Mule Deer Study Update
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City of Boulder Open Space Department
Parks and Recreation Department

MULE DEER STUDY
UPDATE

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PREPARED BY

CITY OF BOULDER
OPEN SPACE DEPARTMENT
PARKS AND RECREATION DEPARTMENT

SUMMARY

This report presents detailed quantitative data on the City of Boulder Mule Deer Study for the 1985 - 1986 period. It also serves as an update of the original study conducted in 1982 - 1984 by Western Resources Development Corporation (WRD) for the City of Boulder Parks and Recreation and Open Space Departments.

The on-going Mule Deer Study was initiated by the City to gather information on the deer population and movements, assess the severity of the deer vehicle accident problem, and to outline possible management alternatives for dealing with the deer population. This update attempts to clarify questions developed by the initial study, and to identify the current status of the deer population, and actions implemented following the earlier study.

Beginning in September 1985, a University of Colorado intern assisted staff in locating previously tagged deer. By mid-November, 26 of the previously tagged 90 deer has been accounted for within the study area. Based on these figures, 70 new tagged deer were needed to bring the marked population above 90 once again (roughly 10% of the total population).

TRAPPING AND MARKING

Additional deer were trapped and ear-tagged between November 26, 1985 and February 5, 1986. This resulted in 75 new deer being tagged, in addition to the 26 remaining of 90 tagged in 1983. After subtracting known road kills and deer not sighted in the spring of 1986, it is believed that there are 97 tagged deer in the study area.

POPULATION ESTIMATE

Deer census transects were walked by staff and four University of Colorado interns in mid-April 1986. Using the methods developed during the initial study, and expanded transects fully cover the 17 square mile study area, a population estimate of 1073 deer was derived, with a 90% confidence interval of 1073 +/- 170, or 903 to 1243 deer. This is an increase over previous censuses (means of 783 in 1983 and 888 in 1984). These date indicate a 10% annual increase for the period 1983 to 1986. Although this rate is well below the biological potential of 25 to 30%, it suggests that the existing population continues to increase.

DEER MOVEMENTS

From January through May 1986, four University of Colorado interns spent ten hours per week each walking transects in the study area. All sightings of tagged deer were recorded on topographic maps to determine movements of individuals accurately. Sightings made by City Rangers and citizen reports were included. The result was approximately seven hundred sightings of tagged deer. These data were used to determine home ranges and monitor deer movements into and around residential areas.

Individual deer were located from one to eighteen times from January to May. After May, many of the tagged deer moved out of the study area, presumably to the west, and were not seen during the summer. Many of these deer returned to the area in which they were trapped in October. During the spring, areas used by individual deer were generally less than 100 acres, but varied from 10 to 506 acres. Straight line distances traveled between locations were correspondingly small, generally around .75 miles, and ranged from .02 mile to 1.74 miles. Most deer stayed close to the area in which they were trapped, and were located within an ellipse oriented east - west and including the trap site. North - south movement along the Flatirons or Dakota Ridge was observed in only a few deer. Long distance dispersal was observed in one deer moving west to Gold Hill from Sunshine Canyon, and one moving south to Golden from the Eldorado Springs area.

Using the data as reported for the 1983 - 1984 period, 37% of all tagged deer were seen in residential areas. That rate is nearly identical to what was found in 1986, when 33% of the deer with multiple sightings were seen in residential areas. Individual deer were seen in residential areas in 1986 from 0% of the time (67% of all tagged deer) to 100% of the time. The 25 deer seen in residential areas at least once were observed there over one half of the time, averaging 52% of the time. These data indicate one-third of the tagged deer were reported in residential areas over 50% of the time during the spring of 1986. The remaining two-thirds of the tagged deer were never reported in residential areas.

DEER-VEHICLE ACCIDENTS

Data on road killed deer have been accumulated since 1983. The number of deer killed during each of these four years has stayed about the same, 119, 133, 113, and 116, respectively. In this same period, the deer population has grown from 783 in 1983 to 1073 in 1986; so the proportion of the population known to be killed each year has decreased. More adults are killed than fawns, and more females than males, but these ratios are similar to the deer population as a whole.

In February 1986, the City Transportation Department installed three sections of Swareflex Reflectors. These sections are being used to evaluate the effectiveness of the reflectors in reducing deer-vehicle accidents. In the three years previous to the Swareflex Reflectors being installed, twenty three deer were killed in each year in all three sections. In the 10.5 months following, thirteen deer have been killed in these sections. These are very preliminary data, and no conclusions should be drawn from less than one year of data. Several years of additional data should be accumulated, including weather patterns and deer movement patterns, before conclusions are drawn.

HABITAT SAMPLING

Three of the four study area subsections were sampled to determine vegetative composition, and on a general basis, forage production. The sampling was designed to cover large areas of the study area on an extensive basis, rather than to intensively determine forage production and all plant species present.

The three sections sampled have a good diversity of plants present, and generally adequate supplies of water, feeding, resting, and thermal cover. Although many shrub species were identified, very few are species that are highly preferred by deer, such as mountain mahogany, bitterbrush, and serviceberry. Most of the shrubs are moderately preferred. Nutritional requirements appear to be well met, judging by the healthy appearance of the deer herd and the observed reproductive rate. Only small areas had been heavily used by deer, mostly areas of preferred species; the habitat as a whole, is not over-utilized, and presently is not being severely impacted by the deer herd.

MANAGEMENT ALTERNATIVES

Eleven management alternatives are presented, along with the advantages and disadvantages of each. The first three alternatives are services the City could perform to increase staff and citizen knowledge, and to attempt to resolve conflicts some members of the public have with the deer. The second three alternatives are research options to increase staff knowledge of some dynamics of the deer population numbers and movement. Alternatives 4.7 through 4.10 deal with manipulating portions of the population. The final two alternatives deal with manipulating portions of the habitat, to encourage, or to force, the deer to use the Parks and Open Space land rather than residential areas.

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1.0 INTRODUCTION

1.1 BACKGROUND AND PURPOSE

This report presents detailed quantitative data on the City of Boulder Mule Deer Study for the 1985-86 period. It also serves as an update of the original study conducted in 1982-84 by Western Resource Development Corporation (WRD) for the City of Boulder Parks and Recreation and Open Space Departments. The original study was initiated due to the recognition, by City of Boulder Parks and Open Space personnel and Colorado Division of Wildlife (CDOW) personnel, of an apparent increase in the number of deer moving into the City, resulting in damage to ornamental plantings, and deer-vehicle collisions on City streets. The City of Boulder, in consultation with the Colorado Division of Wildlife, recognized the importance of continuing to supplement and improve the baseline data gathered in the initial study. It was, therefore, determined in 1984 to continue and expand the study with an eye to focusing on long-term trends and management options.

The specific objectives of the 1985-86 study were to:

1. Provide an accurate estimate of deer numbers on approximately 10,900 acres of Open Space and Mountain Parks lying generally west of Boulder, including population trends over time.

2. From extensive sightings, determine approximate home ranges and movement patterns for tagged deer.

3. After obtaining the data from #2, attempt to determine the amount of time various deer spend in the developed city limits.

4. Continue to gather data on deer/vehicle accidents and examine it for trends.

5. Provide the City administration with a detailed analysis of management options based on the current situation and data.

Continuing to gather information on deer numbers and population trends provides the opportunity to make more informed management decisions.

In recent years it has been suggested that deer from different parts of the study area may have different movement patterns and home range sizes. This assumption can be tested by mapping the movements of individual tagged deer in different sections of the study area.

The 1984 WRD report concluded that separate populations of "city deer" as opposed to "park deer" did not technically exist. In recent years the Parks field staff has questioned the validity of this finding. The basis of this difference of opinion rests more in determining a definition of "City deer" versus "park deer", since there is no dispute about whether deer are present in the City. Suggested definitions range from a single sighting of a deer in the City substantiates a "City herd", to a simple majority of sightings, to an overwhelming majority. Until a working, practical definition is arrived at, a consensus opinion is probably impossible. The extensive number of resightings and resultant home range maps should provide a much clearer view of this question.

Data on deer/vehicle accidents have now been compiled since 1983. By examining this information, it should be possible to see trends in mortality and detect any changes in "high risk" zones. In addition, Swareflex reflectors were installed in February 1986 on three sections of Broadway to prevent deer from crossing the roadway in the path of oncoming vehicles. By collecting detailed data from these areas for several years, the effectiveness of the Swareflex system in Boulder can be further assessed.

Finally, based on the most current data available, a comprehensive listing and examination of management options have been made. This should provide decision makers with the broadest possible view of benefits and costs associated with various management alternatives.

1.2 STUDY AREA

The study area encompassed the Open Space and Mountain Parks land west of Boulder, extending from South Boulder Creek on the south to Longhorn Road on the north, as well as urban areas west of Broadway (Figure 1). The area from Lee Hill Road north to Longhorn Road was added in 1985-86 due to the presence of several marked deer in that area. Western boundaries of the study area were roughly the Flatirons, the Dakota Hogback, and Flagstaff Mountain, and included the mesas that mark the transition from plains to foothills. The eastern boundary generally corresponded to Broadway. Total land area included was approximately 17 square miles, consisting of 62 percent natural habitat and 38 percent urban environment. Several urban areas also represent frequently used deer habitat.

Composition of natural vegetation throughout the study area is determined by elevation, slope, aspect, substrate, and available moisture. Higher forested areas are generally dominated by ponderosa pine (Pinus ponderosa), which in many cases extend along foothills mesas and even into prairie zones. Co-dominant tree species include douglas fir (Pseudotsuga menziesii) on moist or north-facing slopes and rocky mountain juniper (Juniperus scopulorum) on drier or south-facing sites. The quantity and composition of herbaceous understory is quite variable depending on the above listed ecological factors as well as conifer density. Overly dense conifer stands with significant canopy closure have very sparse understories, while more open parklike stands often contain a full complement of grass and forb species. In such open woodland areas, dominant grasses would include western wheatgrass (Agropyron smithii), Canada bluegrass (Poa compressa), green needlegrass (Stipa viridula) and occasionally, king spike fescue (Hesperochloa kingii). In addition, sun sedge (Carex heliophila) is often found on fine soils and little bluestem (Schizachyrium scoparium) on sandy or rocky sites. Most stands which were thinned during the mountain pine beetle outbreak of the 1970's have shown gradual understory improvement, with the exception of the Shanahan area which is progressing more slowly.

Shrubs are not particularly dominant plant types in the Boulder area in contrast to regions north or south along the foothills (e.g., Lyons and Golden). Shrubs in the ponderosa pine woodland are predominantly wax currant (Ribes cereum), Boulder raspberry (Rubus deliciosus), mountain ninebark (Physocarpus monogynus) and snowberry (Symphoricarpus occidentalis and S. alba). More open areas often support extensive stands of skunkbush sumac (Rhus aromatica ssp. trilobata) and smooth sumac (Rhus glabra). Key browse species such as mountain mahogany (Cercocarpus montanus) and bitterbrush (Purshia tridentata), are virtually absent.

Shrubs constitute major habitat types primarily along drainages flowing east from the foothills (e.g., Skunk Creek, Bear Creek, Bluebell Creek, Gregory Creek and Twomile Creek). Species commonly represented include common chokecherry (Prunus virginiana var. melanocarpa), wild plum (Prunus americana), mountain maple (Acer glabrus), golden currant (Ribes aureum) and gooseberry currant (R. inerme). Associated trees include narrowleaf cottonwood (Populus angustifolia), lanceleaf cottonwood (P. acuminata), peachleaf willow (Salix amygdaloides), box-elder (Negundo aceroides), and hackberry (Celtis reticulata).

Native grasslands in the study area include shortgrass, midgrass and relic tallgrass prairie stands. Shortgrasses are located primarily on coarse textured pediment surfaces where midgrasses are sparse due to heavier grazing. Dominant species include blue grama (Bouteloua gracilis),

sideoats grama (Bouteloua curtipendula), buffalograss (Buchloe dactyloides), and Sandberg bluegrass (Poa sandbergii). Midgrass communities are the most widespread and include western wheatgrass, needle-and-thread (Stipa comata), prairie junegrass (Koeleria macrantha), little bluestem, and prairie dropseed (Sporobolus heterolepsis). Remnants of tallgrass prairie communities are present throughout many portions of the study area with significant stands along the South Boulder Creek floodplain along Highway 36 East of Boulder and south of Marshall Lake on the recently acquired Open Space lands. In these stands big bluestem (Andropogon gerardii), switchgrass (Panicum virgatum), Indian grass (Sorghastrum nutans), and to a lesser extent prairie cordgrass (Spartina pectinata) are dominant. In those floodplain areas converted to hay production, introduced species such as smooth brome (Bromus inermis), orchard grass (Dactylis glomerata), common timothy (Phleum pratense), and Kentucky bluegrass (Poa pratensis) dominate.

The urban environment along the eastern edge of the study area near Broadway varies widely in terms of vegetation, and includes older neighborhoods with mature landscaping; newer, more sparsely landscaped residences; open, foothills habitat around National Center for Atmospheric Research (NCAR) and National Bureau of Standards (NSB); some dense commercial developments along Broadway; and City Parks. Older residential neighborhoods, which are among the areas receiving the greatest use by deer, typically are characterized by the presence of large shrubs and a variety of deciduous and coniferous trees. Residential areas generally include irrigated, fertilized lawns which provide nutritious forage throughout much of the year. In addition, a number of foothills residences occupy the transition zone between urban habitats and the more native Mountain Parks or Open Space.

1.3 ACKNOWLEDGMENTS

Numerous individuals and agencies provided information and assistance which made this study possible. The security staffs of NCAR and NBS provided access to their properties for trapping and monitoring activities. Mr. and Mrs. Tom Spencer granted permission to access Open Space property through their land. Mr. and Mrs. Wilbur R. Williams allowed the staff to trap on their property, and Mr. and Mrs. Dick Helmer allowed the staff access through their land to the Kenwood trap site.

The Central region of the Colorado Division of Wildlife (CDOW) granted trapping approval, provided one clover trap, and the eartags used for marking and monitoring. Local District Wildlife Manager, Laurie Kuelthau, was especially cooperative in providing equipment and assisting with the trapping program.

Special thanks must go to the University of Colorado volunteer interns from the Department of Geography and the Department of Environmental, Population, and Organismic Biology. Without the assistance of interns Gail Fontaine, Bob Palkoski, Kelly Petersen, and Tony Turini, a study as comprehensive as this one would not have been possible.

The Boulder County Humane Society (BCHS) provided full access to its records on road-killed deer.

Scott Wait, Open Space Ranger, Brian Peck, Mountain Parks Rangers, compiled and analyzed the data, and drafted this report. Ann Wichmann consultation is also acknowledged. Numerous comments from the Parks and Open Space field and office staffs have been incorporated. In addition, the entire field staff of both departments contributed many hours during the trapping, tagging, and monitoring process.

2.0 METHODS

2.1 TRAPPING AND MARKING

The primary objectives of the deer survey as stated in section 1.1, were addressed by trapping and ear-tagging mule and white-tailed deer (Odocoileus hemionus and O. virginianus) throughout the study area (figure 1). This permits the identification of individual animals by a combination of tag color and number. Radio collars were not used due to excessive cost and limited availability.

Trapping was conducted between November 26, 1985, and February 5, 1986. Deer were caught in portable cages known as clover traps (Clover 1956), which were baited with alfalfa hay and fermented apples. In several cases salt blocks were also used to attract deer to the sites. Traps were located to obtain the most representative population sample possible. True random trap locations were not feasible due to the proximity of Parks and Open Space lands to densely populated residential zones and recreation areas. A total of 17 trap sites were used on a study area of approximately 10,900 acres. All captured deer were physically restrained by crews of three to seven people during marking. No tranquilizing drugs were used.

All deer were marked with numbered and colored soft plastic ear tags placed in both ears. Ear tags were 6.2 x 7.5 cm and permanently numbered with block heat impressed numerals. Double tagging was used because of the potential for deer to lose a single tag, and to assist the observers during the monitoring program.

Two different color ear tags were used to identify deer captured on two study subunits. Deer captured between Gregory Canyon/Baseline Road on the north, and South Boulder Creek on the south, received yellow tags. Animals captured north of Gregory Canyon/Baseline Road were marked with orange tags.

2.2 POPULATION ESTIMATES

The deer population size was estimated using a modified Lincoln-Peterson formula proposed by Chapman (1951), a long established mark-recapture method. A known number of animals are captured, marked and released back into the general population. At varying times after the final release, the population is censused; and the number of marked and unmarked animals is compared. The ratio of marked to unmarked animals is assumed to be the same in this sample census as in the total population, and a population estimate is therefore possible.

Approximately eight weeks after trapping had ended, four independent recapture (census) samples were taken, three on successive days and one the following week. For the purpose of the census, the study area was divided into four distinct sections or districts encompassing a set group of transects. Each day a different observer or team was assigned to each district and its transects. This permitted a more intensive census on each district than would otherwise have been possible with fewer observers. Census samples were obtained by walking and driving transect routes which covered most of the study area. All deer observed were counted, and ear tag number and color recorded for marked animals. Transect routes walked/driven each day were very similar, providing a uniform census effort on each sampling day.

The mean population estimate was calculated using the average of the four individual daily sample estimates. Confidence limits of 90% were constructed as in the 1984 study. Confidence limits define a range around a mean, where the actual population with 90% certainty lies.

In April 1986, the number of tagged deer remaining in the population was determined based on: (1) known losses of marked deer, (2) deer tagged during the 1985-86 trapping were assumed to be alive unless known to be dead, (3) deer tagged in 1983 and seen after January 1, 1986. The result was an estimate of 97 marked deer by April 1986.

2.3 DEER MOVEMENTS

The primary data on deer movement was provided through the efforts of four University of Colorado interns. From January - April 1986, each intern spent 8-10 hours per week walking predetermined transects and recording sightings and their exact location. Additional data were provided by City of Boulder Mountain Parks and Open Space Rangers, Colorado Division of Wildlife personnel, retrap records, road-kill information and numerous citizen reports. The end result was that over 700 recorded resightings were compiled into individual home range maps for each marked deer. It was hoped that a data base of this size would permit very detailed delineation of home ranges by individual, district and even subdistrict.

2.4 DEER-VEHICLE ACCIDENTS

Data on this topic have been kept in increasing detail since the original study in 1983. Information for 1986 was obtained from dead deer pickup records kept by the Boulder County Humane Society, CDOW District Wildlife Managers, and Mountain Parks and Open Space personnel. Data collected included location, date, cause of death, and sex and age class, where possible. In addition, BCHS personnel and Open Space Rangers performed several necropsies on road-killed female deer to determine the reproductive rate and the presence of fetuses. Road-kill information was analyzed to determine trends, not only in total numbers, but also in location, month, and mortality by sex and age.

2.5 HABITAT SAMPLING

Three of the four sectors were sampled for vegetative species composition during the winter of 1984-85, and again in late spring of 1985. The sampling system was designed to provide a general indication of habitat quality, and vegetation production and utilization, but not to intensively sample key deer use areas. The winter sample was obtained using a distance sampling method best suited to obtain shrub species composition and density. The spring sampling system involved the distance method and with 0.9M2 circular plots to sample herbaceous (grass and forb) production.

During the winter, leaders (annual new growth increment of shrubs) were clipped and weighed, yielding average leader weights. At all plots, total number of leaders produced on each shrub encountered was estimated. Number of leaders multiplied by the weight yielded leader weight production per hectare (ha) (one hectare = 2.47 acres).

The herbaceous sampling system was a double sampling system, where the total weight produced in the plot was estimated, and the proportion of the total weight of each species in the plot was estimated. All production in every fifth plot was clipped, bagged, and air dried, then weighed. A correlation was developed between the estimated and actual weights of all plots clipped, and this correlation was applied to all plots to estimate total production per hectare. Production by individual species was derived by multiplying the proportions each species comprised of each plot with the total weights.

The portion of shrubs used by deer was determined by dividing the number of leaders eaten by deer by the number produced. The procedure works well for deciduous shrubs because use during the winter is readily apparent by noting the clipped leader. The method is less suited for evergreen shrubs and conifers, because the leaves or needles often hide browsed leaders or leaves. For example, while conducting the transects, evidence of browsing on Ponderosa Pine was rarely seen, but deer were often seen biting single needle groups off the ends of branches. Unless deer use is heavy, utilization is often not detected in evergreen shrubs or trees.

The procedure for sampling herbaceous utilization is the same, and is often unsuccessful, as with evergreens. Deer are very selective feeders and will often eat only a single blade of grass or a forb leaf. When utilization is low, many bites are missed, which makes utilization appear to be lower than it really is. For this reason, herbaceous utilization was not estimated.

The utilization noted for these transects, therefore, should not be interpreted as representing all of the species eaten by deer, or the total amount eaten. These data do indicate that some species were used to an observable extent.

Species composition, production, and utilization for the three areas sampled are included in Appendices B and C. All areas obviously provide the minimum of food, water, and shelter since the deer are present. But all of the areas differ in the quality of food and shelter.

Kufeld et al (1973 listed grasses, forbs, and shrubs commonly eaten by mule deer in the Rocky Mountain region (Appendix D). This list does not indicate deer preference for these plants, only that they are palatable to deer, and when they are available, deer will eat them. Deer preferences can only be determined when utilization levels are considered in conjunction with production (availability) (i.e., a preferred species is eaten in higher proportion than its availability). To be included in this list, utilization rates were not considered, only the number of times researchers observed the species in deer diets.

Twelve of seventeen browse (shrub) species, noted by Kufeld et al (1973), occur in the study area, as well as five of six grasses and sixteen of seventeen forbs. By these standards, the species composition of the Boulder foothills areas indicates adequate deer range. Several of the browse species within the study area are usually considered to be highly preferred species (Appendix B), while the majority is of moderate or low preference and palatability.

Hiding or security cover is considered to be a vegetative or topographic feature that can conceal an entire deer so that the deer feels secure from predators or people. Densely forested sites, brushy areas, or cliffs provide good hiding cover. Resting cover is vegetative or topographic features that protect deer from direct sunlight, winds, and storms. Hiding cover, by its nature, is good resting cover, though resting cover does not always serve as hiding cover.

Water availability is usually of minor concern because deer can fulfill most of their water requirements from their food. In late summer and fall, additional water may be required, and water availability can determine the distribution of the deer.

3.0 RESULTS AND DISCUSSION

3.1 TRAPPING AND MARKING

A total of 75 mule deer were trapped, marked and released (Appendix A). Animals south of Baseline Road were marked with yellow tags (Y) and animals north of Baseline received orange tags (O). All animals were marked with colored and numbered ear tags in both ears (except 0153 and Y108 which received one tag each). Two animals, Y128 and Y140, were killed by cars soon after being tagged. Their tags were recovered and placed on a doe/fawn pair at NCAR. In several cases, marked animals from the 1983 study were captured and found to have only one ear tag in place. In these cases, old tags were removed and two new tags inserted.

Of a total of 112 animal captures (captures plus recaptures), only one deer died during the trapping process. This animal was a large male, 0188, which had been tagged previously in 1983 as 037. In the interim (1984), he had been struck by a car and sustained multiple breaks of a front leg. It is presumed that the stress of this injury for two years plus being recaptured caused cardiac failure. Unlike 1983, no losses of trapped animals to dogs were recorded, although Y137 was seriously harassed by dogs while in the trap.

Trapping success based on a total of 327 trap efforts, 75 newly marked animals (Y128 and Y140 used twice) and 37 recaptures, was .34 deer per trapping effort (Table 1). This compares to a 1983 trapping success of .32 per trap effort. The trapping success numbers for 1986 were lowered substantially by a significant problem with recaptures. Traps on Shanahan, NCAR, and Sunshine Canyon accounted for 33 recaptures of previously marked animals. Obviously, this prevented unmarked animals from being caught and prolonged the trapping process. A total of 36 recaptures were recorded for 1986.

Age and sex ratios for the 75 marked animals were as follows: 27.5% bucks, 39.1% does, and 33.3% fawns. This yields a buck:doe:fawn ratio of 70:100:85 (Table 2). Twenty-three fawns were captured with a sex ratio of 46% males:54% females. The same ratio for adult animals was 41% males:59% females. The overall male:female ratio was 43% males:57% females. (NOTE: Yearlings were added to the adult age class to calculate these figures.)

TABLE 1

Summary of Deer Trapping Efforts
Boulder Mountain Parks and Open Space Land

TRAPPING PERIOD	TOTAL TRAP DAYS AND NIGHTS	TOTAL CAPTURED	TOTAL RECAPTURED	TOTAL NEW DEER TRAPPED
11/26/85-2/5/86	327	112	37	75

TABLE 2

Sex and Age Composition of Mule
Deer Trapped and Tagged
November 26, 1985 - February 5, 1986

SEX	ADULT	YEARLING*	FAWN	TOTAL
Male	18	4	12	34
Female	27	1	13	41
Total:	45	5	25	75

*Yearlings were added to the adult age class to calculate age/sex ratios in text.

TABLE 3

Sex and Age Composition of
Mule Deer Trapped and Tagged
by Subunit
November 26, 1985 - February 5, 1986

SEX	AGE	SOUTH UNIT	NORTH UNIT	TOTAL MARKED
Male	Adult	6	12	18
	Yearling	3	1	4
	Fawn	5	7	12
	Subtotal:	14	20	34
Female	Adult	14	13	27
	Yearling	1	0	1
	Fawn	10	3	13
	Subtotal:	25	16	41
TOTAL		39	36	75

3.2 POPULATION ESTIMATES

During the spring of 1986, the deer population in the 17 square mile study area was estimated at 1073 +/- 170 (Table 4). This calculation was based on marked deer observed compared to the total number of deer counted during each of the four sampling days (section 2.2). The 1986 estimate is approximately a 21% increase over the 1984 count of 888 +/- 217. (Note: no scientifically accurate survey was conducted in 1985)

The population census conducted in April 1986 involved walking the transects established in 1983, at the initiation of the original study. One transect was added in 1986 to include the area around the northernmost trap. This trap and the area around it was not included in the original study. By using the CU interns along with Rangers, teams of two observers were able to walk the transects, whereas previously, personnel limitations allowed only one observer per transect. The increased personnel enabled greater coverage of the study area, and resulted in higher counts of both tagged and untagged deer than had been obtained previously. The equation used to estimate the population uses the ratio of tagged to untagged deer observed. Therefore, the increased total count of deer increases the accuracy of the count, and does not bias the population estimate. The population estimate would only be biased if the transects were aligned to increase sightings of only tagged, or only untagged deer. The transects, rather, were aligned to maximize sightings of both tagged and untagged deer.

By dividing the mean population estimate (1073) by the study area size (17 square miles), a density of 63 deer per square mile was calculated. This compares with deer densities of $48/mi^2$ in 1983 and $55/mi^2$ in 1984. As mentioned in the 1984 WRD report, these values are high for winter habitats along the front range which normally average between $30/mi^2$ and $40/mi^2$ (Len Carpenter CDOW, pers. comm., 1984, cited in WRD 1984).

During the spring 1986 counts, figures were not kept on the observed buck:doe:fawn ratio. These data were compiled by staff in fall 1986. In 1984, the trapped ratio was 81:100:79 while the observed ratio was 34:100:93. As previously mentioned, the 1986 ratio for trapped deer was 70:100:85 (27%:39%:33%), while the observed ratio was 63:100:60 (28%:45%:27%). The moderate proportion of fawns in the population continues to reflect the good nutritional status of the herd. There is no indication that the Boulder deer herd is exceeding the biological carrying capacity of the available habitat at this time. However, it should be noted that in certain areas a significant amount of the habitat being used is inside developed city areas.

TABLE 4

Census Data and Population Estimates
of the City of Boulder Deer Herd

APRIL 1986

SAMPLING DAY	TOTAL NUMBER DEER COUNTED	TOTAL NUMBER MARKED DEER COUNTED	POPULATION ESTIMATE (N)
1	398	38	1001.6
2	484	36	1283.6
3	472	40	1129.6
4	403	44	878.8
Mean	439.25	39.5	1073
Standard error			86.8

3.3 DEER MOVEMENTS

Movement of tagged deer was noted by City Rangers, citizens, and by four CU student interns. Individual sightings were marked on topographic maps and recorded by date and location. Sightings of individual deer were used to develop "home ranges", the area frequented by a particular deer. Home range areas developed are not the limit of that deer's movement because surveillance was not constant (e.g., daily), and some deer were not seen for several weeks at a time. Their locations during those times may have been within or outside the indicated home range. Also, deer may make temporary movements outside of their home range, but, because of insufficient data, these outlying movements could not be separated from movements within the home range. The area used by deer varied widely, from less than 10 acres up to 506 acres (Table 5). Maximum straight line distances between resightings varied from .02 mile up to 1.74 miles (Table 5). One point of caution to consider in interpreting these data, though, is that resightings were made primarily from January through May 1986. Only a few sightings were recorded during the summer because the deer commonly seen during the spring moved out of the study area during the summer, and, therefore, were difficult to locate. The 17 square mile study area was divided into four sections of observation areas. The study area boundary and trap sites are shown in Figure 1. Movements within each section are discussed below.

3.3.1 North Boulder Section (Trap Sites 12, 13, 14)

This is the area from Linden north to Longhorn Road. Twelve deer were tagged and released in 1986; however, one was killed by an automobile eight days after being tagged. All eleven of the remaining deer were reobserved. In 1983, fifteen deer were tagged in this area; six are known to be dead, and six are presumed to be dead or dispersed from the study area, because they were not seen during intensive censusing efforts. Only three deer tagged in 1983 are still alive in the study area, one of which was recaptured in 1986 and retagged with the new, more visible, ear tags. Therefore, thirteen deer were used to identify movements within this area.

Trap site 12 was located west of Spring Valley, near the ridge top north of Linden. In 1986, six deer were tagged. One was killed by an automobile. In 1983, five deer were tagged at a nearby trap site. Of these five, two are known to be dead, two are presumed to be dead, or dispersed from the study area and one was seen at intervals into the summer. The six living tagged deer were reobserved twenty-nine times, mostly on the upper half of the ridge. Two of the six tagged deer were observed within 100 yards of the Spring Valley residential area, 0184 (1986) once (11% of relocations), and 054 (1983) once (25%). One deer crossed Linden and was seen several times on the northern half of the ridge immediately south of Linden.

Two deer were tagged at trap site 13 in 1986, located near the top of the ridge and west-northwest of Wonderland Lake. Both of these deer were seen in the area several times. Eight deer were ear tagged at the same location in 1983; three are known to be dead, one was seen alive in the study area and four were not located during the intensive search. The one living deer was seen once, within 50 yards of the trap site. The three living tagged deer were seen a total of five times. One of these was seen twice very close to houses in Pinebrook Hills near the ridgetop (66% of the total sightings for that deer).

The northernmost trap site (14) was located north of the Wineglass Ranch on Lee Hill Road, on City Open Space. Four deer were tagged and released from this trap in 1986. Two deer were tagged and released in 1983; one was killed by a hunter in 1985, and the other was seen in 1986. The five living tagged deer were seen twelve times, never near residential areas. All sightings were on Open Space north of Lee Hill Road, but the deer used the entire ridge and dispersed from the area during the summer. Home ranges and distances traveled could only be determined for one deer, 60 acres and .9 miles, respectively.

Western Resources Development Corporation (1984) reported that deer in the North Boulder section moved daily between Open Space lands and residential areas from September through May. During the summer, this movement pattern was reduced. Of the twenty-four deer tagged in this section in 1983, 75% were observed at least once, or killed, within the City (WRD 1984). During the present study, fewer deer were observed within the City (21%), but 64% of the fourteen deer were seen close to residential areas.

Two notable dispersals were reported by WRD (1984), of deer tagged in the North Boulder section. One traveled nearly fourteen miles west and was seen on the Brainard Lake Road, then returned to the study area and was killed by a vehicle at Broadway and Sumac. One other deer was killed by a vehicle in a residential area southeast of Foothills Parkway and Arapahoe. During the present study, no dispersal from the North Boulder section has been observed.

3.3.2 North Central Boulder (Trap Sites 8, 9, 11)

The north central section included the area from Baseline Road north to Linden, including all of Flagstaff Mountain. A total of twenty-three deer were tagged in this area in 1986 and twenty-seven in 1983. Two of the twenty-three deer tagged in 1986 were killed. Twenty of the remaining twenty-one were resighted at least once. Four of the twenty-seven tagged in 1983 are known to be

dead, and fourteen are presumed to be dead or dispersed from the study area. Therefore, twenty-nine tagged deer were seen within the north central section.

Trap site 8 was located on Flagstaff Mountain south of Panorama Point, and south of Flagstaff Road. Seven deer were tagged at this location in 1985. One has not been seen since being released. The other six were sighted thirty-five times. Three of the six deer were seen in residential areas six times out of a total of seventeen sightings (individually 17%, 44%, and 50% of total sightings). Two of the three deer were seen in residential areas near 6th and 8th Streets at the base of Flagstaff Mountain. The third moved southeast, was seen near Bluebell and King Avenues, on the mesa west of NBS, and near NCAR. The other three deer, not seen in residential areas, restricted their movements to the east face of Flagstaff Mountain, from below Panorama Point up to the summit of Flagstaff Mountain. These three deer were seen eighteen times. Six deer tagged in 1983 at Flagstaff were seen sixteen times, always in natural areas in Gregory Canyon or on Flagstaff Mountain. One deer tagged near Linden in 1983 moved south and was seen once on the north face of Flagstaff.

Trap site 9 was located in Sunshine Canyon, approximately .25 miles west of Memorial Hospital. Eight deer were tagged and released in 1985-6; two were killed by vehicles. The remaining six were seen ten times. Five were seen six times, always near the trap site, and never near residential areas. Immediately after being released, the other deer (0158), moved approximately 1.75 miles east, and was sighted twice in the 2200 block of Balsam. It then moved to City Open Space along Boulder Creek, east of Foothills Parkway and was seen there twice during the summer. In 1983, three trap sites were located in the Sunshine Canyon area, and ten deer were ear tagged. Two are known to be dead. The remaining eight were not seen in 1986 and are presumed dead or dispersed from the area.

Trap site 11 was located on City Open Space 75 yards south of Linden, near a residential area. Eight deer were tagged and released in 1986. They were seen subsequently ten times, never in residential areas. Several sightings were within 100 yards of houses near the trap site or in Pinebrook Hills. It is suspected that these deer may move into residential areas late in the evening, but this was never documented.

In 1983, six deer were tagged at a site close to trap 11; one is known to be dead, and one dispersed south to Flagstaff Mountain. Three were not sighted in 1986 and are presumed dead or dispersed from the study area. The remaining single deer was seen once on Open Space between Boulder and Pinebrook Hills.

WRD (1984) summarized movements of deer in the North Central Boulder section that were similar to those observed in the spring of 1986. Deer from Flagstaff Mountain remained in the area, but moved regularly into adjacent neighborhoods (45% of marked animals). One buck moved to North Boulder Park but returned to Flagstaff Mountain. No interchange of deer tagged to the north or south was observed in 1983-1984. One buck tagged in 1986 moved south and was last seen in Bear Canyon, south of NCAR.

Deer tagged in Sunshine Canyon also stayed in the area of the trap and did not enter the City but did approach the Knollwood Subdivision. No dispersals from the areea were noted in 1984. In 1986, one buck tagged in Sunshine Canyon dispersed west and was killed by a hunter on Gold Hill in the fall of 1986. One other buck tagged in Sunshine Canyon moved east of the study area as previously noted.

3.3.3 South Central Boulder (Trap Sites 5, 5A, 5B, 6, 6A, 7)

The south central section extended from Bear Canyon on the south to Baseline Road. This area includes NCAR and NBS and their associated natural areas and the nearby residential areas. Three trap sites were used on NCAR (5, 5A, 5B). Twelve deer were tagged and released at these sites. Trap site 6 was located near Kohler Reservoir, with four tagged deer being released there. Trap site 6A was located in the backyard of a residence on Kenwood Avenue and had two tagged deer released from it. Trap site 7 was located on the mesa west of NBS. Eight tagged deer were released from the "NBS Mesa" trap. Therefore, a total of twenty-six deer were tagged and released in this section in 1985-6. Two of these deer were killed by automobile accidents.

In 1983, traps were placed on NCAR (trapping one deer) and NBS Mesa (fourteen deer). The lone deer tagged at NCAR in 1983 was seen at NCAR in 1986. Seven of the fourteen from NBS Mesa are known to be dead. One deer dispersed east of the study area and was seen at Sawhill Ponds in 1985. One dispersed north and was recaptured in 1986 at trap site 14 north of Lee Hill Road, but was in very poor condition and died during the retagging procedure. One deer from NBS Mesa, tagged in 1983, has not been seen since February 1985 and is presumed dead or dispersed from the study area. Therefore, four deer from NBS, and one from NCAR, tagged in 1983, are still alive in the south central section.

Trap site 5 was located northeast of the NCAR buildings and south of Table Mesa Drive. Only one deer was tagged and released from this site. Trap sites 5A and 5B were on the south-facing slope

south of the NCAR buildings. Eleven deer were tagged at these sites. The twelve NCAR deer were seen 144 times. Six deer were seen in residential areas 17 of 65 total sightings (26%). These residential area sightings were near Kenwood and Kohler Avenues and Table Mesa Drive. The proportion of times individual deer were seen in residential areas varied from 7% to 100%. The other six deer tagged at NCAR in 1985-6, and the one 1983 deer, were seen 83 times, always in natural areas near NCAR, NBS Mesa, or Skunk Canyon.

Trap site 6, near Kohler Reservoir, had four tagged deer released from it. One deer was killed by an automobile. The other three were seen thirty-one times. All three were seen in residential areas a total of twenty-two times (71%). Individuals were spotted in residential areas 57%, 57%, and 100% of their sightings. When they were seen in natural areas, it was at NCAR or on NBS Mesa. When they were spotted in residential areas, it was always near Kohler and Kenwood Avenues and Table Mesa Drive.

The two deer trapped at site 6A (Kenwood Avenue), were seen fourteen times, twelve times in residential areas (86%). One deer was seen in the Kohler and Kenwood Avenue area all six of its sightings. The other was seen twice on NBS Mesa and six times in the Kohler/Kenwood area (75%). The Kenwood Avenue trap was used specifically to see whether deer frequently seen in residential areas were seen exclusively in that residential area, or whether they return to natural areas. The Kohler/Kenwood Avenue area is frequented by deer, but natural areas are readily accessible. The two deer tagged on Kenwood Avenue used that area to a great extent but not exclusively. No sightings were recorded during the summer of 1986, so it is unknown whether these deer returned to natural areas for the summer.

The fourth trap site (7) in the south central section, located on NBS Mesa, had seven deer tagged and released from it. These seven deer were resighted thirty-seven times. Only three were seen in residential areas, areas to the northeast (Bluebell and King Avenues). Deer sightings in natural areas were mostly on NBS Mesa but also on NCAR and in Skunk Canyon. Three deer tagged in the same location in 1983 were seen four times, always on NBS Mesa.

The large herd of deer commonly seen at NCAR seems to be made up of individuals using only the NCAR area, as well as deer wandering from NBS Mesa, Skunk Canyon, and nearby residential areas. Several recaptures were made on NCAR of deer previously tagged at NBS Mesa. Dear tagged at Kohler Reservoir and Kenwood Avenue were seen at NCAR. Some of the deer in this area seem to move freely throughout the whole area, utilizing natural areas as well as residential areas. Deer in the other three sections of the study area seldom wandered near other trap sites, and showed a high degree of fidelity for the area in which they were originally caught.

WRD (1984) reported that 53% of the deer tagged in the South Central Boulder section were observed in residential areas (57% of those from NBS Mesa, and 0% from NCAR). During the present study, 58% of the tagged deer were seen in residential neighborhoods (50% of NCAR, 100% of Kohler Reservoir and Kenwood Avenue deer, and 43% of the NBS Mesa deer).

One long distance dispersal of a deer, tagged on NBS Mesa in 1983, occurred subsequently to the WRD (1984) report moving to Sawhill Ponds. No long distance dispersal of recently tagged deer are know.

3.3.4 South Boulder Section (Traps 1, 2, 2B, 3)

The south Boulder section extended from Eldorado Springs Drive (Colorado Highway 170) on the south to Bear Canyon on the north. Fourteen deer were tagged in 1985, and all were alive throughout the census period. The section had six trap sites in 1983, and thirty-three deer (including four white-tailed deer) were marked and released. Five deer from 1983 are known to be dead, and fifteen were not seen during the inventory, leaving thirteen of the original thirty-three still present in the south Boulder section. One of these was recaptured and retagged in 1985.

Trap site 1 was located east of the Mesa Trail, approximately .5 miles north of Eldorado Springs Drive. Four deer were tagged there in 1985. These four were seen a total of eleven times. They were often seen together near the trap site, never near residential areas. Three deer were tagged in 1983 in the area of trap site 1. They were subsequently seen four times and never near residential areas.

Trap sites 2 and 2B were located on the lower part of Shanahan Ridge. Six deer were tagged there. These six deer were seen a total of twenty-one times (9.5% in residential areas). A doe-fawn pair, both tagged, were seen together in a residential area once but were seen later near the trap site. Eight deer were tagged in the lower Shanahan area in 1983, and two are presumed dead or dispersed. The remaining six were seen nine times, always in natural areas.

Trap site 3 was in the upper part of Shanahan Ridge. Four deer were tagged at site 3 in 1985. Their movements centered around the trap site and southward, away from houses. One deer moved northeasterly and was seen once on Juliard Street off of LeHigh but then returned to Shanahan Ridge. This deer was killed later in the summer by a vehicle on Juliard Street. These four deer were resighted ten times.

In 1983, there were two trap sites between Shanahan Ridge and Bear Canyon. Thirteen deer were marked at these traps. Four are known to be dead, and six were not located during the census effort. The remaining three deer were seen five times, always in the areas near the trap sites, and never in residential areas.

Deer tagged in the South Boulder section had similar movements in 1986 as reported for the 1983-1984 period (WRD 1984). In 1983-1984, 8% of the tagged deer were seen in the City (18% of the Bear/Fern Canyon deer, 0% of the Shanahan Hill deer). Of the ten deer tagged on Shanahan Hill in 1986, 30% were seen in residential areas. All fifteen of the deer tagged south of Shanahan Hill, in 1983 and 1986, restricted their movements to Open Space land.

Three of twelve deer tagged in 1983 were known to have crossed, or attempted to cross Highway 93. This movement was not observed in tagged deer in 1986. However, two bucks, tagged as fawns, moved south as yearlings. One was tagged on Shanahan Hill in 1983 and was killed in June 1984 by a vehicle west of Golden on Highway 6, at the entrance to Clear Creek Canyon. The other was tagged in 1985 south of Shanahan Hill and was killed in October 1986 on Highway 58 south of Table Mountain, east of Golden. These are long distance dispersals of approximately twenty-three miles each, that originated and terminated at similar locations. Both were made by yearling bucks. No other significant north-south movements were documented in this area.

3.3.5 Summary of Deer Movements

Deer at all trap locations tended to stay in the area of the trap site, moving .5 to .75 mile in any direction from the trap. The movements of individual deer away from the trap site were noted in the discussion of individual trap sites. As noted in the earlier report (WRD 1984), there is a great deal of movement into residential areas from adjacent Open Space and Mountain Parks areas, with notable exceptions being the northernmost and southernmost trap locations. At least one deer from each of the traps, except numbers 1 and 14, were seen in or very near residential areas. With the exception of the deer trapped on Kenwood Avenue, very few midday sightings of tagged deer were made in residential areas. It is believed that many deer spent nights in residential areas and returned to natural areas early in the mornings.

There was a great deal of variation in the observance (number of sightings) of tagged deer. Many were seen only once or twice. Others, though, were seen sixteen and eighteen times. If more sightings had been made of all deer, many statistical tests could be conducted and home ranges could be accurately drawn.

Traps were not placed to test the hypothesis that except for the Kenwood trap (6A), deer caught in traps closer to residential areas may frequent those areas more often than deer caught further away from houses. This hypothesis is logical, because deer near residential areas are more exposed to people and associated factors than deer farther away. They may become tolerant enough to come into residential areas. Traps were placed in order to maximize trapping success. Traps were placed an average of .37 mile from medium to high density housing, but varied from 0.0 miles (Kenwood trap 6A) to .75 mile (trap 14). Deer caught in traps within .2 mile of residential areas were seen in residential areas 23% of the time (21 of 90 sightings). Deer caught at distances of .21-.55 mile were seen in residential areas 11% of the time (26 of 245 sightings). Two traps at greater distances had no sightings of tagged deer in residential areas in 23 observations. This is supported by subjective "flushing distances," where deer in the central part of the study area do not flush from people at very close distances. Deer in the areas of the far south and north traps usually flush at the approach of a human at 100 yards or more.

Overall, deer use of residential areas has remained the same since 1983. Using the data reported for the 1983-1984 period (WRD 1984), 37% of the tagged deer were reported at least once in residential areas. In the spring of 1986, 33% of the tagged deer were seen in residential areas. None of the deer tagged in 1983, though, were seen in residential areas in 1986.

Although the majority of the tagged deer were never seen in residential areas, those that were seen in neighborhoods apparently were comfortable there. These deer were seen in neighborhoods an average of 52% of the time, with three deer in the study seen exclusively in residential areas. These three deer were all tagged in the South Central Boulder section, from the NCAR, Kohler Reservoir, and Kenwood Traps.

TABLE 5

Home Range Area and Straight Line
Movement of Tagged Deer, by Trap Site

Trap Number	Number of Deer	Number of Resightings	Home Range (ac)	Home Range Variation (ac)	Distance Traveled (mi)	Distance Traveled Variation(mi)
1	7	15	155	78-193	.83	.60-0.90
2	12	30	114	25-312	.82	.30-0.90
3	4	10	*	*	.84	.75-1.00
5	12	144	136	14-273	.87	.60-1.50
6	3	31	52	20-84	.67	.50-0.80
6A	2	14	38.5	24-53	.70	.40-1.00
7	7	37	94.5	32-168	.75	.20-1.20
8	6	35	135	25-506	.83	.44-1.67
8 (exc. 0157)	5	26	43	25-65	.67	.44-0.89
9	6	10	*	*	.41	*
9 (exc. 0158)	5	8	*	*	.15	*
11	9	11	*	*	.22	.10-0.50
12	6	29	*	*	*	*
13	3	5	*	*	*	*
14	5	12	*	*	*	*
Total	82	417				
Mean			96	30-207	.65	.43-1.04
Weighted Mean			111	30-246	.66	.41-1.06

*Insufficient data to calculate

The second hypothesis is that deer tolerance of people has not significantly changed. The deer trapped and tagged in 1983 that used residential areas have either been eliminated from the population, primarily by vehicle accidents, or have "learned" to stay away from residential areas. The learning portion of this hypothesis cannot be tested except over time. The removal from the population theory can be estimated at this point, with further testing over time. The 1983 tagged deer population decreased by 14.4% the first year due to road kills, 6.5% the second, 2.7% and 2.8% the third and fourth years, respectively. Six of the sixty-nine deer tagged in 1985-6 (8.7%) were killed by vehicles within eight months of being tagged, which, put on a yearlong basis, will approximately equal the data for the 1983 deer. The problem with testing this hypothesis is that more deer have simply disappeared from the population, due to undocumented vehicle accidents, dispersal, or natural causes than have died from documented accidents.

3.4 DEER-VEHICLE ACCIDENTS

With deer living in such close proximity to people and roadways, road kills are to be expected. As deer around Boulder have become accustomed to people and vehicles, they seem to have become more comfortable crossing roadways and feeding along roadsides. At night, drivers may not see deer along roadways in time to adjust their speed, and the deer may be hit and killed or injured. Also, with extensive landscaping along roadways, deer may feed or rest in these areas and not be seen by drivers until it is too late. Some injured deer remain mobile and are able to leave the area. A broken leg may fuse in time, and the deer may live for several more years, despite being less mobile. Multiple broken legs usually cripple the animal, and when found or reported these animals are destroyed by State, County or City officers. Deer that receive internal injuries may be able to leave the accident area but often will die within a few days. An undetermined number of these deer are never reported and not accounted for. The following discussion and data reflect only deer known to have been killed by vehicles or destroyed after having been injured. The actual number of deer killed, therefore, is probably greater, and there is no way to estimate actual mortalities at present.

3.4.1 Annual and Seasonal Patterns

Road kill deer data for four complete years are available, 1983-1986 (Figure 2). Total number of deer killed has varied in the three years, from 119 in 1983, 133 in 1984, 113 in 1985 to 116 in 1986. Age and sex of road killed deer were collected in 1984-1986. In this period, 1 male was

killed per 1.45 females. Adults were killed at a rate of 3.4 adults per fawn in 1984, 4 per fawn in 1985, and 3.3 per fawn in 1986 (3.5:1 for the three year period, Table 6). These data indicate deer were killed in approximately the same proportion as the respective sex and age classes occur in the population. Therefore, no age or sex classes appear to be removed disproportionately. This is significant because behavioral differences are observed in males versus females, or adults versus fawns.

All sex and age classes follow a similar trend in monthly road kill rates. Most deer are killed during the winter months, October through March. Rates begin to elevate to winter levels in July and are markedly lower in April through June (Table 6). These patterns could be influenced by many factors: weather, forage quality, and sex and age behavioral differences. At present, insufficient data are available to differentiate between the factors.

3.4.2 Swareflex Reflectors

The Swareflex Reflector is a red, angled reflector designed to prevent deer from crossing roads in the path of vehicle headlights. The Swareflex system has been used and evaluated in many states and Canadian provinces and has usually been effective in reducing the number of deer-vehicle accidents. One recently published study in Washington state reduced roadkills by 90% over a 3.5 year interval (Schafer and Penland 1985). Other studies have had inconclusive data, or have shown no reduction in road kill numbers (T.N. Woodard et al., unpubl. rep., Colo. Div. Wildl., 1973). The study does not indicate how the Swareflex reflectors were installed or maintained nor how the road kills were monitored. The Swareflex system has been termed a "light-fence" because it reflects the headlights of oncoming vehicles away from the roadway into the eyes of deer near the road. This has the effect of making deer freeze and inhibits them from crossing the road. When the vehicle passes, the light is broken and the deer move. Therefore, the reflectors only work at night, when vehicles have their headlights on, and when the light beam is unbroken from the vehicle to the reflector and from the reflector to the deer. Most deer-vehicle accidents occur at dusk, night, and dawn when deer are more active, so reducing the number of nighttime accidents could significantly reduce the number of deer injured and killed along roadways.

The City of Boulder Transportation Department installed three test sections of Swareflex Reflectors during February 1986. The sections chosen to test the effectiveness of the reflectors were: North Broadway-Linden Drive to Locust (.85 miles), Central Broadway - 27th Way to Dartmouth (.5 miles), and South Broadway - Darley to the south City limits (.8 miles). These

sections were chosen because 1983, 1984 and part of 1985 deer road kill data indicated these were frequent accident areas with twenty-three deer killed in all three sections each year. In 1983, seventeen deer were killed in the north section, five in the central area and one in the south. In 1984, eleven, eleven, and one deer were killed in the north, central and south sections, respectively. In all of 1985, these sections had seven, fourteen and two deer killed within them (north, central and south, respectively).

The road kill deer data for 1986 can be seperated into periods before the Swareflex Reflectors were installed (approximately 45 days) and afterwards (approximately 10.5 months). One deer was killed in each the north and central test sections before the reflectors were placed. None were killed in the south section during this period. Afterwards, six deer were killed in the north section, three in the central section, and four in the south section, for a total of thirteen deer in all three sections. In addition, seven deer were killed within 100 yards of the ends of the test sections. It is impossible to determine if these deer were walking around the test sections, deterred from crossing roads inside of the sections by the reflectors, or merely crossing roadways close to the Swareflex Reflectors.

Since the Reflectors have been in place for less than one calendar year, no conclusions can be drawn at this time. The effectiveness of the Swareflex Reflectors in these sections is being evaluated and suggestions for additional sections will be made in the future. Initial research dealing with the reflectors involved a trend analysis for several years to recognize changes in road kill rates before and after installation. More sophisticated research is being conducted in several states now, recognizing that road kill rates vary widely due to seasons, weather, annual variations and day versus night rates. Current research usually involves covering and uncovering entire test and control sections at weekly intervals for several years. This research requires careful monitoring of the sections to determine time of accidents. This allows more rigorous statistical analysis than the former research allowed, and preliminary results indicate Swareflex Reflectors may reduce deer-vehicle accidents by up to 90% during the night. The test sections in Boulder will be evaluated by using trend analyses, rather than covering and uncovering test sections. This is due to: 1) the time required to cover and uncover the sections and monitor the road kills, 2) three sections are insufficient for statistical tests between sections, 3) possible severe accidents resulting from when reflectors were covered in an urban setting.

Several factors may impact the effectiveness of the reflectors in Boulder. First, the sections are relatively short, which could allow deer to move around the end of the sections. Whether or not this occurs can be determined by precisely identifying accident locations. Secondly, the

urban nature of Boulder's test sections, road intersections, landscaping, and damaged reflectors, all contribute to the light fence being "broken". This creates a corridor through which deer may move. Third, road repairs and snow plowing can cover the reflectors with dirt, which reduces the light reflective capability of reflectors. The second and third factors indicate the importance of constant maintenance of the reflectors to avoid preventable accidents and confounding data. Lastly, the central section, 27th Way to Dartmouth on Broadway, is fully lit by overhead street lights which may reduce the intensity of vehicle headlights by illuminating the whole area. The northern section has only one street light and the southern section has none. The southern section, however, is fragmented by a gap in the reflector sequence on one side. The south section also ends at the city limits and does not fully cover a historic crossing and high deer-vehicle accident area in the county immediately south of the City limits. The effectiveness of the Swareflex reflectors in reducing the number of deer killed on roadways could have the effect of increasing the deer population by removing a major portion of the mortality.

TABLE 6

Number of Road Kill Deer by Sex and Age Class
by Month, 1984-1986

	Total	Males	Females	Adults	Fawns
January	51	11	18	23	3
February	46	16	21	29	5
March	17	4	10	8	5
April	16	3	11	9	6
May	12	5	7	12	0
June	16	6	9	15	1
July	26	10	13	22	2
August	21	10	10	16	4
September	20	11	8	12	8
October	41	9	26	18	19
November	50	18	29	29	8
December	46	24	22	35	7
Total	360	127	184	239	68

3.5 DESCRIPTION OF HABITAT

3.5.1 North Boulder Section

The area from Linden Drive north to Longhorn Road is marked by barren hillsides with Ponderosa Pine limited to the upper quarter of the slopes. Therefore, hiding and resting cover is at the top of the slopes, with hiding cover being restricted to a very few patches of dense trees. On the west side of these ridges, though, are the Pinebrook Hills and Old Stage Road housing areas, which further restrict hiding cover to dense patches of trees away from houses. The best hiding cover on these two ridges is in the northern quarter, north of Lee Hill Road, along the ridge top, where rocky outcrops and dense stands of pine combine to make excellent cover.

There are several water seeps midway up both of the ridges in this section that probably supply enough water to maintain the deer. Wonderland Lake is situated at the bottom of the south half of this section and Silver Lake Ditch is near the bottom of both ridges. Water requirements are probably supplied through these sources.

Forage production on these steep ridges is determined by overstory and the degree of slope. At the top of the ridges, under the trees, the understory is mostly grasses and sedges with a few forbs and scattered shrubs. Mid-slope and lower slope areas are dominated by grasses and sedges, with shrubs widely scattered in clumps in ravines. A few widely dispersed pines are also present.

The north Boulder section has the lowest number of shrub species of the three areas sampled. The northern half of this section, though, has the most extensive stands of mountain mahogany and serviceberry, two shrubs highly preferred by deer found anywhere in the study area. These stands have been heavily browsed (up to 60% in many areas) while many less preferred shrubs show little use. The area was reportedly overgrazed by cattle until 1980 (Wichmann and Peck, 1980, memorandum). Since 1980, cattle have not grazed the area. No specific data for mountain mahogany or serviceberry are available from the 1980 sample, but cattle do often use these shrubs on overgrazed range. In the five years from when the cattle were removed until the area was resampled, the impact from cattle use should have been reduced. The 1985 sample indicated past and current heavy use by deer because the plants were "hedged". It would appear, therefore, that this area has sustained a high population of deer in the recent past. This is supported by an instantaneous count of 68 deer visible from one spot, and another count of 96 deer when this area was walked (which may include some duplicate counts). This many deer in an area of less than one

square mile would be expected to have a visible effect on their habitat, particularly on preferred species.

3.5.2 North Central Section

The sampled portion of this section extends from Memorial Hospital to the west about one mile, and from Mapleton Avenue (Sunshine Canyon Road) north to the Pinebrook Hills subdivision. The first two ridges, Dakota Ridge and Mt. Sanitas, are only forested near the ridge tops but have more shrub areas than the north section. West of Mt. Sanitas, the area is predominantly a Ponderosa Pine forest with a few shrubby draws and grassy meadows. This diversity of habitats provides good deer range, with feeding areas of meadows and draws adjacent to forested resting areas. Part of the forested area, the west slope of Mt. Sanitas, was thinned to minimize pine beetle kill which has the effect of increasing understory production. This provides even greater diversity of habitats.

Forage production in this area, however, is generally low (Appendices B, C), due to the steep slopes and very rocky soils. Scattered mountain mahogany and serviceberry plants once again were the most heavily browsed species, but were less heavily used than in the North Boulder section. Other species that had recorded use were skunkbush sumac, and currant. There was very little use on snowberry. Overall use of mountain mahogany and serviceberry was less than two-thirds of that recorded in the North Boulder section, and no areas of very heavily used shrubs were observed. In addition, no shrubs were severely hedged or otherwise impacted by deer. Several juniper trees had been severely hedged or otherwise impacted but were not located within the sample plots, while the junipers sampled showed little or no current use.

Because of the light use observed on preferred species in an area of low production, the deer population in this area appears to be well within the habitat's carrying capacity. This does not include alternative food sources (residential areas), and the deer in this area have historically ventured into the residential areas on 3rd and 4th Streets.

3.5.3 South Central Section

The area from Flagstaff Mountain south to Bear Canyon was not quantitatively sampled. Upon cursory inspection, however, habitat characteristics in this section are similar to the south section, in that many of the mesa top forests have been thinned for pine beetle management. In this predominantly forested section, there are densely forested draws providing good resting

cover adjacent to thinned forests. With the exception of Skunk Canyon, which is very shrubby, shrub fields are limited in distribution and size and are dominated by skunkbush sumac. Open meadows are very restricted in size and distribution. No areas of heavy use have been seen, but there is some utilization scattered throughout the section. This would indicate the deer population is probably within the habitat carrying capacity, and the deer are well distributed within this section.

3.5.4 South Section

The area from Eldorado Springs Drive north to Bear Canyon is predominantly forested with two large grass/forb meadows in the north and south ends of the area. There are also two perennial streams, South Boulder Creek and Bear Creek, as well as several intermittent streams and springs. Each of these watercourses is lined with typical riparian vegetation: cottonwood, willow, hawthorne, mountain maple, chokecherry, and plum. The south section has the highest shrub species diversity, with eighteen species sampled, and the highest production of herbaceous (grass and forb) vegetation. The area, however, has only one extensive shrub field. The section's forest stands were thinned during Project Greenslope and Pine Beetle management, but have only scattered shrubs. Nearly 19% of the shrub density is Ponderosa Pine (Appendix B).

Mountain mahogany is very limited in this section and none was sampled. Mountain mahogany that has been observed in this area is limited to the ridge east of the Mesa Trail and south of Bear Creek and has not been heavily browsed. Serviceberry is more widely scattered, occurring throughout the area, but seldom in extensive patches. Serviceberry was used by deer to a small degree and appears to be vigorous and not heavily browsed in the past. The shrubs with the greatest overall density (22% of the total) were three species of currant (Ribes aureum, golden currant; R. cereum, wax currant; and R. inerme, gooseberry). These three species vary in degree of palatability, depending on the presence of thorns or spines, but are usually considered to be moderately preferred by deer. In this sample, currant was used by deer to a small degree.

Finally a species not usually used by deer, poison ivy, exhibited the heaviest use by the deer. This species was very restricted in distribution and density and would appear to be an anomaly commonly encountered when studying wild animals' food habits. Wild animals will occasionally heavily use a species not usually found in their diet for reasons not completely understood. Since this species is a minor component of the habitat and the plants appear to be vigorous, one year's observation of heavy use should not be alarming.

The deer population in this area, based on habitat analysis, appears to be within the habitat carrying capacity; and since no areas of heavy use were observed, the population seems to be well distributed.

3.5.5 Summary

Plant species composition was quantitatively sampled in three of the four subunits of the 17 square mile study area. The fourth area was summarized only in general qualitative terms. None of the urban areas, supporting substantial vegetation, were sampled. Shrub species composition is not of high quality for deer range, due to the scarcity of mountain mahogany and serviceberry and the absence of bitterbrush. Where the former two occur, they are usually moderately utilized by the deer. These two species make up only 10% of total woody vegetation density in the study area. In more "chaparral-type" areas to the north (Lyons, Ft. Collins) and south (Golden), these highly preferred species, along with the bitterbrush, may account for 30-50% of the woody vegetation.

Due to the abrupt rise of the Flatirons and the long history of fire suppression in Boulder's foothills, conifer forest cover is much more extensive than in some adjacent areas. This may serve to maintain more of a resident deer population near Boulder due to thick forest areas providing thermal cover during the hot summers. In areas to the north and south, deer herds are more migratory, possibly because of the lack of conifer forests and thermal cover. In these areas, deer are forced to higher elevations with forest cover to avoid the hot and dry summer. Many native shrubs are intolerant of conifer cover, requiring a great deal of direct sunlight. The combination of these two factors, greater conifer forest coverage and a paucity of desirable shrubs, presents a situation unique to Boulder. In this area, deer have a good physical habitat which provides adequate thermal, resting and hiding cover year-round. The area, however, has a poor representation of highly preferred shrub species for food.

The majority of the shrubs in the Boulder area are of moderate palatability and preference and few are of low preference. The moderately preferred species can be thought of as the staple of deer diets. In most areas, highly preferred shrubs are considered "ice cream" plants, because they will be utilized first, and the degree of use may be high even when the deer population is low in terms of the habitat carrying capacity. Most population management decisions, therefore, should be based on the degree of use observed on moderately preferred species. With the exception of the North Boulder subunit, observed use of preferred species was moderate, and use of moderately preferred species was light. Deer populations in these areas appear to be within

the habitat's carrying capacity. In the North Boulder subunit, degree of use was somewhat higher but not excessivly high. The deer in this subunit are slightly more migratory than in the other subunits; so light use in the summer may compensate for heavier winter use, allowing the plants to maintain vigor during the growing season. The deer population and shrub utilization levels should be monitored in the future to detect increasing deer numbers, habitat use, or habitat deterioration.

In addition to the habitat characteristics noted above in each section, additional food and cover is available for deer in residential areas adjacent to natural areas. The North Central and South Central sections are close to residential areas which provide a great deal of forage and cover for deer coming from these sections. The North Boulder and South Boulder sections are further removed from residential areas; therefore, alternative sources of food and cover are less accessible.

4.0 MANAGEMENT ALTERNATIVES

These management alternatives are based on the current deer population and habitat conditions. As Western Resources Development Corporation (1984) suggested, a population of 1,000 deer requires different management alternatives than a population of 14,000 or 400 deer.

4.1 CONTINUE WITH PRESENT COURSE

a. Provide informational brochures on deer to concerned parties.
b. Continue ordinances prohibiting feeding deer and the use of salt licks.
c. Continue the ordinance allowing electric fences to control deer movements in residential areas.
d. Provide information to the public on what actions, as defined in the Division of Wildlife policies, may be taken by property owners to discourage deer from using private property. harassing deer in order to discourage deer using yards.
e. Provide information on deer warning devices for automobiles.
f. Provide information on fencing varieties and specifications to control deer movement in residential areas.

Advantages:

a. This is perhaps the least controversial and most acceptable to the public of the alternatives.
b. Some members of the public may be expecting the City to provide these options. Providing these options may improve the public's perception of the City.
c. Parts a-c of this alternative have already been initiated.

Disadvantages:

a. This option does not affect the deer population trends or the problems associated with increasing deer numbers. It entails mitigation of conflicts rather than outright prevention. This alternative may be viewed by some members of the public as no decision.
b. There is presently no way to determine the effectiveness or compliance of the ordinances already in place. No single agency has the responsibility, time, or personnel to strictly enforce the feeding/salt lick ordinance.

4.2 CONDUCT A SCIENTIFIC SURVEY OF BOULDER RESIDENTS

A scientific survey could be used to determine:

a. Extent of deer use of private property.
b. Perception by residents of deer as a benefit/conflict.
c. Extent of deer "damage" to private plantings and degree of tolerance by residents.
d. Resident support for a variety of management alternatives.

Advantages:

a. Council and staff would be better informed to the desires of a broad cross-section of residents.
b. Positive public relations tool to indicate City concern and efforts to address the potential conflict.
c. Would enhance overall public awareness and interest in the deer situation.
d. Could provide a better basis for evaluation of usage by deer of the urban habitat.

Disadvantages:

a. Would entail additional costs of setting up, conducting, and analyzing a scientific questionnaire; mailed to approximately 10% of all City residents, randomly distributed throughout the City.
b. Unless the survey is scientifically designed, the data could be seriously biased.
c. This option does not affect the deer population trends.

4.3 EVALUATE REPELLANT EFFECTIVENESS

The City could provide information on repellants and assure the local availability of a variety of repellants. The City could also investigate and evaluate the effectiveness of various repellants at selected residences. The location of the test site would be based upon the severity of damage claimed.

Advantages:

a. City testing would give factual data on repellant effectiveness in the study area west of Broadway.
b. This alternative would show City concern and willingness to address citizen concerns.
c. Widespread use of repellants might make the urban habitat less attractive to deer.
d. If repellants work, the economic loss claimed by some residents would be expected to decline.
e. Repellants would be a non-consumptive/non-destructive way of reducing deer impacts on private property.

Disadvantages:

a. Limited use of repellants might shift the deer from one yard to another.
b. Testing would entail increased staff time and variable repellant costs for the winter months.
c. If residents perform the application themselves, the results would be highly variable.
d. Part of this option duplicates existing, published research.
e. This option does not affect the deer population trends.

f. Providing information on repellants might be construed as City endorsement of those products.

4.4 EXPAND THE USE OF RADIO-COLLARED DEER

Only four or five of the original ten radio-collared deer are still in the study area, and the batteries are no longer operating. Fifteen to twenty additional collars are recommended to provide additional information for the on-going deer study. New collars cost approximately $300 a piece; the four or five still in the study area could be recharged for approximately $150, if those deer could be recaptured.

Advantages:

a. Would enable staff to efficiently monitor a number of animals' movements on a daily basis, which is not presently possible.
b. Would enable staff to efficiently locate groups of deer which seem to leave the area in the spring.
c. Collars could be put on during regular scheduled trapping, thereby incurring no additional staff time for placement.

Disadvantages:

a. This system would entail added costs for new collars.
b. This option does not affect the deer population trends.
c. Additional staff time would be necessary to regularly relocate the radio-collared deer.

4.5 STUDY DEER TRAPPED IN THE CITY SPECIFICALLY

A study could be designed to investigate movements, behavior, and reproduction of deer specifically in residential areas. Such a study would require four to six additional trap sites within residential areas and radio-collars for at least four deer from each trap.

Advantages:

a. This study would provide additional data addressing the issue of a "City herd".

b. This study would provide additional data concerning deer causing conflicts in residential areas.

Disadvantages:

a. Substantial cost for sixteen to twenty-four radio-collars.
b. Substantial staff time would be devoted exclusively to monitoring the collared deer (approximately 5 hours per trap site per week).
c. This study could not replace the on-going deer study but rather would be additional staff time for trapping, collaring, etc.

4.6 INSTALL AND MONITOR ADDITIONAL SWAREFLEX REFLECTORS

Additional Swareflex Reflectors could be installed to provide further coverage in high deer-vehicle accident locations. Possible locations should include lengthening the South Broadway section into the county, and along Linden and Lee Hill Roads west of Broadway, and U.S. 36 from Broadway north to Longhorn Road. These locations would provide more sections for evaluation, and also extend the South Broadway section to fully cover a heavy deer crossing area. This alternative must include clearly designating the Departments responsible for installing, maintaining, and evaluating the system

Advantages:

a. This alternative would improve the ability of staff to evaluate the effectiveness of the Swareflex Reflectors in the study area.
b. The Swareflex system has been effective in some studies, and may have reduced accidents in Boulder in their first 10.5 months, thereby reducing the potential for serious injury or property damage accidents.

Disadvantages:

a. Increased cost for purchasing, installing, and maintaining additional Reflectors.
b. The effectiveness of the Swareflex Reflectors in reducing deer-vehicle accidents may actually result in more deer surviving to reproduce, adding to the population.
c. This alternative does not affect the deer population trend.

4.7 FERTILITY MANIPULATION

Birth control implants that render females sterile for various periods of time have been researched recently. These implants could be used to reduce the annual increase of the population.

Advantages:

a. This is a non-destructive, non-lethal alternative to manage the deer toward a stable population.
b. Specific areas of the deer population could be targeted to reduce population increases.

Disadvantages:

a. This program would involve periodic (annual or semiannual) trapping of female deer to place the implants. Costs per deer would start at $500, plus the cost of the implants and veterinary costs. (Six days per female x four people x three hours per day x $11 per hour, based on current trapping data).
b. The use of the implants is still in the research mode and has not been evaluated for maintaining a large free-ranging population.
c. It would be difficult to determine the number of females to receive the implants due to insufficient data on natality.

4.8 TRAP AND TRANSPLANT DEER

This program would involve the annual trapping of some predetermined number of deer (possibly the annual increase increment) to maintain the deer population at some desired level. The trapped deer would ideally be ear tagged and then transported to a release site.

Advantages:

a. This is a relatively non-destructive, non-lethal alternative to maintain the population at a desired level.
b. Specific classes of the population by age, sex or area could be targeted for transplanting.
c. City staff is already experienced and proficient in the trapping techniques.

Disadvantages:

a. The procedure of trapping and transplanting is expensive in terms of labor and equipment requirements. Estimates would begin at $412 per deer released. (Ishmael and Rangstad, 1984)

b. This alternative may not be as humane and non-lethal as it appears due to high mortality observed in transplanted deer.

c. Other transplanting studies have shown that many deer return to their original area even when released up to 20 miles away (Harrison, 1983).

d. Release sites are not readily apparent due to the nature of Boulder's deer (conditioned to humans) and because population levels elsewhere in the state are at or near Division of Wildlife target levels.

e. Additional traps, holding facilities, and manpower may be necessary to make the effort feasible.

f. A "desirable population level" would be difficult to determine due to biological and cultural factors, therefore, the number to be removed would be difficult to determine.

g. Annual trapping and transplanting would be required.

h. The City's vehicle fleet is not equipped to transport live wild animals.

i. In all options aimed at reducing the number of deer, it would be difficult to determine a "desired" population level due to social and biological factors.

4.9 SELECTIVE TRAPPING AND EUTHANASIA

To be conducted in residential and natural areas by City staff in cooperation with the Colorado Division of Wildlife. Deer could be donated to a variety of community service groups, providing the drugs used do not affect the meat.

Advantages:

a. This method would specifically target the deer spending part of their time in the City. Those which remain in Mountain Parks and Open Space would be unaffected.

b. This method would employ trapping techniques which staff has used over the last four years.

c. This technique eliminates virtually all safety hazards to citizens that are inherent in hunting.

d. This method could be carried out in conjunction with the ongoing mule deer population survey, although additional resources would be required.

e. Staff could specifically target the deer entering the City.

f. This technique might be viewed more favorably by some members of the public than various hunting methods.

g. Like other direct removal methods, this could provide supplemental food to needy community groups.

Disadvantages:

a. Would involve the death and removal of animals, although the method may be viewed by some as being more humane.

b. Involves manipulation of a wild population.

c. Would require a substantial amount of time, vehicles and personnel to dress and transport harvested animals.

d. In some locations, would probably require permission to trap on private properties.

e. Some members of the public may strongly object to killing the deer.

4.10 RESTRICTED, LIMITED HUNT

This alternative includes a special Colorado Division of Wildlife sponsored public hunt with firearms, archery, or black powder firearms, a limited and selective hunt by City Rangers or by bonded and insured professionals.

Advantages:

a. Depending on structure (limited licenses, sex ratio) and harvest, this alternative could have significant impact on overall deer numbers.

Disadvantages:

a. Public safety would be a major concern.

b. Possibly increased costs to properly equip Rangers or to hire a professional.

c. Significant added staff time for enforcement, public announcements, etc. of a public hunt.

d. Possible liability considerations in case of personal injury or property damage.

e. Under Boulder Revised Code, firearms could only be permitted by City Manager for purposes of game management, as defined under 8-3-5. Loaded firearms are prohibited within City Limits. With these constraints, a hunt of any kind may not be selective enough to remove deer causing conflicts.

4.11 INSTALLATION OF "DEER PROOF" FENCING BETWEEN NATIVE HABITATS AND RESIDENTIAL AREAS

This alternative would involve the installation of eight-foot high woven wire fencing in selected areas to prevent deer from entering residential areas. This fencing should include "one way" gates to allow deer to return to native habitats but not allow movement into residential areas.

Advantages:

a. This is a non-destructive, non-lethal alternative to reduce deer entry into residential areas and road kill hazards.
b. Specific areas of the City could be fenced.

Disadvantages:

a. Deer proof fencing is very expensive (approximately $37,000 per mile) (Bob Hernbrode, CDOW, pers. comm., 1986) in terms of installation and maintenance costs. Regular maintenance is critical to eliminate unwanted movement.
b. Through-roadways could not be fenced, thus resulting in continued movement into residential areas and the probability of increased road kills in these areas.
c. Pedestrian and emergency access gates would be required to permit access into Mountain Parks and Open Space recreation areas. These would be a potential "weakness" in the fence if they were left open.
d. The presence of such a fence would not be visually or psychologically appealing.
e. This option does not slow the rate of increase in deer numbers.
f. This alternative could shift deer use to residential areas outside the City limits and lead to habitat deterioration on Open Space and Mountain Parks.

4.12 HABITAT IMPROVEMENT

This management alternative would involve manipulating portions of the natural habitat areas of Open Space and Mountain Parks. Improvements considered could include forest thinning, water

development, palatable and preferred food species planting, prescribed burning of selected areas, and provision of salt licks. In general, these efforts would be an attempt to make the natural areas more attractive to deer than residential areas. These efforts could have the effect of increasing the number of deer in the natural areas without decreasing the number of deer using residential areas. These options also do not slow the growth of the deer population, but rather may actually increase the growth.

Option 1 - Forest Thinning

Advantages:

a. Can be used to create a mosaic of feeding, resting, and cover areas.

Disadvantages:

a. These habitat features are not restricted in the existing habitat mosaic.
b. This is a long lasting disturbance.
c. This effort would have marginal benefits at this time, following Project Greenslope and Mountain Pine Beetle thinning by less than 20 years.

Option 2 - Water Development

Advantages:

a. Can be used to redistribute deer if water is a limiting factor.

Disadvantages:

a. Water does not appear to be a limiting factor, so this effort would probably have limited benefit.

Option 3 - Palatable and Preferred Species Planting

Advantages:

a. Preferred browse species are very limited near Boulder, so this would improve the species composition.

Disadvantages:

a. Additional expense of purchasing, planting, and maintaining shrubs.
b. Would probably benefit deer using the natural areas more than the deer using residential areas.
c. There is an abundant supply of preferred herbaceous species already present in the food supply.

Option 4 - Prescribed Burning of Selected Areas

Advantages:

a. Can be used to increase forage quality and quantity, increase nutrient availability, shape growth forms to increase availability, eliminate undesirable species, and maintain early successional mosiac.

Disadvantage:

a. Local habitats do not need to be stimulated to increase quality, nutrient availability, or to shape growth form.
b. Preferred shrubs that are enhanced by fire are not sufficiently distributed to make burning practical.
c. Even well planned prescribed fires may be dangerous and may create many social concerns.
d. This option would also have to take into account air pollution standards.

Option 5 - Use of Salt Licks to Redistribute Deer

Advantages:

a. Salt licks can attract deer into certain areas.
b. Relatively cheap to purchase and place.

Disadvantages:

a. Salt licks are likely to concentrate deer, causing biological concerns and possibly severely damaging the habitat.

b. Many salt licks would have to be maintained to simultaneously keep deer in natural areas while attracting deer away from residential areas.

c. Salt stations would have to be maintained indefinitely, to prevent deer from returning to residential areas.

d. Deer may be expected to increase daily movements to use salt stations, but still return to residential areas. This may increase the possibility of deer-vehicle accidents.

5.0 LITERATURE CITED

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APPENDIX A

Mule Deer Trapped and Tagged, November 1985 - February 1986

Date Tagged	Trap Site	Ear Color	Tag Number	Age	Sex	
11/26/85	6	Y	126	F	M	
	7	Y	127	Ad	F	
	8	O	151	Ad	F	
	3	Y	101	F	F	
11/27/85	1	Y	102	Ad	F	
	8	O	152	F	M	
12/02/85	1	Y	103	F	M	
	2	Y	105	F	M	
	3	Y	104	Ad	F	
12/03/85	2	Y	106	Ad	F	
	6	Y	128	F	F	Killed by car 12/5-12/6/85 Tag recycled
	7	Y	129	F	F	
	7	Y	130	F	M	
	8	O	153	Ad	F	
12/04/85	3	Y	107	Ad	M	
	7	Y	131	Ad	F	Killed by car 1/11/86
	7	Y	132	F	F	Killed by car 10/86
12/05/85	1	Y	108	F	F	Killed by car
	2	Y	109	Ad	M	
	5	Y	133	Ad	M	
	7	Y	134	Ad	F	
12/06/85	6	Y	135	Ad	M	
	7	Y	136	Y	M	
12/09/85	6	Y	137	Ad	F	
	8	O	154	Ad	M	
12/12/85	2	Y	110	Ad	F	
	3	Y	111	F	F	
12/16/85	8	O	155	F	F	
	9	Y	139	F	M	
	9	Y	140	F	M	Killed 12/24/85 Tag recycled
12/17/85	8	O	157	Ad	M	
	9	O	156	Ad	M	
12/18/85	8	O	159	Ad	M	
	9	O	158	Ad	M	
12/19/85	5A	Y	138	Y	M	
	9	O	160	Y	M	Killed by car 2/18/86
12/20/85	1	Y	112	Ad	F	
	5A	Y	141	Ad	M	
12/23/85	2B	Y	113	F	F	
12/30/85	2B	Y	114	Ad	F	
01/06/86	9	O	161	Ad	F	
01/07/86	5A	Y	142	Y	M	
	6A	Y	143	F	F	

Date Tagged	Trap Site	Ear Color	Tag Number	Age	Sex	
01/08/86	5B	Y	144	F	F	
	11	O	176	Ad	F	
	12	O	177	Ad	M	Killed by car 1/16/86
	12	O	178	Ad	M	
01/09/86	9	O	162	Ad	F	
	5A	Y	145	Ad	F	
	5B	Y	146	Ad	F	
	11	O	179	Ad	M	
01/10/86	6A	Y	147	F	M	
	11	O	180	Ad	F	
01/16/86	11	O	181	F	F	
	14	O	182	F	M	
	14	O	183	Ad	F	
01/20/86	11	O	185	F	M	
	12	O	184	Ad	F	
01/21/86	5B	Y	148	Y	F	
	9	O	163	Ad	M	
01/22/86	14	O	186	Ad	M	
01/23/86	11	O	187	Ad	M	
	14	O	188	Ad	M	Killed 1/23/86
01/24/86	11	O	189	F	M	
01/27/86	12	O	190	F	F	
01/28/86	5	Y	149	Ad	M	
	11	O	191	F	M	
	12	O	192	Ad	F	
01/29/86	5	Y	150	Ad	F	
01/30/86	13	O	193	Ad	F	
01/31/86	5	Y	128	F	F	Tag used from killed deer
	5	Y	140	Ad	F	Tag used from killed deer
02/03/86	13	O	194	Ad	F	
	14	O	195	Ad	F	
02/05/86	12	O	196	Ad	F	

APPENDIX B

Browse Species Composition of Habitat and Utilization

North Section: Linden to Longhorn Road

Scientific Name	Common Name	Density #/ha	Production g/ha	Utilization %	Preference
Amelanchier alnifolia	Serviceberry	43.1	183.4	34.0	H
Cercorcarpus montanus	Mountain Mahogany	6.6	852.7	30.3	H
Gutierrezia sarothrae	Snakeweed	88.3	107.6		L
Juniperus scopulorum	Juniper	11.0	1628.0		M
Physocarpus malveceous	Ninebark	33.1	4534.7		M
Pimus ponderosa	Ponderoas Pine	6.6	147.8		L
Rhus trilobata	Skunkbush Sumac	45.3	980.5	0.6	M
Ribes spp	Currant	3.3	83.2		M
Rosa woodsii	Rose	94.9	140.5		M
Symphoricarpos occidentalis	Snowberry	34.8	40.0	10.4	M
Toxicodendron rydbergii	Poison Ivy	11.0	104.5		L
	TOTAL	378.0	8802.9		

H = High M = Medium L = Low

North Central Section: North half, Sunshine to Linden

Scientific Name	Common Name	Density #/ha	Production g/ha	Utilization %	Preference
Acer glabrum*	Mountain Maple	1.3			M
Amelanchier alnifolia	Serviceberry	9.7	264.3	19.7	H
Berberis repens	Oregon Grape	6.2	486.1		M
Cercorcarpus montanus	Mountain Mahogany	9.7	1661.0	16.0	H
Gutierrezia sarothrae	Snakeweed	31.6	414.3		L
Juniperus scopulorum	Juniper	2.5	4617.6		M
Pinus ponderosa	Ponderosa Pine	53.5	42820.3		M
Prunus americana	Plum	9.0	234.0		M
Pseudotsuga menziesii	Douglas Fir	4.9	3403.0		L
Rhus trilobata	Skunkbush Sumac	10.1	687.0	6.7	M
Ribes spp	Currant	15.4	138.6	6.2	M
Rosa woodsii	Rose	7.6	5.0		M
Symphoricarpos occidentalis	Snowberry	25.1	261.8	0.4	M
Toxicodendron rydbergii	Poison Ivy	2.4	237.1		L
	TOTAL	189.0	55,230+		

*weight estimates not available

H = High M = Medium L = Low

South Section: Eldorado Springs to Bear Canyon

Scientific Name	Common Name	Density #/ha	Production g/ha	Utilization %	Preference
Amelanchier alnifolia	Serviceberry	9.7	47.9	10.3	H
Artemesia frigida**	Fringed Sage	0.6			L
Berberis repens	Oregon Grape	4.0	15.2		M
Ceanothus fendleri	Fendler Ceanothus	0.3			M
Crataegus erythropda	Hawthorne	20.7	130.8		L
Gutierrezia sarothrae	Snakewood	19.2	40.6		L
Juniperus scopulorum	Juniper	1.9	5849.0	0.8	M
Physocarpus malveceous	Ninebark	2.0	3.7		L
Pinus ponderosa	Ponderosa Pine	41.4	14250.0	0.6	M
Prunus americana	Plum	2.6	67.6		M
Pseudotsuga menziesii	Douglas Fir	4.2	323.0		L
Rhus glabra	Smooth Sumac	0.9	49.3		M
Rhus trilobata	Skunkbush Sumac	33.0	1336.1	0.9	M
Ribes spp	Currant	48.8	113.9	6.5	M
Rosa woodsii	Rose	7.4	7.1		M
Salix spp	Willow	0.3	8.7		M
Symphoricarpos occidentalis	Snowberry	23.2	27.0		M

Toxicodendron rydbergii	Poison Ivy	0.7	86.4	35.7	L
	TOTAL	220.9	22,356.3+		

**Weight estimates not available

H = High M = Medium L = Low

APPENDIX C

Herbaceous Species Composition of Habitat

South Section: Eldorado Springs to Bear Canyon

Scientific Name	Common Name	Total Prod. (kg/ha)	Frequency (%/plots)
GRAMINOIDS:			
Agrostis alba	Redtop	40.2	16.2
Agropyron smithii	Western Wheatgrass	45.4	29.4
Andropogon gerardii	Big Bluestem	64.5	39.7
Bouteloua gracilis	Blue Grama	1.8	1.5
Bromus brizaeformis	Rattlesnake Brome	4.1	5.9
Bromus tectorum	Cheatgrass	77.1	64.7
Buchloe dactyloides	Buffalo Grass	6.5	7.4
Carex filifolia	Sun Sedge	36.3	33.8
Carex nebraskensis	Nebraska Sedge	2.8	1.5
Carex spp	Sedge	29.9	16.2
Koeleria cristata	Prairie Junegrass	6.2	5.9
Muhlenbergia spp	Muhly	0.3	1.5
Phleum pratense	Timothy	5.2	2.9
Poa compressa	Canada Bluegrass	20.4	10.3
Poa pratensis	Kentucky Bluegrass	106.2	50.0
Poa secunda	Sandberg Bluegrass	5.7	2.9
Stipa comata	Needle-and-Thread	44.8	23.5
Stipa viridula	Green Needlegrass	7.5	7.4
Total Graminoids:		504.9	
FORBS:			
Achillea millifolium	Yarrow	18.6	11.8
Agoseris glauca	Pale Agoseris	1.8	1.5
Artemesia ludoviciana	Cudweed	20.8	19.1
Artemesia spp	Annual Sage	6.2	2.9
Cerastium arvense	Thistle	0.6	1.5
Cersium spp	Thistle	28.6	10.3
Convolvulus arvensis	Bindweed	1.1	1.5
Cryptantha spp	--------	1.5	1.5
Erysimum spp	Wallflower	4.2	8.8
Geranium spp	Wild Geranium	2.0	1.5
Iris missouriensis	Wild Iris	3.3	1.5
Lomatium nudicale	Lomatium	4.1	4.4
Lupinus argenteus	Lupine	1.8	1.5
Opuntia polyacantha	Pricklypear	33.2	22.1
Plantago patagonica	Wooly Indianwheat	6.4	4.4
Polygonum cristatum	Sneezeweed	2.0	1.5
Potentilla spp	Cinquefoil	10.5	10.3

Psoralea tenuifolia	Slimflower Scurfpea	39.1	20.6
Ranunculus spp	Buttercup	2.9	4.4
Rumex spp	Dock	1.5	1.5
Saxifraga rhomboidea	Saxifrage	3.8	4.4
Senecio intergerrimus	Senecio	4.2	2.9
Taraxacum officinale	Dandelion	12.4	7.4
Tragopogon dubius	Salsify	21.6	16.2
Verbascum thapsus	Mullen	0.3	1.5
Unknown forbs	------	31.9	19.1
Total Forbs:		264.4	
Total Graminoids and Forbs:		769.3	

North Central Section: North Half Sunshine Canyon to Linden

Scientific Name	Common Name	Total Prod. (kg/ha)	Frequency (%/plots)
GRAMINOIDS:			
Agropyron intermedium	Intermediate Wheatgrass	6.8	3.8
Agropyron smithii	Western Wheatgrass	40.2	23.1
Andropogon gerardii	Big Bluestem	20.1	15.4
Bromus brizaeformis	Rattlesnake Brome	4.7	7.7
Bromus inermis	Smooth Brome	27.8	15.4
Bromus tectorum	Cheatgrass	70.5	73.1
Buchloe dactyloides	Buffalo Grass	1.7	3.8
Carex filifolia	Sun Sedge	24.4	30.8
Carex spp	Sedge	46.2	34.6
Koeleria cristata	Prairie Junegrass	7.7	7.7
Poa pratensis	Kentucky Bluegrass	70.9	42.3
Stipa comata	Needle-and-Thread	59.4	30.8
Stipa viridula	Green Needlegrass	14.1	7.7
Total Graminoids:		394.5	
FORBS:			
Achillea millifolium	Yarrow	5.6	3.8
Artemesia ludoviciana	Cudweed	18.4	26.9
Cersium spp	Thistle	5.6	3.8
Epilobium spp	-------	5.6	11.5
Iris missouriensis	Wild Iris	1.7	7.7
Lupinus argenteus	Lupine	12.4	11.5
Opuntia polyacantha	Pricklypear	25.6	15.4
Penstemon confertus	Penstemon	0.8	3.8

Petentilla spp	Cinquefoil	11.5	19.2
Taraxacum officinale	Dandelion	6.0	11.5
Tragopogon dubius	Salsify	2.6	7.7
Verbascum thapsus	Mullen	13.2	3.8
Xanthium strumarium	-------	3.0	3.8
Unknown forbs	-------	48.3	46.2
Total Forbs:		160.3	
Total Graminoids and Forbs:		574.0	

North Section: Linden to Longhorn Road

Scientific Name	Common Name	Total Prod. (kg/ha)	Frequency (%/plots)
GRAMINOIDS:			
Agrostis alba	Redtop	40.8	13.5
Agropyron smithii	Western Wheatgrass	187.0	83.8
Andropogon gerardii	Big Bluestem	25.8	18.9
Bromus tectorum	Cheatgrass	140.0	75.7
Bromus inermis	Smooth Brome	2.4	2.7
Carex spp	Sedge	24.2	10.8
Koeleria cristata	Prairie Junegrass	45.4	21.6
Oryzopsis hymenoides	Indian Ricegrass	0.1	2.7
Poa pratensis	Kentucky Bluegrass	91.4	27.0
Stipa comata	Needle-and Thread	4.7	2.7
Total Graminoids		561.8	
FORBS:			
Artemesia ludoviciana	Cudweed	31.4	32.4
Astragalus spp	Milkvetch	16.7	24.3
Cersium spp	Thistle	5.0	5.4
Cryptantha spp	-------	2.7	2.7
Erysimum spp	Wallflower	2.0	5.4
Geranium spp	Wild Geranium	16.6	5.4
Lomatium nudicale	Lomatium	13.2	16.2
Oenothera brachycarpa	Evening Primrose	0.7	2.7
Opuntia polyacantha	Pricklypear	8.9	8.1
Psoralea tenuifolia	Slimflower Scurfpea	33.0	24.3
Ranunculus spp	Buttercup	4.7	5.4
Senecio intergerrimus	Senecio	7.8	5.4
Taraxacum officinale	Dandelion	0.7	2.7

Tragopogon dubius	Salsify	15.3	18.9
Unknown forbs	-------	14.7	16.2
Unknown legume	-------	0.1	2.7

Total Forbs:	173.5
Total Graminoids and Forbs:	735.3

APPENDIX D

Most Frequently Cited Forages of Rocky Mountain Mule Deer (from Kufeld et al, 1973)

Type of Forage	Number of Citations
BROWSE:	
Snowberry	69*
Big Sagebrush	67*
Rose	67*
Black Chokecherry	64*
Antelope Bitterbrush	52
Quaking Aspen	49*
Oregon Grape	47*
Willow	45*
Saskatoon Serviceberry	41*
Curl-leaf Mountain Mahogany	39
Rubber Rabbitbrush	37*
Ponderosa Pine	32*
Rocky Mountain Juniper	28*
Tobacco Brush	26
Skunkbush	24*
True Mountain Mahogany	23*
Gamble Oak	21
GRASSES AND SEDGES:	
Bluegrass	31*
Wheatgrass	29*
Chess	22
Sedge	22*
Fescue	10*
Squirreltail	7*
FORBS:	
Buckwheat	63*
Aster	50*
Lupine	49*
Phlox	46*
Beardtongue	38*
Fleabane	35*
Balsamorrhiza	33
Sagebrush	32*
Cinquefoil	30*
Yarrow	27*
Fringed Sagebrush	27*

Type of Forage	Number of Citations
Alfalfa	26*
Thistle	25*
Dandelion	25*
Pussytoe	22*
Vetch	22*
Clover	21*

*Indicates presence in Boulder area (Source = Kufeld et al., 1973)

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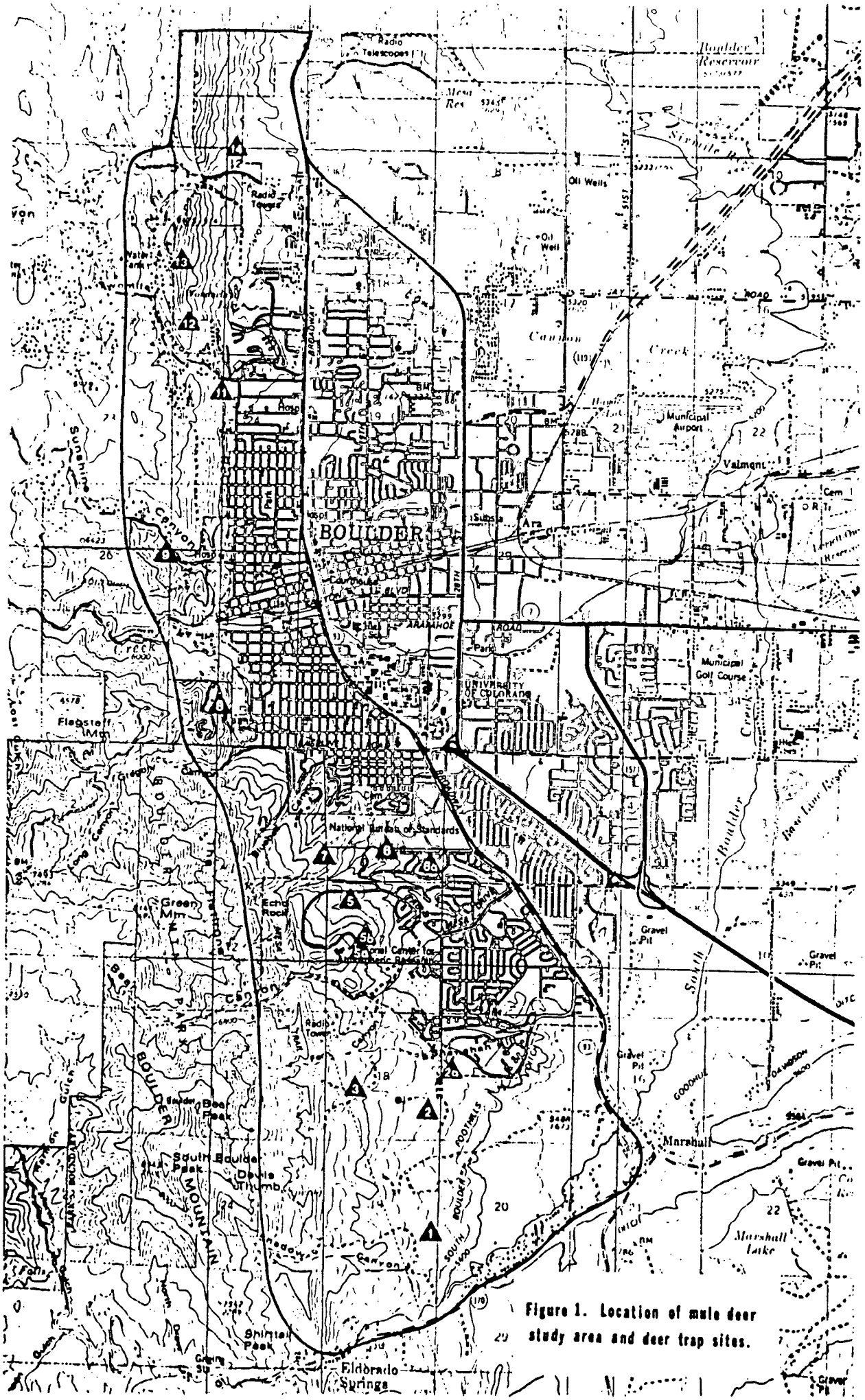

Figure 1. Location of mule deer study area and deer trap sites.

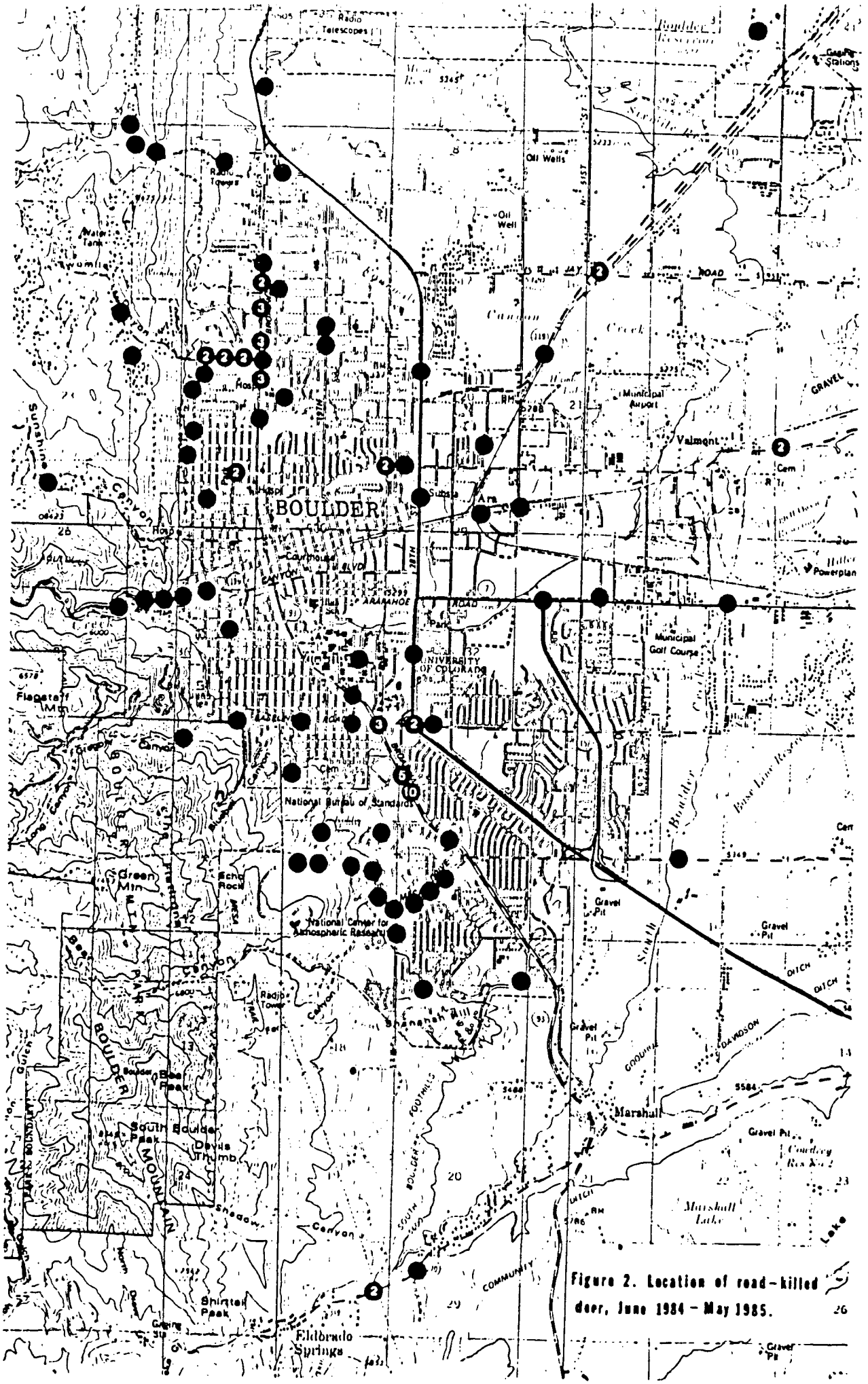

Figure 2. Location of road-killed deer, June 1984 - May 1985.

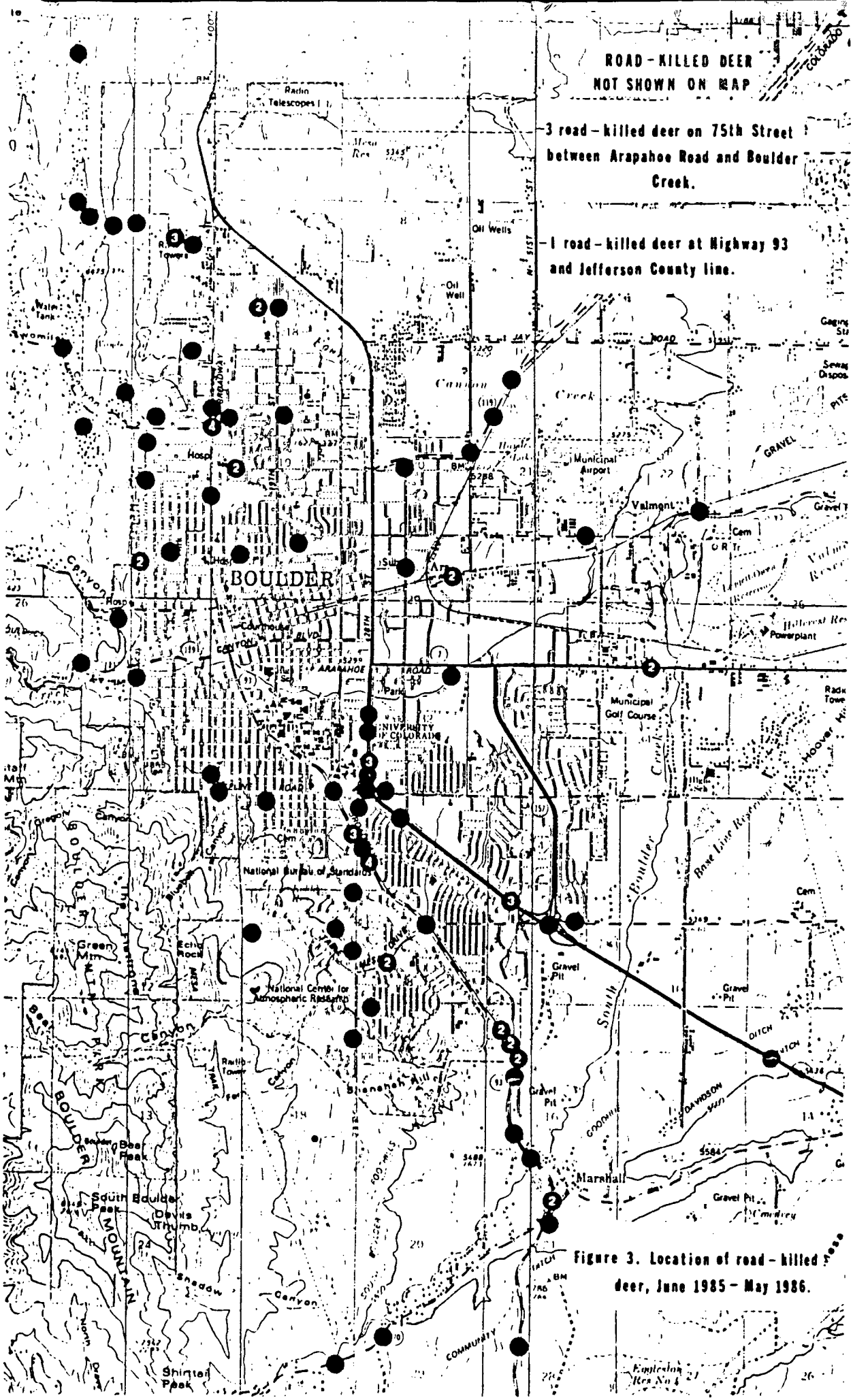

Figure 3. Location of road-killed deer, June 1985 - May 1986.