washed each week in a 10 percent bleach solution to avoid potential hantavirus transference. These data were used for the population and survival estimates.

In order to capture data on hibernation, we ran 65 traps three days a week along East Boulder ditch from September 16 to October 30, 1998 (two weeks after the last jumping mouse capture); 50 traps from May 5 to June 11, 1999 (when the summer season's trapping for the ditch commenced); and again August 30 to October 29, 1999 (two weeks after the last jumping mouse capture).

Jumping mice were marked individually with Passive Integrated Transponder (PIT) tags, inserted subcutaneously on the dorsum near the scapulae. All jumping mice, including recaptures, were weighed with a pesola scale in the field. We followed Nichols and Conley (1982) in aging animals. We used Destron-Fearing PIT tags and a mini portable reader from Biomark of Boise, Idaho. The tags had a scanner exciter frequency of 125 kHz.

Population Size Estimation

Estimation of jumping mouse population size employed the Robust Design model (Kendall et al. 1997, Kendall and Nichols 1995, Kendall et al. 1995) for capture-recapture studies (Pollock et al. 1990; Seber 1982, 1986, 1992) in program MARK (Cooch and White 1998, White and Anderson 1998).

A random immigration/emigration model was assumed in which these rates were set equal to each other. As in all closed population studies, permanent migration out of the study areas can not be distinguished from mortality, only temporary migrations can be measured. Sex, time (week and session), and site were tested for effects on capture probabilities. Because of the large

number of trapping occasions, and the small population sizes, estimation of separate probabilities for each trapping occasion was not possible. Instead, we estimated separate capture probabilities by week and session. The possibility that recapture probability differs from capture probability was also examined.

These alternative models were compared and population size was then estimated using model averaging over the best models (Burhnam and Anderson 1998). The support for a non-zero temporary migration rate, and for sex, time, and site effects was tested using a likelihood ratio test of models with and without these parameters.

Population Adjustments and Extrapolations

Because there is no natural or artificial boundary to ensure geographic closure of populations on each trap grid (an important assumption of the analytical techniques used), the linear population estimates include individuals drawn to the trap grid from outside its boundaries. To adjust for this, an estimate of the biological boundary strip on either side (upstream and downstream) of a trap grid was estimated independently based on telemetry studies conducted by Tanya Shenk (Colorado Division of Wildlife, personal communication). The calculated correction factor, or percent residency, represents the proportion of animals captured on her transects in Douglas County, Colorado, that were true residents (defined has having more than 50 percent of their telemetry observations on the transect). This correction factor was then adjusted for the length of the grid/transect to which it was to be applied. Through this process we determined that 31, 47, and 64 percent of captures represented residents on our 64 m, 125 m, and 250 m grid and transects, respectively; thus final population estimates represent only 31 to 64 percent of the number of animals captured.

Population size estimates for each site were converted to linear population density estimates of the number of animals per km of stream reach. It was assumed that trap grids on one side of South Boulder Creek measured the population size along that side of the creek only, and thus the animals from the two grids are combined for each site. This assumption is justified by the width and swiftness of the creek and the very low estimates of trapping probability for individuals from the other side of the creek. Conversely, estimates from trapping along one side of East Boulder Ditch were assumed to measure the entire population on both sides. This assumption is supported by several observations of individuals swimming in the narrow and slow moving ditch, and the fact that telemetry observations in El Paso and Douglas counties showed

small creeks did not present a barrier (Rob Schorr, Colorado Natural Heritage Program, and Tanya Shenk, personal communication).

Extrapolations to the South Boulder Creek Natural Area were made by measuring the length of the creek within its boundaries for a population estimate on the creek, and by measuring the length of all major ditches fed by the creek within the boundaries for an estimate of the number of mice along ditches. These were then combined for a total number of jumping mice within the boundaries of the Natural Area.

RESULTS

Small Mammals

A total of 1810 individual small mammals were captured, and 963 recaptures, over the three years during 19,374 trap nights (Table 1). This represents an overall capture rate of 14.3 percent. Ten species were represented: Thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*), hispid pocket mouse (*Chaetodipus hispidus*), western harvest mouse (*Reithrodontomys megalotis*), deer mouse (*Peromyscus maniculatus*), Mexican woodrat (*Neotoma mexicana*), Norway rat (*Rattus norvegicus*), house mouse (*Mus musculus*), meadow vole (*Microtus pennsylvanicus*), prairie vole (*Microtus ochrogaster*), and meadow jumping mouse (*Zapus hudsonius*). Deer mice, meadow voles, and meadow jumping mice were the three most common small mammals captured, and jumping mice represented 14.6 percent of the individuals captured overall.

Population Estimates

A total of 265 jumping mice were captured, 124 along South Boulder Creek and 141 along East Boulder Ditch. The population and survival estimates were based on an effective sample size of 356 captures of 192 individuals. Including the fall and spring hibernation study, the entire data set involved 586 captures of 256 marked *Z. h. preblei*.

The data support only a single capture and recapture rate over all time periods, sexes, and sites. The probability of capturing an animal from one site at another site operated during a different week was zero for all possible pairs of grids except four, representing movement between sites 1, 2, and East Boulder Ditch.

Animals may emigrate from the study site temporarily between the trapping sessions. Once they have emigrated, they may return or remain away with the probabilities show below:

Probability that an animal is on site in June and emigrates before August = 0.502 ± 0.378
Probability that an animal off site in June remains offsite in August = 0.746 ± 0.172
Probability that an animal on site in August emigrates before subsequent June = 0.951 ± 0.033
Probability that an animal offsite in August emigrates before subsequent June = 0.842 ± 0.977

These results indicate that site fidelity is very low. Animals spend only a small part of their time on the trap grid.

Linear population estimates were calculated separately for South Boulder Creek and East Boulder Ditch, due to the differences in vegetation, drainage type, hydrology, and concomitant animal abundances. The mean population estimates for South Boulder Creek, shown in Table 2, range from a low of 14.7 animals per km in August 1998 to a high of 41.2 animals per km in August 1997. Along East Boulder Ditch, values ranged from a low of 28.1 animals/km in August 1998 to a high of 63.1 animals/km in July 1997. No jumping mice were captured on Sites 2 and 3 in July 1997 and Sites 1 and 3 in August 1998. The ditch consistently maintained higher densities than the creek in each session. The extreme amount of variation across sites and sessions is apparent.

We calculated the length of South Boulder Creek in the Natural Area to be XX km. We also calculated the length of major ditches, fed by South Boulder Creek and with similar vegetation, in the Natural Area, to be XX km. We used the above range of linear densities for the creek and the ditch to develop an estimate of the number of jumping mice on the Natural Area. With this calculation, we estimate a range of xxx and xxx jumping mice on the 486 ha (1200 acres) parcel.

Survival

Summer survival averaged 0.53 (±0.145 se) per month over the three summers. Winter survival averaged 0.93 (±0.049 se) over the two winters. There is insufficient evidence to support any difference in survival rates between years or sexes. The combined annual survival rate is thus 13.7 percent (0.527^2 x 0.932^{10} = 0.137).

Hibernation

The first emergence from hibernation was 19 May. Males preceded females and remained more numerous until July when sex ratios evened out (Table 3).

Animals trapped in May and early June (1998-1999) had the lowest adult weights, including five animals weighing 14g or 14.5g. The mean first weight of 78 males (May 3-June 18) was 18.1 g (± 2.0 g). The mean first weight of 47 females (May 3-June 18) was 18.2 g (± 2.8 g). This included 10 pregnant (with bulging abdomens) or lactating (with enlarged nipples) (Muchlinski 1988) females all weighing more than 22 g. All other females were classified as non-reproductive (neither obviously pregnant nor lactating). The first pregnant female was encountered the second week in June, and no others were encountered until the third week in June.

After 1 July, animals weighing less than 15 g were classified as either subadult or juvenile using the criteria of Nichols and Conley (1982). The first juveniles and subadults were encountered in the mid-July trapping session (Table 3).

Muchlinski (1980) found that *Zapus* kept in a laboratory under short daylength and cold temperatures, short daylength and warm temperatures, or decreasing photoperiod and attaining at least 25 g subsequently entered hibernation. By the third week in August we captured 17 animals weighing in excess of 25 g. Of these, seven were males and included one weighing 33.3 g. The remaining 10 animals were females; three weighed 30 g or more and were classified as nonreproductive; two lost 8 g and 9 g within three days and were classified as pregnant and then lactating; five were described as having nipples visible but with hair growing over them suggesting that they had reproduced and nursed but were no longer reproductive.

Through late August and into mid-September we continued to capture juveniles, subadults, and large adults (25-34 g). Of 40 animals captured after 18 September, only 5 weighed more than 25 g. The rest weighed less than 25 g, and likely were all young of the year and probably born in August. The last animal captured in 1998 was on October 14 (a 21.5 g female that was first captured 18 September weighing 12 g) and the last capture in 1999 was October 15 (a 21 g female). Trapping continued for two weeks after these dates with no captures. We assume this indicates that all animals had entered hibernation.

Weight gains for some individuals were substantial; six individuals gained 6 g at a rate of 1 to 1.5 g per day. There were 17 known adults that had survived the previous winter's hibernation and for which we had multiple weights. The

weights of these known animals were plotted against time to develop a lower limit of weight against time for adults. Superimposed on this graph are the weights of "unknown" animals (those for which we did not have multiple weights and which had not been PIT tagged the previous year) (Figure 3).

DISCUSSION

Small mammal diversity at this site was high, with ten species represented. The historic and present agricultural land use and present recreational land use appear not to have compromised habitat, and presence, of small mammals.

These population estimates cover a period of three years, which may be a very short time period in which to judge the true range of a population of Preble's meadow jumping mice. The absence of jumping mice at certain sites during particular sessions, for example, was observed at Sites 1-3 in July 1997 and Sites 1 and 3 in August 1998. Longer periods of ten or even twenty years may be necessary for this species, known for extreme fluctuations in abundance (Bailey 1929, Blair 1940, Quimby 1951, Sheldon 199?). At Rocky Flats Environmental Technology Site, jumping mice were captured along Woman Creek in the early 1990s, were absent in 1995, and captured again in 1996, although in low numbers. We selected the highest and lowest values for extrapolation in an attempt to encompass the true range of variation. In addition to potential natural cycles, stochastic factors such as flooding and drought, both common in Colorado, may cause yet larger fluctuations.

Capture data from June represents population numbers of the post-hibernation adults available for breeding prior to a birth pulse. August numbers should reflect expansion of the population as the result of reproduction. Interestingly, the August population numbers are not higher for either South Boulder Creek or East Boulder Ditch except for 1997 along the former and 1999 along the latter. This may be due to annual variation, which may obscure possible patterns of difference between early (June) and later (August) in the season.

Our data indicate that these animals spend only a small part of their time on the trapping grid. The problem of lack of geographic closure when sampling small grids or transects in a species that is known for much movement was dealt with by the correction factor that was applied to all calculations. It was felt that this was a conservative approach that adequately dealt with the problem.

Our study design allows for the extrapolation of findings to the full extent of South Boulder Creek in our 3.7 km (2.3 mile) study area. However, the larger

boundary encompassed by the South Boulder Creek State Natural Area takes in a larger portion of the creek and seven additional ditches. The selection of these boundaries was done with the goal of further protecting *Z. h. preblei* habitat and reflects the fact that this broad floodplain has generally consistent land use, flora, fauna, and biological integrity. For these reasons, we feel that there is justification in applying the population extrapolations to the South Boulder Creek Natural Area.

Agricultural ditches can be an important habitat element for *Z. h. preblei.* In fact, the type specimen (*Zapus hudsonius preblei* Krutzsch, University Kansas Publications, Museum of Natural History, 7:452, 21 April 1954; type locality, Loveland, Larimer County, Colorado) was collected along an agricultural ditch. Whereas in eastern North America these animals are not obligate riparian dwellers, in the more arid west they are. Agricultural ditches mimic small creeks with slow moving water and are easy for the mice to swim across as frequently observed in the field. Typically, water flows in them for most of the active season of the mice. The higher densities found along the ditch compared to the creek were consistent throughout the three years. It has been suggested that density can be a misleading indicator of habitat quality in some cases (Van Horne 1983), but jumping mice do not appear to fit most of the criteria outlined for this paradigm: seasonal habitat, social dominance interactions, high reproductive capacity, and ecological generalist. Only two of the six criteria, temporal unpredictability and habitat patchiness, do fit jumping mouse habitat.

Although the reason for the higher densities along the ditch are not known, we offer the following possibilities: The vegetation was not always as well-developed along the creek as the ditch; mice can more easily negotiate smaller drainages with slow moving water; forbs, which were more abundant along the ditch, may provide an important food resource either directly or indirectly (e.g. insects). In regard to vegetation, it is remarkable to see East Boulder Ditch in winter compared to summer because of the dearth of visible vegetation in winter after the three months of limited grazing (Figure 4).

Some adults captured in May and June weighed 14 to 14.5 g, typical weights for subadults, as they emerged from hibernation. In consideration of the gestation period of 17-21 days, and that at 30 days of age animals weigh 8 to 11 g (Quimby 1951), we suggest that all animals captured in June must be adults.

By the third week in August we were seeing both male and female adults reaching weights which would enable them to enter hibernation. Subadults born late in the year (August) require additional time to gain the weight necessary

to enter hibernation, and were still active through September and into mid-October.

With the baseline established by the known adults, we infer that those individuals with weights above the line (Figure 3) are adults, either previously unmarked animals having made it through at least one hibernation or young of the year from a first litter born in late June or early July (and therefore indistinguishable from older adults by fall). Those below the line are young of the year born in August.

Total active time, from date of first animal trapped to date of last animal trapped was 150 days, 12 days less than the average reported by Muchlinski (1988). This may be due to a later date of emergence than is that reported elsewhere (Bailey 1929, Quimby 1951, Whitaker 1972, Muchlinski 1988). These other populations were either in the upper midwest or in the northeast. There are no other reports for *Z. h. preblei* in the Front Range of Colorado.

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Table 1. Individual small mammals captured by species along South Boulder Creek (SBC) and East Boulder Ditch (EBD), Colorado, 1997-1999.

Species	SBC	EBD	Total	Total Captures per 100 trap nights
Spermophilus tridecemlineatus 13-lined ground squirrel	3	0	3	0.02
Chaetodpidus hispidus Hispid Pocket Mouse	1	0	1 (1)	0.01
Reithrodontomys megalotis Western Harvest Mouse	11	3	14 (1)	0.08
Peromyscus maniculatus Deer Mouse	452	155	607 (449)	5.45
Neotoma mexicana Mexican woodrat	3	3	6 (1)	0.04
Rattus norvigecus Norway Rat	1	2	3	0.02
Mus musculus House Mouse	20	9	29 (3)	0.17
Microtus pennsylvanicus Meadow Vole	369	221	590 (131)	3.72
Microtus ochrogaster Prairie Vole	146	73	219 (50)	1.39
Microtus spp. vole species	51	22	73 (6)	0.41
Zapus hudsonius preblei Preble's Meadow Jumping Mouse	124	141	265 (321)	3.02
Total	1181	629	1810 (963)	14.30
# trap nights	14724	4650	19374	

Captures per 100 trap nights includes recaptures
Values in parentheses indicate recaptures

Table 2. Population estimates for Preble's meadow jumping mice by site and session. Sites 1 through 6 are along South Boulder Creek; EBD is East Boulder Ditch.

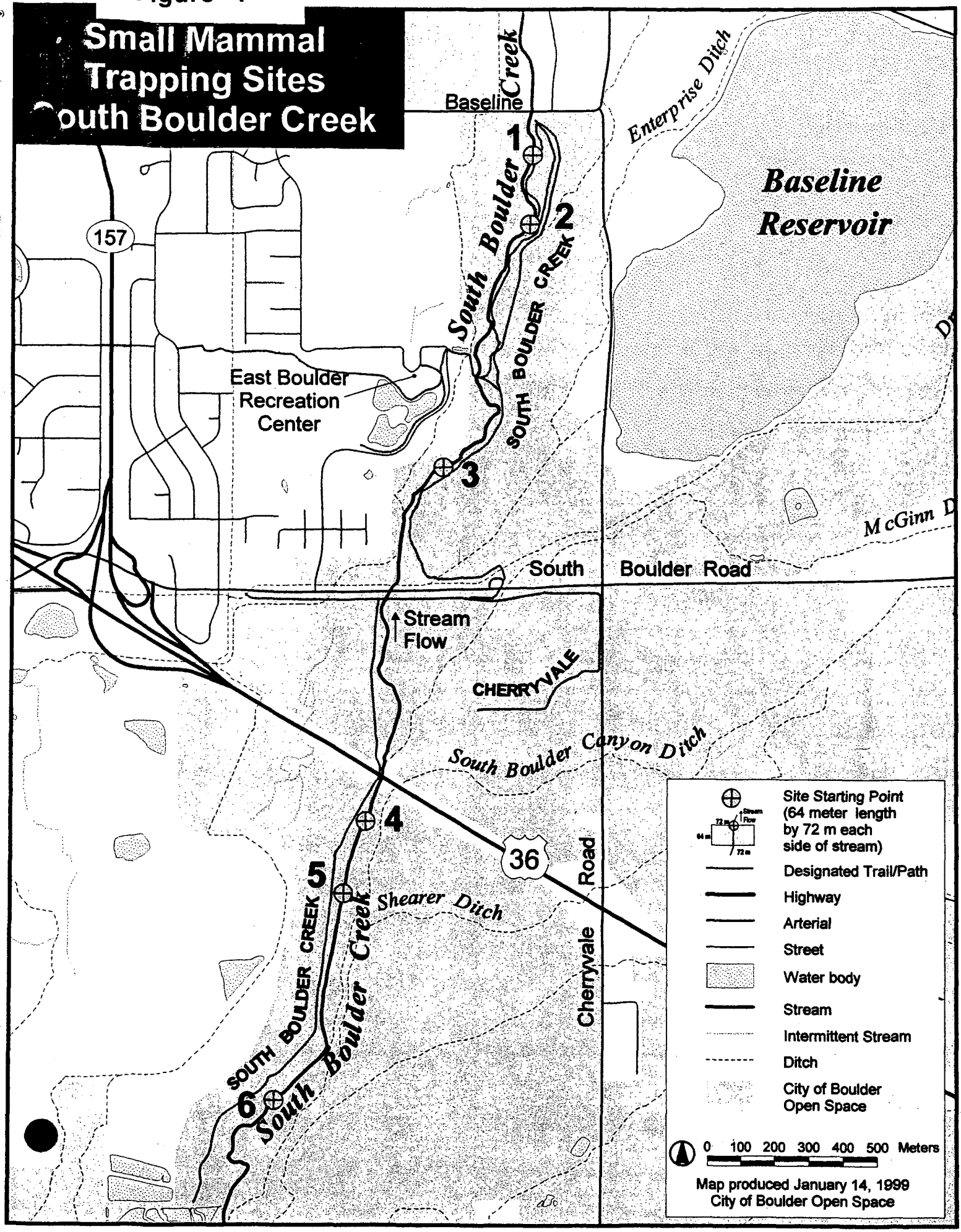
Site	July 1997	Augus 1997	June 1998	August 1998	June 1999	August 1999
1	0.0	---	41.0	0.0	14.6	4.9
2	0.0	50.6	53.6	39.0	24.4	14.6
3	0.0	22.5	19.5	0.0	60.7	29.6
4	---	---	19.8	4.9	19.5	24.7
5	---	---	19.8	14.6	4.9	4.9
6	---	---	56.2	78.6	24.4	9.7
1-6	0.0	41.2	35.0	21.2	24.7	14.7
EBD	63.1	53.1	40.5	28.1	40.5	43.6

Table 3. Captures of *Zapus* by session (spring, summer, fall), gender, and age along South Boulder Creek and East Boulder Ditch, 1997-1999.

	males				females			
session	**adult**	**subadult**	**juvenile**	**total males**	**adult**	**subadult**	**juvenile**	**total females**
Spring	78	0	0	78	47	0	0	47
Summer	39	15	8	62	50	12	5	67
Fall	18	14	3	35	17	5	2	24
Totals	135	29	11	152	114	17	7	138

Notes:
Only includes captures and recaptures of individuals for which gender and weight are available.
Spring = May-June
Summer = July-August
Fall = September-October

Figure 1


Small Mammal Trapping Sites South Boulder Creek
Baseline
Creek
Enterprise Ditch
Baseline Reservoir
1
2
3
South Boulder
SOUTH BOULDER CREEK
157
East Boulder Recreation Center
McGinn D
South
Boulder Road
Stream Flow
CHERRYVALE
South Boulder Canyon Ditch
4
36
Road
5
Shearer Ditch
SOUTH BOULDER CREEK
South Boulder Creek
6
Cherryvale
Site Starting Point (64 meter length by 72 m each side of stream)
Designated Trail/Path
Highway
Arterial
Street
Water body
Stream
Intermittent Stream
Ditch
City of Boulder Open Space
0 100 200 300 400 500 Meters
Map produced January 14, 1999
City of Boulder Open Space

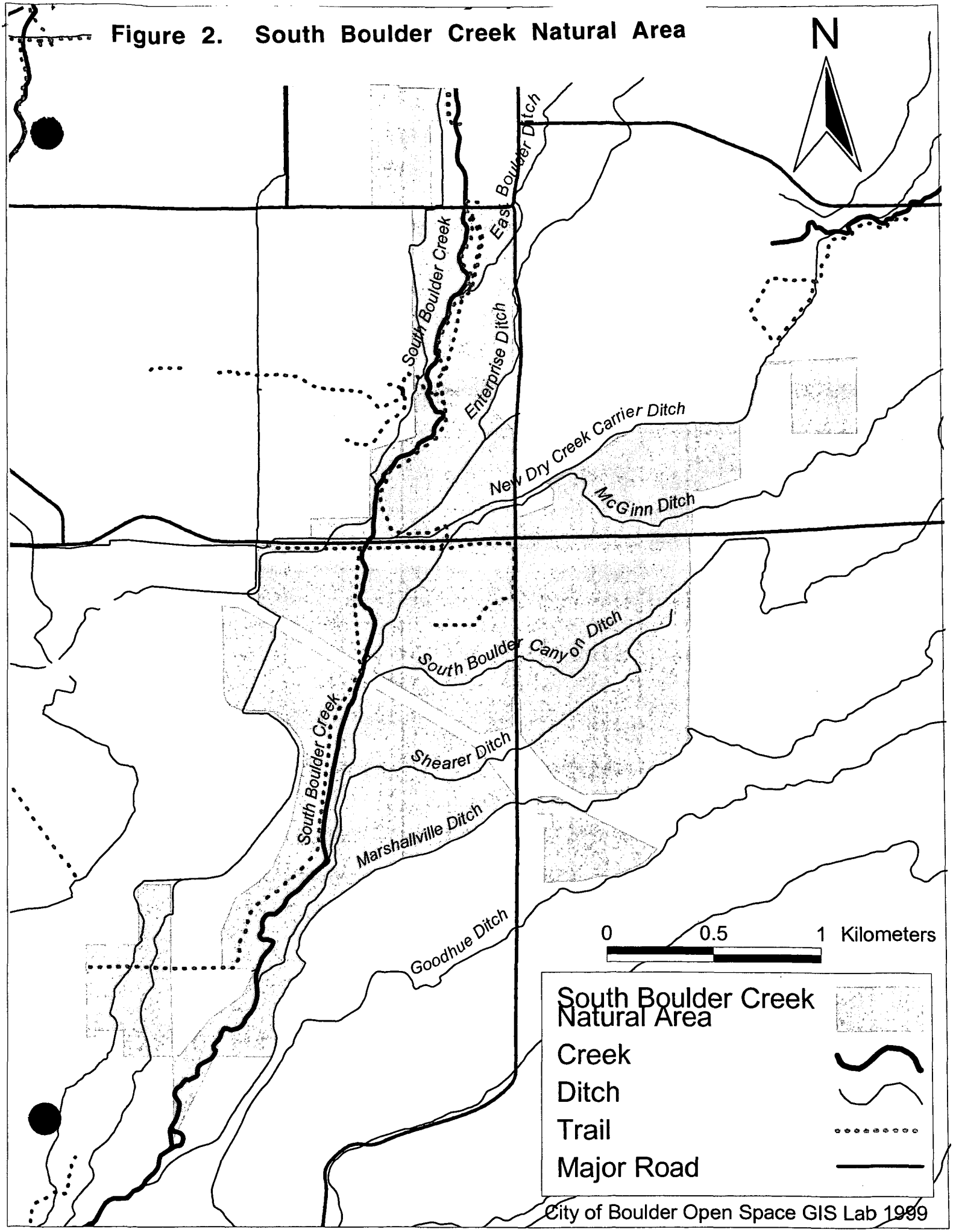


Figure 2. South Boulder Creek Natural Area
N
East Boulder Ditch
South Boulder Creek
Enterprise Ditch
New Dry Creek Carrier Ditch
McGinn Ditch
South Boulder Canyon Ditch
South Boulder Creek
Shearer Ditch
Marshallville Ditch
Goodhue Ditch
0
0.5
1 Kilometers
South Boulder Creek Natural Area
Creek
Ditch
Trail
Major Road
City of Boulder Open Space GIS Lab 1999

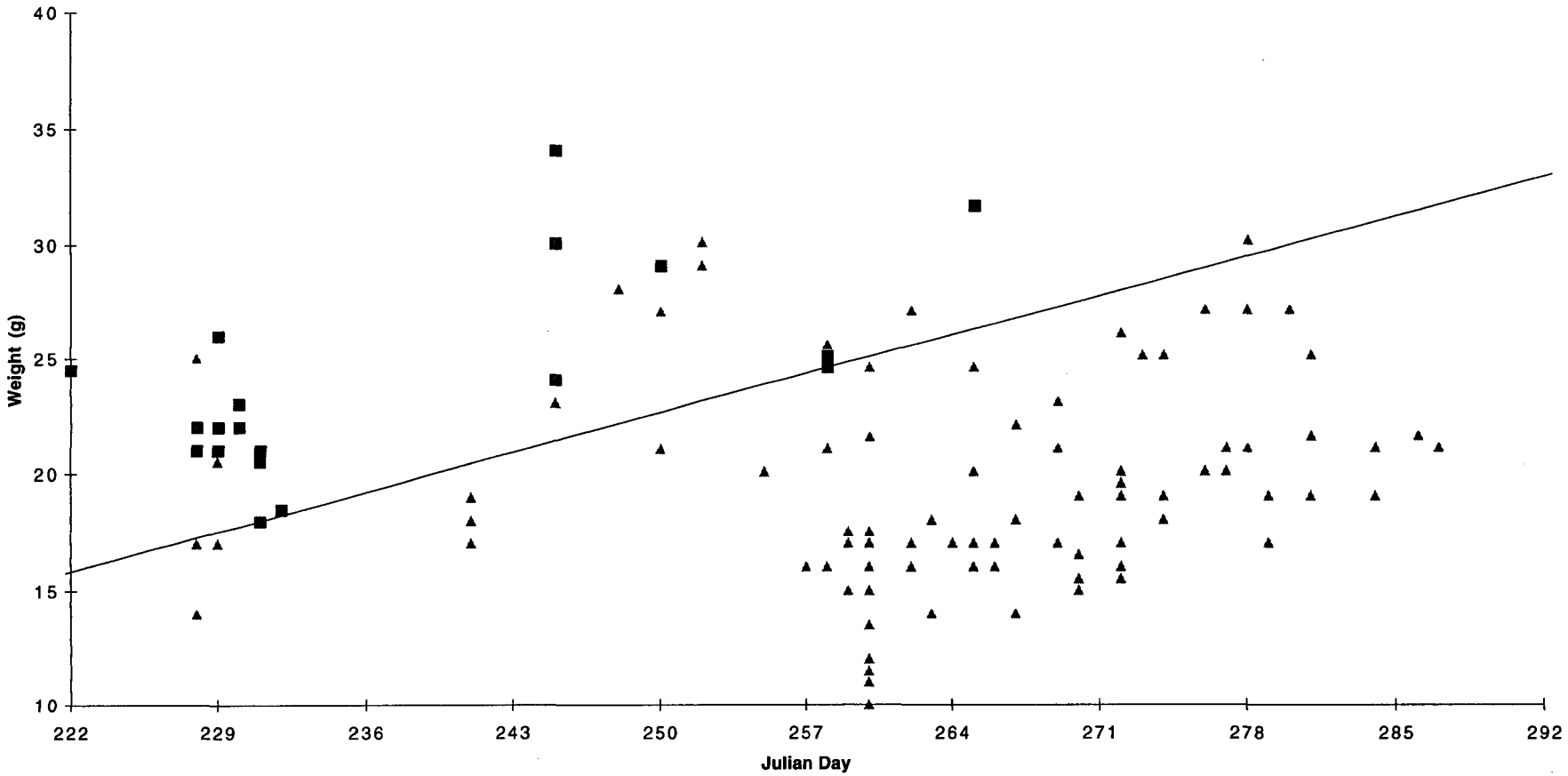


Figure 3. Weights of jumping mice against date. Squares are weights of known adults who emerged from hibernation and were captured in the fall. Triangles are for all others. Julian day 222 is August 11.

Small Mammal Trapping sites (125 m)
South Boulder Creek

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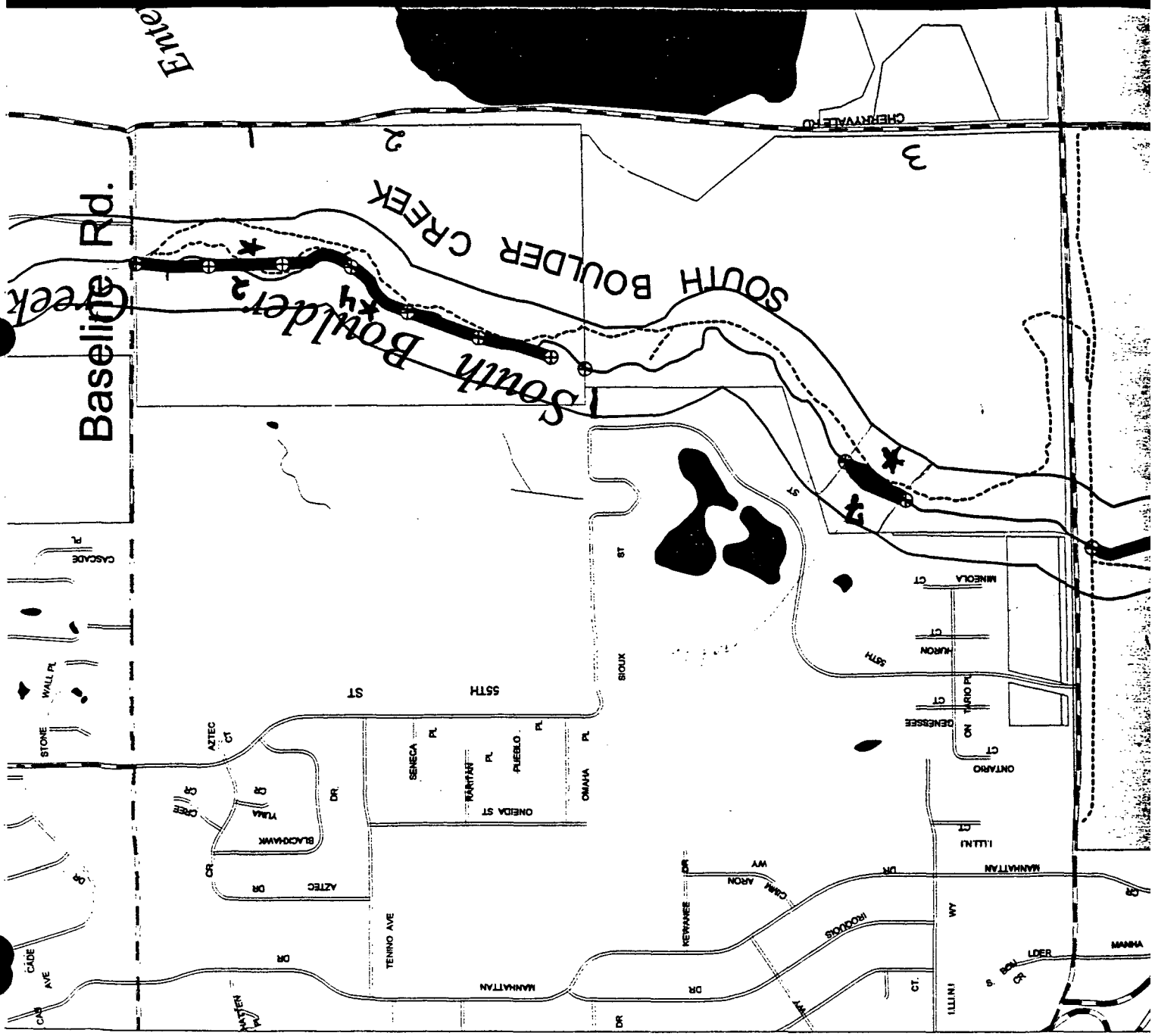

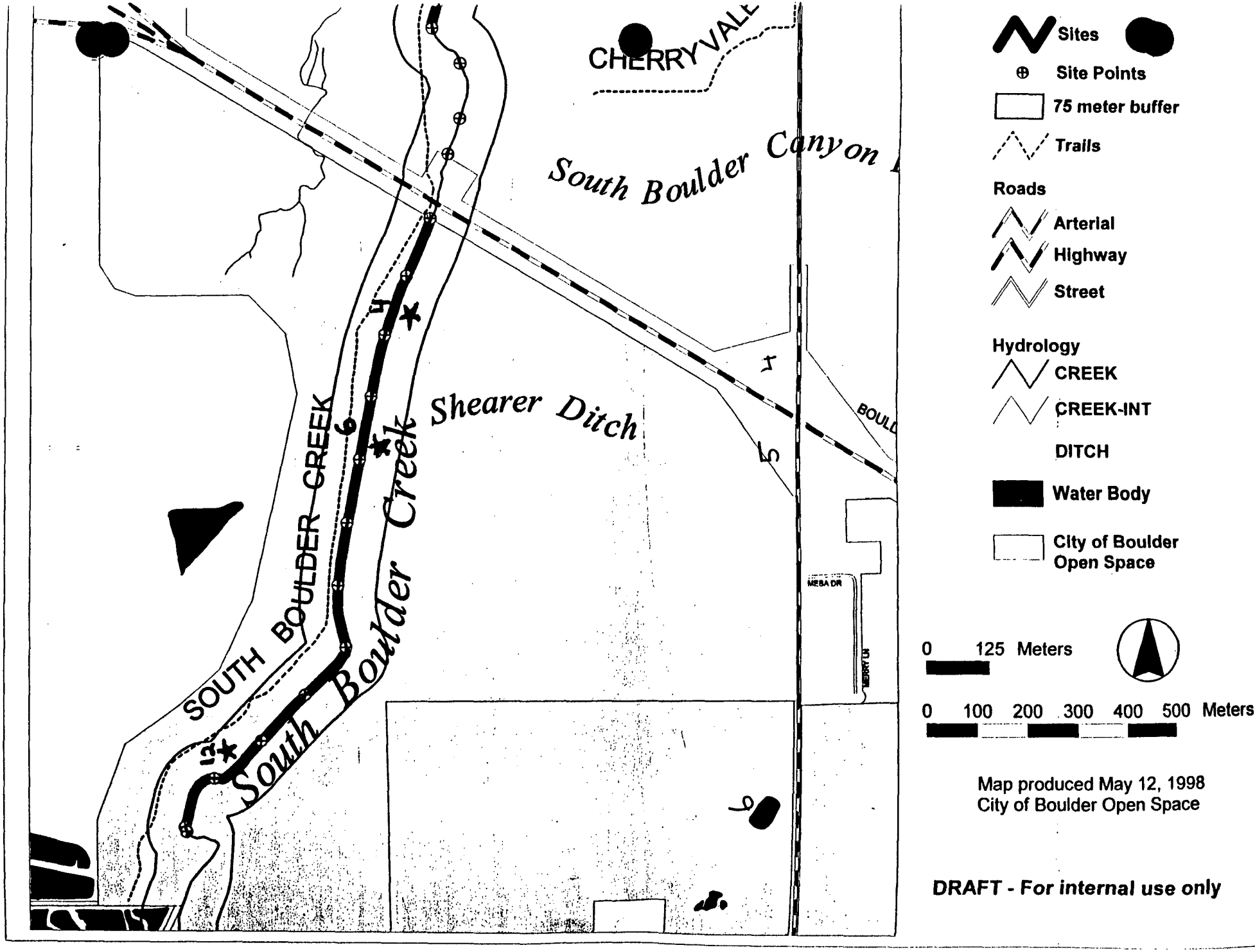
CHERRYVALE
South Boulder Canyon
Shearer Ditch
SOUTH BOULDER CREEK
South Boulder Creek
MESA DR
MERRY LN
Sites
Site Points
75 meter buffer
Trails
Roads
Arterial
Highway
Street
Hydrology
CREEK
CREEK-INT
DITCH
Water Body
City of Boulder Open Space
0 125 Meters
0 100 200 300 400 500 Meters
Map produced May 12, 1998
City of Boulder Open Space
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