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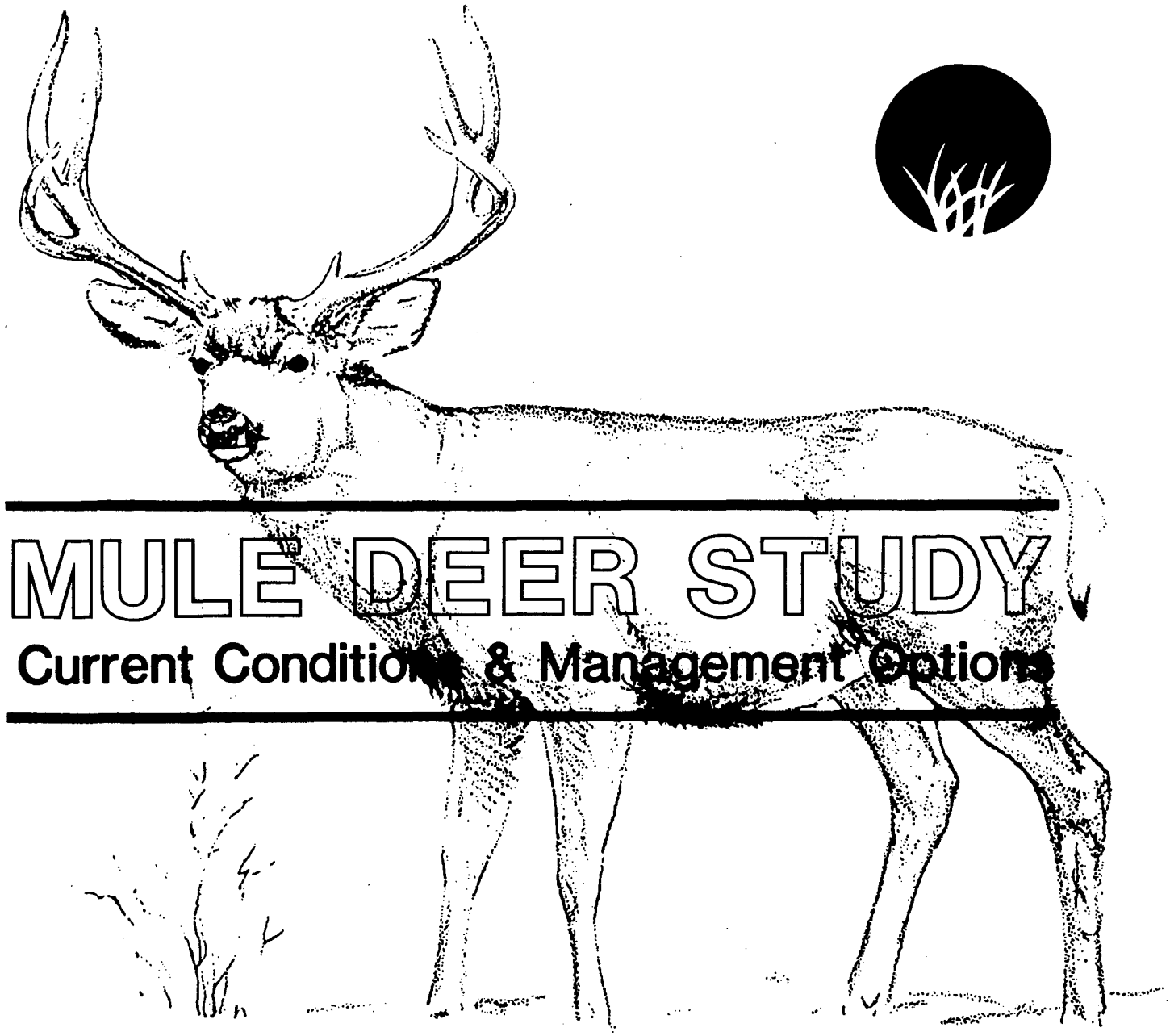

MULE DEER STUDY

Current Conditions & Management Options

prepared for

City of Boulder
P.O. Box 791 Boulder, Colorado 80306

prepared by

Western Resource Development Corporation
P.O. Box 467 Boulder, Colorado 80306

October 1984

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INTRODUCTION

1.0 INTRODUCTION

1.1 BACKGROUND AND PURPOSE

This report presents the results of a two-year deer study (1982-1984) conducted by Western Resource Development Corporation (WRD) for the City of Boulder Real Estate/Open Space and Parks and Recreation Departments. The impetus for this study was the recognition by City of Boulder Open Space and Mountain Parks personnel and Colorado Division of Wildlife (CDOW) district managers of an apparent increase in the number of deer moving into the city, resulting in increased damage to ornamental plantings and deer-vehicle collisions on city streets. Of immediate concern was the lack of adequate documentation. Although the problem was readily apparent, the available information was inadequate for formulating management plans and presenting them to the public.

The specific objectives of this study were to:

1) Estimate the number of deer in the Open Space and Mountain Parks of Boulder and determine movement patterns.
2) Estimate the proportion of deer moving into the city and determine whether there are deer with high fidelity to either park or city areas.
3) Assess the severity of the deer-vehicle accident problem and identify areas of greatest conflict.
4) Develop possible management alternatives for consideration by the City of Boulder and CDOW.

Although knowing the number of deer in the population is not sufficient by itself for understanding or solving the deer problem, it is invaluable basic information for evaluating management options. For example, a population of 1,000 deer is a more difficult management problem than a population of 200 or 500 deer by mere virtue of their numbers. Also, an initial population estimate was needed as a basis for monitoring long-term population trends.

Prior to the initiation of this study, questions were asked concerning what proportion of the deer population actually moves into the city. Various opinions suggested that there were "city deer" and "park deer"--i.e., that some deer habitually move into the city and are responsible for damaging ornamental plantings and gardens and are the

cause of deer-vehicle accidents, while other deer remain on Open Space and Mountain Parks land, contributing very little to the problem. The upshot of this would be that any attempt to solve the problem by population control would be futile unless efforts were directed at specific "city deer."

While it was apparent that deer-vehicle accidents were occurring more frequently, information on the number and location of collisions had never been fully documented. Using this type of information, it would be possible to identify "high-risk" areas within the city and determine the severity of the problem.

Finally, possible management options were formulated based on the information gathered and experience in other areas. The management options are presented in this report as alternatives, not formal recommendations. Rather than suggesting that one or more options be undertaken, it was felt that presenting an array of alternatives would be more appropriate, because of the fact that social policy and not simply ecology would have to be considered in the decision-making process.

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 approximately Lee Hill Road on the north, as well as urban areas west of Broadway (Figure 1). The western boundary of the study area included the Dakota Hogback, Flagstaff Mountain, and the mesas that mark the transition from plains to foothills. The total land area involved was about 16 square miles (mi^2), comprised of 60 percent natural habitat and 40 percent urban environments. Most of the urban area also represents deer habitat.

Native vegetation in the study area is controlled by elevation, slope, aspect, substrate, and available moisture. Highest elevations are dominated by ponderosa pine (Pinus ponderosa), which extend well away from the base of the foothills on the coarse alluvium-capped mesas. The amount and type of herbaceous understory is variable, depending on the ecological factors listed above and the density of the conifer stands. The latter ranges from overly dense stands with complete canopy closure and a sparse understory to open, park-like stands with a well developed

grass stratum. Dominant grasses in the open woodland areas include western wheatgrass (Agropyron smithii) and Canada bluegrass (Poa compressa) with sun sedge (Carex heliophila) on fine soils and little bluestem (Schizachyrium scoparium) on sandy or rocky soils. Dense stands that have been thinned in response to the bark beetle outbreak of the 1970's continue to show a relatively poor ground stratum because of the residual concentration of pine needles and the abundance of slash.

Shrubs generally are not well represented in the Boulder area, compared to foothills localities in both directions (e.g., Lyons and Golden) supporting a "chaparral" belt. Most shrubs present in the ponderosa pine woodland are understory species such as wax currant (Ribes cereum), Boulder raspberry (Rubus deliciosus), mountain ninebark (Physocarpus monogynus), buckbrush (Ceanothus fendleri), and snowberry (Symphoricarpos occidentalis and S. alba). More open areas occasionally support extensive stands of skunkbrush sumac (Rhus aromatica ssp. trilobata) and smooth sumac (R. glabra), but highly prized deer browse species, including mountain mahogany (Cercocarpus montanus) and bitterbrush (Purshia tridentata), are virtually absent.

Shrubs are best developed along the minor drainages flowing east from the foothills (e.g., Skunk Creek, Bear Creek, Bluebell Creek, Gregory Creek, Twomile Creek)--both along the protected sideslopes and the moist valley floor. Riparian species present include common chokecherry (Prunus virginiana var. melanocarpa), wild plum (P. americana), hawthorn (Craetegus erythropoda), mountain maple (Acer glabrum), golden currant (Ribes aureum), gooseberry currant (R. inerme), and shrub cinquefoil (Pentaphylloides floribunda). Associated riparian trees in the valleys 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 relict tallgrass prairie stands. The shortgrass areas are located primarily on coarse textured pediment surfaces devoid of most midgrass development because of past overgrazing. The dominant species in these areas are blue grama (Bouteloua gracilis), buffalo grass (Buchloe dactyloides), prairie junegrass (Koeleria macrantha), and Sandberg

bluegrass (Poa sandbergii). The only midgrasses of much consequence in these areas are western wheatgrass and needle-and-thread (Stipa comata). Grasslands on sheltered slopes and protected mesa tops include midgrasses such as Indian grass (Sorghastrum nutans) and prairie dropseed (Sporobolus heterolepis), along with a heavy cover of sun sedge. Remnants of relict tall grass prairie communities are present in portions of the South Boulder Creek floodplain that have not been converted to hay production. In these stands, big bluestem (Andropogon gerardii), switchgrass (Panicum virgatum), and porcupine grass (Stipa spartea) are strongly dominant. In the floodplain area that has been converted to hay production, introduced forage grasses such as smooth brome (Bromopsis inerme), orchard grass (Dactylis glomerata), and common timothy (Phleum pratense) dominate.

Urban environments in the study area consist of mature, well landscaped residential neighborhoods; younger, more sparsely landscaped residential neighborhoods; open, mostly undisturbed habitats at the National Center for Atmospheric Research and National Bureau of Standards; dense commercial developments in downtown Boulder and along outlying portions of Broadway; and city parks. Older residential neighborhoods, which are among the areas receiving the greatest use by deer, typically are characterized by an abundance of large shrubs, occurring as individual specimens, mass plantings, or hedges, and a variety of deciduous and coniferous trees. The residential areas also include irrigated lawns that are used for food throughout much of the year. Deer normally do not consume much grass except during green-up in the spring, when it is nutritious and highly palatable. Irrigated lawns essentially maintain these qualities from early spring through late fall.

Transitional between urban and native habitats are mountain residences, some areas of which are partially surrounded by Open Space land.

1.3 ACKNOWLEDGMENTS

Numerous individuals and groups provided assistance throughout the course of this study. The security staffs of the National Center for Atmospheric Research (NCAR) and National Bureau of Standards (NBS) provided access to their properties for deer trapping and monitoring of

tagged deer. Mr. and Mrs. Tom Spencer granted permission to access City property through their land. Mr. and Mrs. Max Goodwin, Mr. K. K. Parsons, Mrs. Mary Marr, Mr. and Mrs. William Sullivan, and Mr. Bernie McConnell a-lowed us to trap on their properties and/or provided apples for bait.

The Northwest Region of the Colorado Division of Wildlife (CDOW) provided traps, eartags, eleven radiocollars, and the radio receiver and antenna to track and monitor the deer. Local District Wildlife Managers Gary Berlin and Laurie Roe were especially cooperative in obtaining the necessary equipment and assisting with the trapping efforts.

The City of Boulder Mountain Parks and Open Space rangers and maintenance crews assisted during the trapping program and reported observations of tagged deer. A special thanks should go to Mountain Parks rangers Dick Lyman, Ann Wichman, Brian Peck, and Jeanne Scholl, Open Space rangers Jack Kissell and Rich Smith, and Open Space maintenance supervisor Chris Wilson for their assistance and continued interest in the project.

Observational data were contributed by volunteer students from the University of Colorado, Department of Environmental, Population, and Organismic Biology. Ms. Susan Weinberg of EPOB was particularly helpful.

The Boulder County Humane Society provided full access to their disposition records of road-killed deer.

SECTION 2.0

METHODS

2.0 METHODS

2.1 TRAPPING AND MARKING

The basic objectives of estimating the deer population, determining movement pattenrs, and evaluating fidelity to specific areas were addressed by trapping and marking a number of mule and white-tailed deer (Odocoileus hemionus and O. virginianus) at various sites throughout the study area (Figure 1). This procedure allowed individual deer to be recognized by the combination of tag color and number. In addition, radiocollars were placed on subsamples of the marked population to facilitate more detailed monitoring.

Most of the trapping was accomplished in January-March 1983 with a supplemental effort in December 1983. The deer were caught in portable cages ("clover" traps, Clover 1956) baited with crushed apples, alfalfa hay, and pieces of livestock salt block. Crushed apples proved to be the most effective bait. Traps were located to obtain a representative sample of the population (Figure 1). Random trap locations were impossible because of the proximity of Parks and Open Space land to houses and heavily used recreational areas, and because many of the habitats (e.g., grasslands) were unsuitable due to a lack of cover. Thirteen trap sites were used during January-March 1983, while five sites were used in December 1983. All captured deer were physically restrained by a crew of three to six people. No tranquilizer drugs were used.

Initially, all deer were marked with soft plastic two-colored neck collars and a small eartag in the right ear. Because of potential problems with deer catching their legs in the collars, fawns outgrowing the collars, and the necks of bucks swelling larger than the collars during rut, use of neckbands was discontinued.

Collars and small eartags (3 x 5 cm) were replaced with a large eartag (4.5 x 7.2 cm) in each ear. Double tagging was used because of the potential for deer to lose a single tag (Beasom and Burd 1983) and to assist the observer during the monitoring program. Each pair of eartags was permanently numbered with heat impressed numerals.

Four different eartag colors were used to identify deer captured in the two study area subunits during the 1982-83 and 1983-84 trapping sessions. Deer captured between Gregory Canyon-Baseline Road and South Boulder Creek were marked with yellow tags in January-March 1983 and red tags in December 1983. Deer captured north of Gregory Canyon-Baseline Road were marked with orange tags in January-March 1983 and green or orange tags in December 1983.

2.2 POPULATION ESTIMATES

The deer population size was estimated using a mark-recapture method. The basis of this approach is to capture, mark, and release a known number of animals from a larger population. At varying intervals subsequent to the release the population is censused, and the number of marked animals observed is compared to the number of unmarked animals observed. The ratio of marked to unmarked animals is assumed to be the same in the sample census as in the total population, and a population estimate is therefore possible.

After the mark-recapture (actually, mark-census) data were collected, a modified Peterson estimator originally proposed by Chapman (1951) was used to estimate population size:

$$N = \frac{(n_1 + 1)(n_2 + 1)}{(m_2 + 1)} - 1$$

where n_1 is the number of deer caught, marked, and released; n_2 is a sample of deer recaptured (censused) at a later time, of which m_2 deer have been marked; and N is the population estimate.

Approximately 6-7 weeks after the initial marking, four independent recapture (census) samples were taken on four successive days. Census samples were obtained by walking transect routes covering most of the study area. All deer observed were counted, and the eartag and/or neckcollar number was recorded for each marked deer. This procedure provided individual recapture histories for each marked deer over the four samples. A similar number of transect routes were walked each day, providing a uniform census effort for each sample.

The population estimate was calculated as an average of the four individual sample estimates. Confidence limits (alpha = 0.10) were constructed using the standard error about the four sample means:

$$SE(\hat{\bar{N}}) = \sqrt{\frac{1}{K(K-1)} \sum_{i=1}^{K} (\hat{N}_i - \hat{\bar{N}})^2}$$

where k is the number of samples, N_i is the population estimate for the ith sample, and N is the average population estimate of the K samples.

Population estimates were made in April 1983 and 1984. The estimate in 1983 was made shortly after the major trapping and marking effort in January-March, and therefore the number of tagged animals in the population was known. In 1984, the number of tagged animals in the population was approximated based on known losses of marked deer, the assumption that deer which had not been resighted since initial capture were lost from the population, and the number of deer marked and released in December 1983.

2.3 DEER MOVEMENTS

Data on deer movements were collected by observing marked deer along walked and driven transect routes. Additional information was provided by Colorado Division of Wildlife district managers, City of Boulder Mountain Parks and Open Space rangers, volunteer students from the University of Colorado, retrap records, road-kill records of tagged deer, and observations by local residents. Locations of successive re-observations of marked deer were used to delineate general movement patterns and fidelity to certain areas and as an index to the proportion of the deer population using city residential areas.

2.4 DEER-VEHICLE ACCIDENTS

Data pertaining to this study element included the number and location of deer-vehicle accidents reported during each month for a 47-month period from November 1980 through September 1984. This information was obtained from dead animal deposition records kept by the Boulder County Humane Society. Animal control officers and CDOW District Wildlife Managers collect most dead deer along city streets and record the

location, date, cause of death, and sex and age class, if possible. Locations of road-kills were mapped to examine the spatial distribution and identify problem areas.

In addition to road-kill locations, information on city traffic patterns was obtained from the City of Boulder Transportation Department. These data included estimates of daily traffic volume on most of the city streets and traffic volume by 15-minute intervals on some of the major arterial streets.

3.0 RESULTS AND DISCUSSION

3.1 TRAPPING AND MARKING

A total of 90 mule and white-tailed deer were trapped, marked, and released (Appendices A and B). Fourteen deer were marked with colored neckbands and eartags, 65 were eartagged only, and twelve were marked with radiocollars and eartags. One adult doe radiocollared in February 1983 was killed by a vehicle in October 1983. The radiocollar was recovered and put on another adult doe in December 1983. Another adult doe first captured and marked with a yellow neck collar in January 1983 was recaptured in December 1983, at which time she was re-marked with red eartags and fitted with a radiocollar.

Of the 133 deer captured, only three deer died during the trapping process. All three were victims of domestic dog attacks while they were still in the trap. No deer were killed or injured while being handled by trapping crews.

Trapping success was substantially less than first anticipated considering the tame demeanor of the Boulder deer herd. A total of 64 trap-days yielded only 90 tagged deer, for a trap-success of 1.4 deer per day of trapping effort (Table 1). Recaptured deer accounted for 26 percent of the 133 total captures, thereby significantly reducing the capture rate of new deer. No captures were made on 11 of the 64 field days (17 percent). Reasons for the low capture rates are not known, but it is possible that the deer were not food-stressed and thus not easily enticed into the traps.

The sex and age composition of the 86 marked mule deer was as follows: 31.4 percent bucks, 38.4 percent does, and 30.2 percent fawns. These data yield a buck:doe:fawn ratio for mule deer of 82:100:79 (Table 2). Four white-tailed deer also were marked, including three adult does and one yearling buck. All four of the white-tailed deer were trapped on the southern part of the study area south of Shanahan Hill. The number of marked deer was nearly equally divided between the north and south subunits of the study area (Table 3). Bucks were caught with greater frequency on the northern half of the study area, while does were caught more frequently on the southern half. Twenty-six fawns were captured, with a sex ratio of 54 males:46 females.

SECTION 3.0

RESULTS AND DISCUSSION

TABLE 1

SUMMARY OF DEER TRAPPING EFFORTS
BOULDER MOUNTAIN PARKS AND OPEN SPACE LAND

Trapping Period	Total Trap-Days	Total Trap-Nights	Total Captured	Total Recaptures	Total New Deer Caught
January-March 1983	56	392	107	31	71
December 1983	8	25	26	4	22
Total	64	417	133	35	93*

*Includes three female deer (two adults, one yearling) killed in the trap by dogs.

TABLE 2

SEX AND AGE COMPOSITIONS OF MULE AND WHITE-TAILED DEER* CAPTURED AND TAGGED ON BOULDER MOUNTAIN PARKS AND OPEN SPACE LAND JANUARY-MARCH 1983 AND DECEMBER 1983

Sex	Age Class Adult	Yearling	Fawn	Total
Male	22	5(1)	14	41(1)
Female	28(3)	5	12	45(3)
Total	50(3)	10(1)	26	86(4)

*White-tailed deer data are presented in parentheses.

TABLE 3

SEX AND AGE COMPOSITION OF
MULE AND WHITE-TAILED DEER*
TRAPPED AND MARKED WITHIN EACH SUBUNIT
ON MOUNTAIN PARKS AND OPEN SPACE LAND,

Sex	Age	Subunit South	Subunit North	Total Marked
Male	Fawn	7	7	14
	Yearling	4	2	6
	Adult	7	15	22
	Subtotal	18	24	42
Female	Fawn	7	5	12
	Yearling	4(1)	0	4(1)
	Adult	14(3)	14	28(3)
	Subtotal	25(4)	19	44(4)
	Total	43(4)	43	86(4)

*White-tailed deer data are presented in parentheses.

3.2 POPULATION ESTIMATES

During the spring of 1983, the deer population within the 16 mi^2 study area was estimated at 783 ±52, based on the number of marked deer re-observed (68) compared to the total number of deer counted during the four surveys (248 to 344, with a mean of 295) (Table 4). This estimate includes both mule and white-tailed deer because they occur sympatrically in the southern portion of the study area. The proportion of white-tailed deer in the population was quite small; the highest nonduplicated count was nine.

During the spring of 1984, a second population estimate was made. As previously discussed under Methods (Section 2.2, above), the number of marked deer in the population was estimated by accounting for all known losses of tagged animals and assuming that marked deer not re-observed between December 1983 and April 1984 were lost from the population. Tagged deer observed during the census counts that had not previously been resighted were added to the marked population. Of the 90 marked deer, fourteen were known to be dead. An additional seventeen deer had not been resighted within the specified time period preceding the recapture counts, but two of these were observed during the April 1984 surveys. Therefore, the marked segment of the population in April 1984 was estimated to be 61 deer (90 - 14 - 17 + 2), and the total population was estimated at 888 ±217 (Table 4). This estimate was based on three census counts.

Dividing the mean population estimates by the approximate study area size yields crude densities of 48/mi^2 for April 1983 and 55/mi^2 for April 1984. Even after accounting for the imprecision of the estimates, these density values are fairly high for winter habitats in the Front Range area, reportedly averaging between 30/mi^2 and 40/mi^2 (Len Carpenter, CDOW, pers. comm., 1984). It should be emphasized that distribution is irregular within the 16 mi^2, so that some high-use areas have effective deer densities much greater than the average values.

The buck:doe:fawn ratio in December 1983-January 1984 was estimated at 34:100:93. Bucks almost certainly were underestimated, because they are more solitary and more difficult to observe. Even so, however, the percentage of bucks appears low for a nonhunted population.

TABLE 4

CENSUS DATA AND POPULATION ESTIMATES
OF THE CITY OF BOULDER DEER HERD

18-21 April 1983

Sampling Day	Total No. Deer Counted (n_2)	Total No. Marked Deer Counted (m_2)	Population Estimate (N)
1	342	27	845.25
2	248	22	747.00
3	293	25	780.23
4	296	26	759.00
Mean	295	25	783.00
Standard Error	39	2.2	21.9

25-27 April 1984

Sampling Day	Total No. Deer Counted (n_2)	Total No. Marked Deer Counted (m_2)	Population Estimate (N)
1	285	23	737.83
2	324	20	958.52
3	326	20	964.43
Mean	312	21	888.00
Standard Error	23.1	1.7	74.7

The proportion of fawns was relatively high, which can be attributed to a high pregnancy rate, a large percentage of multiple births (twins), and/or high survivorship of the young. All of these factors reflect the good nutritional status of the herd (Connolly 1981). Informal observations suggest that the number of twins was greater than normally expected.

Large proportions of young in December-January generally would indicate that a herd is increasing in number, although late winter mortality could offset the trend. There is no indication that the Boulder deer herd is exceeding the carrying capacity of the habitats available, based on the doe:fawn ratios, observations of individual deer health and vigor, or casual assessments of the "range condition" in natural habitats.

3.3 DEER MOVEMENTS

Based on re-observations of marked deer and relocations of radiocollared deer, most of the animals showed a high degree of fidelity to the general vicinity in which they were trapped and marked. Most movements were localized or generally east-west in direction (Figure 2) between natural habitats and adjacent residential areas. There apparently is little north-south movement along the foothills. Movement patterns within specific parts of the study area are discussed below.

3.3.1 North Boulder (Trap Sites 12-15, 17)

Deer movements in this area generally were characterized by continual movement between residential areas and Open Space land. These movements often were on a daily basis, with deer moving into the city at dusk and leaving at dawn, although some deer frequently remained in residential areas for extended periods of time, essentially living in the city. These movement patterns were most common and involved the greatest number of deer between September and May.

Some deer remained in or near the city throughout the year, as indicated by road-kills and observations of marked and unmarked deer. In a few instances, adult does were reported to fawn (i.e., bear their young) in residents' backyards in June (Gary Berlin, CDOW, pers. comm.,

1984). However, most deer migrated into the foothills during the late spring and remained there throughout the summer.

The longest documented movement was by an adult doe radiocollared in February 1983 above Wonderland Lake. In September 1983, she was observed by District Wildlife Manager Gary Berlin near the Left Hand Reservoir and Brainard Lake Road intersection west of Ward. This movement was about 14 miles from its last previous sighting in late April 1983. By October 1983, the doe had returned to the Twomile Canyon vicinity. On April 24, 1984, she was killed by a vehicle at North Broadway and Sumac east of Wonderland Lake.

The other documented dispersal from the North Boulder area was by an adult buck tagged west of North Broadway in February 1983 and killed by a car in a residential area southeast of the intersection of Arapahoe and Foothills Parkway in December 1983. Although his exact movement route is unknown, he covered a minimum distance of 3 1/2 miles.

Of the 24 mule deer marked in the North Boulder area, 75 percent were observed at least once or killed within the city, and several were sighted repeatedly. Five of the marked deer were killed by cars, and two had to be shot by CDOW officers due to severe injuries. The movement of large numbers of deer into North Boulder residential areas probably is related to the proximity of Open Space land and the favorable habitat conditions that exist within the city. Most of the Open Space land immediately west of North Boulder consists of foothills grassland with low shrubs, sparse tree cover, and little topographic diversity. Even where ponderosa pines do occur at higher elevations, the understory is predominantly graminoids (i.e., grasses and sedges), which are not a preferred winter food source. In contrast, the nearby residential areas of North Boulder are characterized by mature landscaping, with an abundance of trees, shrubs, and irrigated lawns. The residential habitat provides a nearly unlimited, highly nutritious food source and better protection against frequent winter winds and cold temperatures than much of the Open Space land.

3.3.2 Sunshine Canyon (Trap Sites 11, 16)

Deer trapped in Sunshine Canyon remained in the canyon throughout the study. Most movement by marked animals was east-west along adjacent

sideslopes or across the canyon floor. Although the adult doe radiocollared in this area did move toward the mouth of the canyon on several occasions, no movement into the city was ever documented. The two adult does radiocollared behind Red Rocks Park between Pearl Street and Sunshine Canyon also remained in the general vicinity. Typical movements were east-west, with occasional movements into the Knollwood subdivision just below Red Rocks Park.

3.3.3 Lower Flagstaff Mountain (Trap Site 10)

Deer tagged on lower Flagstaff Mountain showed a high degree of fidelity to the capture area and adjacent neighborhoods. Forty-five percent of the marked animals were sighted in residential areas, but only two were reported more than twice. The general movement was up and down the east face of Flagstaff Mountain. As in North Boulder, these movements typically occurred on a daily basis, but some deer occasionally remained near the edge of residential areas. The slope below Panorama Point was heavily used from fall through spring, and the lower portion of Flagstaff Road below Panorama Point was a major crossing route for deer during this period. Heaviest crossing rates were in the morning, evening, and night, when deer moved between feeding sites on the lower slopes and daytime bedding sites above the road. During the summer, most deer moved to slightly higher elevations on Flagstaff Mountain.

There appeared to be little interchange of deer between the Flagstaff Mountain area and the Bluebell Canyon-Long Mesa area west of the Bureau of Standards. There was one report of an orange-tagged (Flagstaff) deer on Long Mesa (yellow tags), but it was never confirmed. None of the deer marked on Long Mesa was ever observed in the Flagstaff Mountain area. During the fall of 1983, an adult buck tagged on Flagstaff Mountain moved to the vicinity of North Boulder Park. He returned to Flagstaff Mountain sometime in late December 1983.

3.3.4 Long Mesa (Trap Sites 6, 7)

Like most other deer in the study area, mule deer tagged on Long (or Kohler) Mesa--located between Enchanted Mesa and Skunk Creek, west of the Bureau of Standards--exhibited strong fidelity to the area (i.e., a small home range). During the fall, winter, and spring, many of

the tagged deer stayed within a 1/2 - 3/4 mile radius of their capture point, usually on Bureau of Standards property or adjacent Open Space land. There also was movement between Long Mesa and surrounding residential areas, with 57 percent of the tagged animals observed in the city at least once.

Several sightings of tagged deer were reported in the neighborhood between Chautauqua Park and the Bureau of Standards. One tagged deer was killed by a car along Broadway at Ash Street just east of the Bureau of Standards in late August, reflecting the year-round residency of some animals. Another tagged deer (an adult buck) was found dead of apparent injuries on Bureau of Standards property just west of Broadway in December 1983.

Deer from Long Mesa also moved into the residential area between the Bureau of Standards and Table Mesa Drive. Only one of the tagged animals was sighted in this area, but repeated observations indicated that he spent most of the winter there, as did a number of unmarked animals. Deer frequently bedded in residents' backyards or fed on ornamental shrubs throughout this neighborhood, particularly along Kohler Drive.

No deer tagged on Long Mesa are known to have dispersed to other parts of the study area prior to the completion of field studies in May 1984. However, one adult doe was reported to have moved from Long Mesa to the vicinity of Sawhill Ponds in October 1984, a distance of about 5 miles.

3.3.5 National Center for Atmospheric Research (Trap Site 21)

Only one mule deer was trapped and marked on NCAR property. This animal, an adult doe, was captured and fitted with a radiocollar in December 1983 and has remained on NCAR property throughout the study period. During the first year of the study, deer were monitored on NCAR to detect influx of marked deer from the north or south, but none was observed.

3.3.6 Bear Canyon-Fern Canyon (Trap Sites 3, 4)

As in most of the study area, deer trapped here showed little tendency to disperse north-south, except for minor movements

across Fern Canyon during periods of heavy snow or cold weather, when they frequently fed and bedded in thinned ponderosa pine stands on either side of the canyon. The lack of movement to the south is somewhat surprising, considering the vegetational and topographic continuity of Open Space land between Bear Canyon and the southern end of the study area.

Movement of deer did occur between Bear Canyon-Fern Canyon and the residential areas on Shanahan Hill and near Viele Lake, but in relatively low numbers compared to other parts of the study area. Only 18 percent of the marked deer were observed within the city, probably because of the immature quality of most landscaping in this area. Accordingly, deer-vehicle collisions are a minor and recent problem.

The only documented dispersal by a deer out of Bear Canyon-Fern Canyon (aside from the minor movement onto Shanahan Hill) was a buck, tagged as a yearling at Bear Canyon in January 1983 and observed in North Boulder during the spring of 1984.

3.3.7 Shanahan Hill (Trap Sites 1, 2, 5, 20)

Movements in this area were primarily east-west between the foothill mesas and open grassland areas west of Marshall, with some movement east across Highway 93 along South Boulder Creek to Davidson Mesa. Three of the twelve deer (25 percent) marked in this area are known to have crossed Highway 93. Two were killed by vehicles and a third was seen along South Boulder Creek east of the highway.

None of the deer tagged in the Shanahan Hill area was observed within the city. However, one unexpected movement by a tagged deer did occur. A yearling buck originally tagged as a fawn near Shanahan Hill in January 1983 was killed by a car at the entrance to Clear Creek Canyon west of Golden on U.S. Highway 6 in June 1984. This is approximately 16 miles south of the study area.

3.3.8 Overview of Movement Patterns

Based on the documented movements of tagged and radiocollared deer, it appears that some individuals do show a high affinity for residential neighborhoods. For the most part, however, there is regular movement of animals between natural habitats on Parks

and Open Space land at the western edge of the city and adjacent residential areas. Thus, the terms "park deer" and "city deer" have little if any significance.

In evaluating the predominantly east-west mixing depicted by Figure 2, one should bear in mind an ecological axiom: that a species generally will occur wherever there is suitable habitat, as long as other factors (climate, disturbance, competition, etc.) are not prohibitive and there is no barrier to dispersal. The results of this study indicate that the mule deer habitat along the mountain front is contiguous with similarly suitable habitat in mature residential areas immediately adjacent.

In some respects, well landscaped residential areas of western Boulder are better habitat than nearby Parks and Open Space land, because of a greater abundance of palatable browse (shrub) species and generally more snow-free conditions. A well landscaped yard, free of dogs and with a tolerant land-owner, is prime deer habitat, especially in winter and spring but throughout the year to some extent.

Elevational movement exhibited by Boulder deer is typical of mountainous areas. The ramifications of this predominantly east-west pattern are discussed in Sections 3.4 (Deer-Vehicle Accidents) and 4.0 (Management Alternatives), below.

3.4 DEER-VEHICLE ACCIDENTS

Data on the number of deer killed or injured by vehicles or other causes within Boulder during the past 3 1/2 years are presented in Table 5. These data are based solely on the number of dead deer disposed of at the Boulder County Humane Society and therefore represent a minimum value. The numbers for 1980-1981, 1981-82, and possibly part of 1982-83 may be underestimates because of changes in dead deer disposition methods (Gary Berlin, CDOW, pers. comm.). Specifically, all road-kills are now taken to the Humane Society, whereas many of the carcasses used to merely be moved off the roadway or dumped elsewhere.

Based on Humane Society records, the number of deer road-kills during 1983-84 was about 2.5-4.0 times as high as in previous years. A total of 146 mule deer reportedly were killed within the city from June 1983 through May 1984. The majority of these deaths were a

TABLE 5

MONTHLY DEER ROAD-KILL AND INJURY-RELATED DEATHS WITHIN THE CITY OF BOULDER[1]

Month	Year[2] 1980-81[3]	1981-82	1982-83	1983-84	Monthly Average
June	-	3	6	5	4.7
July	-	4	3	7	4.7
August	-	4	0	8	4.0
September	-	4	5	8	5.7
October	-	1	6	32	13.0
November	7	11	3	23	12.0
December	21	7	4	14	11.7
January	6	7	2	18	8.3
February	2	5	3	13	5.7
March	1	3	2	9	3.7
April	2	5	2	7	4.0
May	0	3	2	2	2.3
Total	39	57	38	146	

[1]Data obtained from Boulder County Humane Society disposition records

[2]Yearly totals based on a biological year beginning June 1 when new fawns are born

[3]Records unavailable for June-October 1980.

direct result of deer-vehicle accidents, with a smaller number resulting from domestic dog attacks and injuries suffered from other hazards such as fences.

Except for May and June, there was an increase in road-kills every month in 1983-84 compared to 1982-83 (Table 5). The greatest percentage increase during this period was in January (800 percent, or eight-fold) although increases also were high during the previous three months (October-December) and the following three months (January-April). Road-kill rates increased less dramatically during the summer of 1983-84 and represented a smaller percentage of the yearly total (19 percent in 1983-84 vs. 37 percent in 1982-83 and 26 percent in 1981-82). However, the total number for the period June-September was about twice as high in 1983 as in 1982 or 1981. Data for the summer of 1984-85 were similar to values for 1983-84, although slightly lower with a total of 22 for the four-month period June-September, compared to 28 the previous year.

The following subsections discuss probable factors influencing the number and location of deer-vehicle collisions, seasonal differences, and variations between years.

3.4.1 Traffic and Road-Related Factors

In general, increased traffic along a given stretch of road will result in increased deer-vehicle collisions, due simply to the greater frequency of vehicles passing a particular point where a deer may attempt to cross. This is true only to a degree, however, because extremely heavy and consistent traffic precludes attempts by deer to cross. Traffic speed also is an obvious factor, in terms both of the ability of motorists to avoid a collision and the extent of the resultant damage.

Road width also may play a role, but not in a clearcut manner. On one hand, a wider road may increase the risk because a crossing deer must cover a greater distance, and road width generally is correlated with higher vehicle speeds and traffic volumes. On the other hand, a wider road improves the opportunity for a motorist to see a deer and avoid it, and may discourage deer from attempting to cross.

Other important road-related factors are the type and quality of adjacent habitats and the positioning of the road relative to deer movement routes. Thus, deer are more likely to cross roads located in rural or well landscaped residential areas or across movement corridors than roads located in highly developed urban areas or parallel to movement corridors. Also, well vegetated roadsides increase the risk by causing the animals to remain hidden until they actually move onto the roadway.

3.4.2 Seasonal and Daily Patterns

Reports in the literature (e.g., Bellis and Graves 1971, Pugalisi et al. 1974, Reilly and Green 1974, Allen and McCullough 1976, Pils and Martin 1979) indicate that late fall generally is the period of peak road-kill frequencies in other area with similar problems. This also was the case in Boulder in 1983-84 (Table 5), with October and November contributing 38 percent of the yearly total.

The increase in late fall probably is related to two major factors: (1) a greater overall activity level of deer because of the breeding season, and (2) a general movement from higher elevations to lower elevations. Although the breeding season is fairly consistent in timing, weather and habitat conditions may vary considerably from year to year, therby adjusting the onset of "late fall." Thus, for example, the peak month for road-kills was December in 1980-81, November in 1981-82, and October in 1982-83 and 1983-84.

Ecological factors may include frequency and depth of snowfall, persistence of snow cover, absolute minimum and average minimum temperatures, and habitat variables such as condition of browse. No clear correlations were evident between road-kills and meteorological data obtained from the National Oceanic and Atmospheric Administration (NOAA), and the effect of weather appears to be subtle and complex.

Road-kill rates tend to decline in middle winter compared to late fall (Table 5). This may seem surprising, considering that more persistent snow cover, colder temperatures, and occasionally strong winds seemingly would entice deer into more sheltered residential areas. However, deer also are more sedentary during this time and therefore are

less likely to cross major roads. Other factors, such as lower vehicle speeds, may also be involved.

Road-kill rates tend to drop off slightly in the spring as they did in 1983-84 (Table 5). Although deer activity levels increase with warmer temperatures, emergence of new forage, and onset of the fawning season, the general pattern in spring is for deer to move out of the city and onto Mountain Parks and Open Space land, thereby decreasing their vulnerability. Of course, late snows and cold spells could affect the timing of this spring movement, and some years (notably 1981-82) have shown essentially no spring decline in road-kills.

Contributing to road-kills is the fact that deer are most active from dusk through dawn, when they are least visible to motorists. During the late fall-early spring season, the peak activity period includes the morning and evening "rush hours." Commuter traffic is especially heavy on South Broadway (e.g., city residents who work at Rocky Flats or the Denver Federal Center) and North Broadway (e.g., mountain residents who work in Boulder). This helps to explain the high road-kill frequencies along these road segments.

3.4.3 Deer Population Size and Behavior

The previous subsections have discussed factors affecting the distribution of road-kill rates throughout the year, and to some extent variations between years. However, they are not sufficient to explain the dramatic increase in 1983-84 compared to previous years, especially in light of the poor correlation with snowfall and minimum temperatures described above. The two remaining factors that seemingly could cause the documented increase are deer population size and deer behavior.

Total deer population size for the study area was estimated at 747-845 (mean = 783) in April 1983 and 738-964 (mean = 888) in April 1984. As explained in Section 3.2, the 1984 figure was less precise because of the smaller number of tagged deer remaining in the population. Even so, the number of deer in the study area in April 1984 apparently was higher than in April 1983, despite the intervening road-kill loss of nearly 19 percent of the population. This mortality estimate is substantiated by the fact that eleven of the 68 deer tagged in 1983 (16

percent) were victims of collisions with vehicles during the following 12 months period.

Nonetheless, the estimated deer population increase (with a range of about 13-27 percent) cannot by itself account for the 284 percent road-kill increase, unless the population growth has occurred not in the total population, but in that portion of the population occurring in the city. That is, the increased number of road-kills is related not just to a total population growth of deer, but to an increased tendency for deer to utilize city habitats.

There are two plausible explanations for the latter conclusion: (1) that deer have shifted their use from natural areas to urban areas because of a decrease in the quality of the natural habitat, or (2) that the trend represents not a shift in use, but rather a range expansion. Habitat studies were not conducted as part of this study, but there appears to be no evidence that Mountain Parks and Open Space habitats have a lower carrying capacity now than they did a few years ago or that the deer population is stressed for food. Thus, the first plausible explanation is not supported.

The second explanation is more likely. Observations by long-term Boulder residents support the notion that Boulder deer have come to view mature residential neighborhoods as prime winter habitat and acceptable year-round habitat. As discussed in Section 3.3.8 (above), species generally occupy any suitable habitat that is not foreclosed by competition, disturbance, or movement barriers. Deer residing within residential neighborhoods do not appear to be under stress (i.e., using the areas only as a last resort); on the contrary, they regularly are seen to feed or rest in full view of roadways, scarcely moving unless approached directly. At NCAR, they go through their rutting and mating ritual in full view of countless citizens, tourists, and photographers.

A thorough analysis of reasons for the increased use of urban environments is beyond the scope of this study. It seems likely that the present situation stems from the proximity of natural deer range to quiet residential neighborhoods characterized by mature landscaping (including an abundance of palatable shrubs) in conjunction with a virtual absence of harassment. There are relatively few free-roaming dogs, the deer are not hunted, and for the most part they are tolerated

or even appreciated by the citizenry. Thus, the residential habitat is suitable from the perspectives of vegetation, elevation, and water, and there is nothing to prevent the deer from using it. In short, parts of Boulder have become a deer preserve.

3.4.4 High Collision-Risk Areas

Several deer-vehicle accident problem areas were identified based on the distribution of road-kills over the past 3 years (Figures 3-5).

The greatest collision-risk area is North Boulder, probably because of a large deer population, proximity to natural habitats, heavily landscaped streets, sparse commercial development, high traffic volumes (e.g., 15,000-30,000 vehicles per day on North Broadway), high vehicle speeds (often in excess of the posted 45 mph), and the fact that much of the volume is commuter traffic occurring at hours when deer are most active. The two worst street segments in this area are Broadway between Balsam and Lee Hill Road, and Linden between Broadway and Twomile Canyon. Both roads also cut across major deer movement routes (Figure 2), which helps explain their road-kill frequency for 1983-84 of over ten per mile. The residential area between Pearl and Kalmia west of Broadway also is a fairly high risk area, even though traffic volume and speeds are lower.

The second major problem area is in South Boulder, including Broadway between the Bureau of Standards and the edge of Shanahan Hill, Greenbriar along the edge of Open Space land, and the western portion of the Table Mesa subdivision on Table Mesa Drive and Lehigh. Other high collision-risk areas are the neighborhoods near Baseline between 22nd Street and Chautauqua and along the base of Flagstaff Mountain. As with North Boulder, these areas all have a large deer population, nearby natural habitats, well landscaped lawns, and some high volume/high speed road segments that cut across deer movement routes.

3.5 OTHER DEER DAMAGE

Besides the economic loss to individual motorists from deer-vehicle collisions and the risk of personal injury, deer in the city

also represent a nuisance and economic loss by damaging or destroying ornamental plants (roses are especially favored and vulnerable) and vegetable gardens.

The second type of deer damage was not emphasized in this assessment because it represents a smaller dollar loss than a deer-vehicle collision, does not pose a threat of human injury, and is difficult to quantify. Also, road-kills are a better index to the deer problem, because the data are on record, objective, and relatively accurate.

The amount of deer-related damage should occur in proportion to the overall deer population size, unless homeowners take preventive measures such as building fences or mitigative measures such as replacing expensive ornamentals with less costly or less palatable plants.

SECTION 4.0

MANAGEMENT ALTERNATIVES

4.0 MANAGEMENT ALTERNATIVES

The following subsections describe management options that could be undertaken in an attempt to alleviate the deer-human conflict in Boulder. For purposes of discussion, they have been grouped into four categories: (1) habitat manipulation, (2) population control, (3) roadside improvements, and (4) public education and involvement. Alternatives are presented as possible approaches for the City to consider but are not necessarily recommendations. Although the management options have been treated as distinct actions, combinations of alternatives may also be worthy of consideration.

4.1 HABITAT MANIPULATION

Many of the city residential areas provide deer habitat equal to or better than habitats on Mountain Parks and Open Space land. During the late fall and winter, the abundance of ornamental shrubs provides an easily obtained, highly nutritious source of food. Snow cover generally is thinner and less persistent than in the foothills or mesas, further increasing the attractiveness of the neighborhoods. Many of the older residential areas also provide excellent thermal cover and protection from winter winds.

From a management standpoint, nothing can be done to decrease the quality of city habitats other than to discourage people from purposely attracting deer by setting out salt blocks and food. Some have suggested a program of habitat improvement on Mountain Parks and Open Space land in hopes of attracting deer from residential areas. Programs of this type could include planting browse species, which are less well developed west of Boulder than most of the Front Range and controlled burning to increase available forage (Hobbs and Spawart 1984). Shrub plantings would be expensive, slow to mature, and of questionable value. Prescribed burns would create a myriad of aesthetic, ecological, and safety concerns, while also being expensive and of doubtful benefit.

Even if a habitat manipulation program were successful in establishing shrub stands or improving forage, it could well make the situation worse by increasing the total deer population rather than

causing deer to move from the city into the foothills. As noted earlier in this report, it is not that the natural habitats are bad, but that the residential habitats are good.

4.2 POPULATION CONTROL

Population control consists of direct manipulation of animal numbers by removing individuals from the population. Although a variety of methods can be used to remove animals, the principles of population control are the same. Before a control program is begun, it is important to specify the objectives, such as the desired population density. The number of deer that must be removed to reach and maintain this density over a specified time period should then be calculated based on estimates of population size and rate of increase at the time the control measures are to be initiated. The population estimates in this report may not be appropriate in the future if and when such a program is implemented.

The effectiveness of any control program is related to the dynamics of the population (e.g., population size, sex and age composition, rate of increase). The various population parameters will determine the number of animals by sex and age class that must be removed and how quickly the population will recover. For example, mule deer are polygynous breeders (i.e., one buck services several does), and reducing the number of adult bucks would therefore not significantly lower the reproductive capacity of the herd. The removal of adult does, however, would directly impact the reproductive capacity of the herd. The duration of the effects of control efforts on the population could be enhanced if females were removed primarily from the younger age classes, including fawns and yearlings.

Because there is little apparent north-south movement of deer along the foothills, control measures could be applied to smaller subpopulations. This has two important implications: first, efforts could be directed at specific problem areas; second, a smaller number of animals would need to be removed. Although most of the movement is east-west, enough north-south movement occurs that any such control would have to be repeated at intervals that cannot yet be determined.

Removal could occur as shooting or trapping-transplanting. Shooting programs could be administered in several different forms: (1) conduct a regulated sport hunt, (2) conduct a regulated "game damage"

hunt, or (3) allow professionals to shoot a specified number of deer at bait stations. A sport hunt is impractical from a public safety standpoint, due to the close proximity of homes and the high number of recreationists that use the Mountain Parks and Open Space land. In addition, the tame demeanor of most Boulder deer would make such a hunt anything but sporting. Under the most controlled circumstances, a "game damage" hunt or shooting at bait stations probably could be conducted safely. However, any type of proposed shooting program is likely to meet a tremendous amount of public opposition. In spite of the damage that the deer cause and the number of road-kills that occur, the Boulder deer herd is a highly prized aesthetic resource for many. Public opinion should be carefully evaluated before a shooting program is considered.

An alternative control method is trapping and transplanting deer to other areas. A trapping-transplanting program would have the advantage of being used in specific problem areas including neighborhoods. The primary disadvantage of this approach is that it is labor-intensive and therefore costly. Like other population control methods, trapping is a short-term solution, and the recurring cost must be considered. Also, there is always a problem of determining where the trapped deer should be released. Although there would be some public opposition to trapping, it probably would not be as controversial as shooting. In spite of its potentially high cost, trapping and transplanting deer may be the most feasible and acceptable method if population control is deemed necessary by the City.

4.3 ROADSIDE IMPROVEMENTS

In recent years, a new type of roadside relector has been used to reduce deer-vehicle accidents along highways in Europe and coal haul roads in our region. These reflectors work by redirecting the light from an approaching vehicle in a manner that creates a so-called "light fence" which deer are reluctant to cross. The SWAREFLEX system manufactured in Austria and now distributed in the United States has received the most use. Most biologists who have used the reflectors feel that there has not been adequate time to evaluate their effectiveness, while others have indicated that the reflectors apparently have reduced road-kills in limited test areas. The cost of reflectors and posts, excluding installation cost, is about $4,200 per mile. Therefore, before

reflectors are seriously considered, it would be advisable to more fully evaluate the results from other areas and perhaps to use them along a test road segment.

The other type of roadside improvement that might prove effective in reducing roadkills is to erect deer-proof fences along high-risk road sections. This technique poses somewhat of a risk because animals could get through gaps in the fences where sideroads enter, but might not easily find their way off the road.

These techniques would address the road-kill problem but have little if any effect on other types of damage. Ironically, deer-vehicle collisions are an effective population control measure. For example, in 1983-84, road-kills exacted a mortality toll of 16-19 percent, many of which probably were deer that also were a nuisance to homeowners. Thus, a decrease in road-kills other than as incident to an overall population decrease would have an adverse effect in another way, and this trade-off would have to be considered. As noted above, however, the economic loss and safety risk of deer-vehicle collisions are of greater concern than the problem of deer damage to ornamental plants and gardens.

4.4 PUBLIC EDUCATION AND COMPENSATION

This approach represents a sort of "no action" alternative, because it does not involve active measures to control the deer population. Adopting this "no action" approach would be based on the recognition that (1) active habitat manipulation or population control techniques would be costly and have no guarantee of success, and (2) although the growing numbers of deer in town are a problem for some, they are an amenity to others. Before attempting to correct the deer "problem," it first should be determined whether they really are a problem from the viewpoint of the public at large. They obviously represent a problem for individual homeowners, motorists, or agency personnel.

This fourth management alternative consists of two distinct elements, which could be implemented separately or together. The first element, public education, would have two basic objectives: (1) to inform the public about the deer issue, its possible causes, and economic

effects (residents of unaffected neighborhoods may be unaware of the situation), and (2) to provide information about ways of protecting ornamental plantings and gardens by the use of deer repellants or fences. In conjunction with this, residents should be prohibited from intentionally attracting the deer, such as with salt blocks and feed, because it puts an unfair burden on their neighbors who may not want the deer. Citizens should be made aware that the City recognizes their concerns and will make an effort to assist them. Education sources could include pamphlets, newspaper articles, and radio programs.

Another aspect of the public education program could be to encourage people to view deer in town as a "uniquely Boulder" experience. In a way, the presence of the deer reflects the quality of our urban environment and our long-standing policy of protecting wildlife within or near the city (no hunting, no free-running dogs, etc.). For example, a disgruntled homeowner who has had his roses destroyed could decide that having deer around is more important (you can grow roses anywhere, but you cannot see deer in your yard anywhere), or he could take responsibility for protecting his roses by enclosing his yard. The latter is analogous to his taking responsibility for keeping robins out of his cherry tree with a net or squirrels out of his oak tree with a trunk guard, although more expensive.

To assist in reducing the road-kill hazard, public education could be used to inform citizens about high risk areas and times of day and year when the risk is greatest. This should be supplemented with warning signs (possibly with flashing lights) and lower speed limits in problem areas, and perhaps with the reflectors described above (Section 4.3).

The second element, compensation, could be undertaken to relieve individual citizens of the cost of deterring deer or of repairing a damaged vehicle. It would spread the economic burden among the populace as a whole, thereby lessening the impact on any one person. Although seemingly expensive, the cost not be high in comparison to the other alternatives, and it may be more acceptable.

4.5 RECOMMENDED MONITORING PRORGAM

Regardless of the management approach(es) selected, a monitoring program would be beneficial to ensure that data on which the management decisions are based remain valid. The number and location of road-killed

deer should continue to be monitored to determine whether the large increase in 1983-84 was an anomaly or a trend. Since the Boulder County Humane Society keeps disposition records on all road-kills picked up along city streets, maintaining such records should require a minimal effort. Although sex and age are recorded for most road-killed deer, it is suggested that added emphasis be placed on accurately recording this information. These data are useful for estimating mortality rates of different age classes, which in turn are useful for population analyses. More accurate aging of road-killed deer could be achieved by having animal control officers collect an incisor tooth from each animal for aging by the dental cementum annuli technique.

Population numbers also should continue to be monitored on an annual basis. Deer counts along standardized transects could serve to assess annual trends. A quadrat census method also could be employed (Caughley 1977, Kufeld 1980). Sampling of quadrats should be stratified based on known areas of high and low deer densities. Estimates should be done in October or early November before most of the annual road-kills have occurred. In conjunction with these estimates, buck:doe:fawn ratios should be estimated (Bowden and Andersen 1984). Four replicated estimates of population numbers and sex and age ratios could be obtained with about 8 man-days of labor.

SECTION 5.0

SUMMARY

5.0 SUMMARY

The City of Boulder, in cooperation with the Colorado Division of Wildlife, funded a 2-year study of deer in Mountain Parks and Open Space land along the mountain front west of Boulder and adjacent urban environments. The study was prompted by increases in the number of deer-vehicle collisions on city streets and reports of damage to gardens and ornamental plants.

The basic study design involved capturing, tagging, and releasing deer at various trapping sites. A total of ninety deer were marked, of which twelve were radiocollared. Population estimates based on the mark-recapture (census) technique were 783 $\pm$52 in April 1983 and 888 $\pm$217 in April 1984 for the 16 mi^2 study area. Analyses of movement patterns revealed a strong tendency for deer to move east-west between Mountain Parks and Open Space land and nearby residential neighborhoods, especially those supporting mature landscaping. Very few deer moved north-south along the mountain front.

Road-kills of deer increased by 250-400 percent from 1982-83 to 1983-84. Fall and winter was the period of greatest road-kill frequency--as has generally been reported in Boulder and elsewhere--but absolute increases occurred in ten of the twelve months. The seasonal increase is related to a general movement to lower elevations, greater activity levels associated with breeding, and the coincidence of daytime activity peaks (dusk till dawn) with "rush hour" trffic periods.

Road segments having the highest deer-vehicle collision rates are Broadway north of Balsam, Linden west of Broadway, and Broadway between Ash and Greenbriar. High hazard neighborhoods include the area between Mapleton and Kalmia west of Broadway, western University Hill, Chautauqua east to the Bureau of Standards, western Table Mesa, and Shanahan Ridge/ Devils Thumb. High hazard road segments are characterized by heavy traffic, relatively fast vehicle speeds, well developed roadside vegetation, orientation across major deer movement corridors, and proximity to natural habitats supporting a resident herd.

The marked increase in road-kills in 1983-84 probably was related to (1) an overall increase in the deer population, (2) the high quality of urban habitats in terms of cover and food, and (3) a growing tolerance

of deer for human presence and activity. The third factor has evolved over several deer generations, during which time the deer have been neither hunted nor harassed.

Management alternatives include habitat manipulation, population control by shooting or trapping, roadside improvements, and public education. The most costly and potentially most controversial alternatives--habitat manipulation and population control--also have a limited likelihood of long-term success. However, they could be applied in individual instances (e.g., a problem deer in one yard). Public education may be successful in helping to alleviate the damage to vehicles, risk of personal injury, and destruction of gardens and ornamental plants. The four alternatives are not mutually exclusive.

Before a management alternative is selected, the views of the citizenry should be thoroughly considered to determine whether the current deer situation represents a "problem" that needs to be "solved" for the community as a whole. Despite the increased economic loss suffered by some, the general public may value the presence of deer in the urban setting as a unique amenity. If so, then methods could be devised by which to assist individuals in deterring deer and to compensate those who do sustain a significant financial burden.

The increased costs of responding to citizen complaints and disposing of dead or injured deer also will have to be dealt with by the various state and local agencies involved, and responsibilities perhaps redefined.

SECTION 6.0

LITERATURE CITED

6.0 LITERATURE CITED

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APPENDIX A

APPENDIX A-1

MULE DEER TAGGED AND MARKED IN THE SOUTH SUBUNIT
OF THE BOULDER MOUNTAIN PARKS AND OPEN SPACE LAND
JANUARY-MARCH 1983

Date Tagged	Trap Site	Sex	Age	Eartag Left	Eartag Right	Neck Collar Color/Number	Remarks*
				Color: Yellow			
1/ 4/83	3	F	Ad	formerly 1 radiocollared			12/8/83 see Red tags #2 148.500
1/ 4/83	3	F	Yr	-	2	-	killed by dog 1/25/83
1/ 4/83	3	F	Fn	-	3	-	
1/ 4/83	2	F	Ad	-	4	4	
1/ 5/83	3	F	Ad	-	5	5	
1/ 5/83	4	F	Yr	-	6	6	killed by unk Dec (wk 2) '83
1/ 5/83	2	F	Yr	-	7		white radiocollar - RC 148.110
1/ 6/83	2	F	Ad	-	-	8	white-tail
1/12/83	2	M	Yr	-	14	14	white-tail
1/12/83	7	F	Ad	-	10	10	
1/13/83	6	M	Ad	-	11	-	
1/13/83	7	M	Ad	-	12	-	
1/13/83	4	M	Fn	-	13	-	
1/13/83	7	M	Ad	-	19	-	dead - 12/5/83 (HBC)
1/14/83	7	F	Ad	-	20	-	scar behind left leg
1/14/83	1	F	Ad	-	15	15	dead - 10/27/83 (HBC)
1/15/83	4	M	Fn	-	16	-	dead - 10/24/83 (HBC)
1/15/83	2	M	Fn	-	17	-	
1/16/83	6	F	Ad	-	18	18	
1/19/83	2	M	Fn	-	22	-	
1/20/83	5	F	Ad	21	21	21	
1/22/83	1	F	Ad	-	9	9	
1/22/83	6	F	Fn	23	23	-	
1/24/83	5	F	Ad	24	24	24	white-tail
1/24/83	3	M	Yr	-	25	25	dead - 9/19/83 (unk)
1/24/83	6	F	Ad	26	26	26	
1/19/83	3	F	Fn	27	27	-	
1/21/83	3	F	Fn	-	28	-	
1/25/83	6	M	Fn	29	29	-	dead - 10/26/83 (HBC)
1/26/83	4	F	Fn	30	30	-	
1/27/83	5	M	Fn	31	31	-	
1/27/83	6	F	Yr	32	32	-	
1/28/83	5	F	Ad	33	33	-	
1/29/83	3	M	Yr	34	34	-	
1/29/83	6	M	Fn	35	35	-	dead - 8/27/83 (injury - shot)
2/15/83	3	F	Ad	-	-	-	RC 148.290
2/19/83	6	M	Yr	36	36	-	
2/23/83	6	M	Ad	37	37	-	
2/27/83	6	M	Ad	38	38	-	

*unk = unknown; HBC = hit by car; RC= radiocollar frequency

APPENDIX A-2

MULE DEER TAGGED AND MARKED IN THE SOUTH SUBUNIT
OF THE BOULDER MOUNTAIN PARKS AND OPEN SPACE LAND
DECEMBER 1983

Date Tagged	Trap Site	Sex	Age	Eartag Left	Eartag Right	Neck Collar Color/Number	Remarks*
			Color:	Yellow			
12/ 7/83	21	F	Ad	40	40	650	RC 148.650
				Color:	Red		
12/ 8/83	20	F	Ad	1	1		
12/ 8/83	20	F	Ad		2	Yellow/500	RC 148.500 #1-Spr 1983
12/ 9/83	20	F	Fn	3	3		
12/ 9/83	20	F	Ad	7	7		
12/12/83	20	F	Ad	4	4		white-tail
12/12/83	20	F	Yr	5	5		
12/14/83	20	F	Fn	8	8		
12/15/83	20	M	Ad	9	9		

*RC = radiocollar frequency

APPENDIX B

APPENDIX B-1

MULE DEER TAGGED AND MARKED IN THE NORTH SUBUNIT
OF THE BOULDER MOUNTAIN PARKS AND OPEN SPACE LAND
JANUARY-MARCH 1983

Date Tagged	Trap Site	Sex	Age	Eartag Left	Eartag Right	Neck Collar Color/Number	Remarks
				Color: Orange			
1/31/83	10	F	Ad	31	31		
1/31/83	10	F	Fn	32	32		
2/ 1/83	12	M	Ad	39	39		dead 12/9/83 (HBC)
2/ 2/83	12	M	Ad	34	34		
2/ 2/83	10	M	Ad	35	35		
3/ 4/83	11	F	Fn	63	63		
2/ 5/83	12	M	Ad	38	38		
2/ 5/83	10	M	Yr	41	41		
3/ 4/83	13	F	Ad	61	61	900	RC 148.900
2/15/83	14	M	Ad	47	47		
2/15/83	10	M	Ad	43	43		
2/16/83	12	F	Ad	46	46		
2/16/83	13	F	Ad	36	36	640	RC 148.640 3/3/83 dead--10/29/83 (HBC)
2/18/83	13	M	Ad	37	37		antlers in velvet
2/21/83	11	F	Ad	45	45		
2/22/83	13	M	Ad	49	49		
2/22/83	15	M	Ad	50	50		
2/23/83	11	F	Ad	44	44	600	RC 148.600 3/2/83
2/23/83	13	M	Ad	51	51		dead 11/26/83 (HBC)
2/23/83	15	M	Ad	52	52		dead 12/4/83 (injury - shot)
2/24/83	15	M	Fn	53	53		dead 11/?/83 (injury - shot)
2/24/83	15	F	Ad	54	54		
2/24/83	13	M	Fn	55	55		
2/25/83	13	F	Ad	58	58		
2/26/83	13	F	Fn	57	57		
2/27/83	10	M	Ad	59	59		
2/28/83	14	F	Ad	60	60	690	RC 148.690
2/25/83	15	M	Ad	56	56		
2/12/83	11	F	Ad	42	42		

*HBC = hit by car; RC = radiocollar frequency

APPENDIX B-2

MULE DEER TAGGED AND MARKED IN THE NORTH SUBUNIT
OF THE BOULDER MOUNTAIN PARKS AND OPEN SPACE LAND
DECEMBER 1983

Date Tagged	Trap Site	Sex	Age	Eartag Left	Eartag Right	Neck Collar Color/Number	Remarks*
			Color:	Orange			
12/ 6/83	10	M	Yr	64	64		
12/ 6/83	10	F	Fn	67	67		
12/ 6/83	17	F	Ad	71	71	700	RC 148.700
12/ 7/83	17	M	Fn	70	70		
12/ 7/83	10	M	Ad	75	75		
12/ 7/83	10	F	Fn	66	66		
			Color:	Green			
12/ 8/83	17	M	Fn	4	4		
12/ 8/83	16	F	Ad	2	2	Orange/950	RC 148.950
12/ 8/83	17	M	Fn	7	7		
12/ 9/83	17	F	Ad	1	1	Orange/640	RC 148.640
12/ 9/83	10	M	Ad	3	3		
12/ 9/83	16	F	Ad	5	5	White	RC 148.925
12/ 9/83	17	M	Fn	8	8		

*RC = radiocollar frequency

APPENDIX 2

APPENDIX 3

WETLAND MITIGATION GUIDELINES FOR TWO FORKS AND RELATED ALTERNATIVES

Although the Environmental Protection Agency, the Corps of Engineers, the U.S. Fish and Wildlife Service, and the National Marine Fisheries Service are presently working toward a common National Wetland Mitigation Policy, there is no current, formally adopted National or Regional policy which applies to wetlands mitigation.

In Region VIII, our wetland mitigation goal, and the goal of the Clean Water Act, is to maintain and protect existing wetland resources and restore wetland functions on a functionally equivalent basis. Toward this end, we have developed these general guidelines. Wetland mitigation proposals are reviewed on a case-by-case basis, considering specific wetland values and functions and types of mitigation proposed. Unless it is clearly demonstrated that an alternative project site does not exist or that alternative sites will have more adverse impact, avoidance of wetland impacts is required by the Section 404(b)(1) Guidelines.

Where impacts are unavoidable, the preferred sequence for mitigation is: 1) hydrologic restoration, 2) creation, 3) vegetative restoration, and then additional mitigation measures. This sequence is based on the probability of success in compensating for project impacts, existing functions and values of the mitigation site, functions lost during the time from initiation of mitigation actions to the time of successful completion of the mitigation plans, and consideration of the potential for achieving functional equivalency through mitigation. These mitigation terms, as used throughout this document, are defined below:

"Hydrologic restoration" is defined as the act of restoring the natural hydrology of a former wetland area (which was previously impacted by hydrologic modifications and which is not upland) to its original condition so that wetland is restored and the natural hydric soil and vegetation will be restored and be self perpetuating.

"Wetland creation" is defined as the establishment of a wetland in an upland area which was not a wetland in the past. Wetland creation often requires manipulation of topographic contours, hydrology, soil structure, vegetation, and other factors to allow for establishment and maintenance of wetland functions.

"Vegetative restoration" is defined as the act of restoring natural vegetation which existed before man-induced factors were introduced which resulted in degradation of the original wetland functions. Vegetative restoration requires replacement with a self-perpetuating flora and often involves changes in land management practices. Vegetative restoration may require replacement of naturally occurring vegetation when natural vegetation does not or will not develop in response to the changes in management.

"Additional Mitigation Measures" is defined as all other measures which are intended to compensate for adverse impacts of a proposed project. These mitigation measures may include improvement of wildlife habitat, flood retention, water quality, or other wetland functions. The development of wildlife habitat improvement generally involves the act of inducing changes in the vegetative and physical characteristics of an existing wetland area to increase diversity through hydrologic or topographic changes generally for the purpose of enhancing the wildlife habitat functions.

The following ratios are provided as guidance for determining what may constitute acceptable mitigation. The ratios are expressed as acres of mitigation : acres of wetland impact and are based on achieving a goal of 1:1 replacement of wetland functions.

Hydrologic Restoration	1:1
Creation	2:1
Vegetative Restoration	3:1
Additional Mitigation Measures	*

Except in very unusual cases or rare circumstances, preservation of fully functional, existing wetlands is <u>not</u> an acceptable mitigation technique. The acceptability of a mitigation plan for any specific project will be judged by application of these ratios on a case-by-case basis.

The preferred sequence and the ratios presented above are based on the following rationale:

Hydrologic Restoration -- Due to the existence of a viable wetland on a given site in the past, the chances of success in restoration of the wetland and the reestablishment of natural wetland vegetation are good. Through the restoration of these wetland characteristics, wetland functions are restored and mitigative credit can generally be given at a 1:1 ratio.

Creation -- There is considerable risk involved with the creation of wetlands due to the uncertainty of creating a suitable soil, hydrology, and vegetation complex in areas which have not previously been wetlands. Additional risks are related to the diversity and abundance characteristics of vegetation in mitigation areas and the related wetland functions. In recognition of these inherent risks, mitigation proposals for wetland creations will be reviewed using a 2:1 ratio as our guideline.

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* The initial ratio for any additional wetland mitigation will be 4:1; however, final ratios will be determined on a case-by-case basis considering wetland functions of the project site, proposed mitigation features, probability of mitigation success, and other site-specific factors.

Vegetative Restoration -- In these areas, impacts are generally due to changes in species composition and abundance resulting from grazing, hay production, cropping, or other similar activities. Vegetative restoration often involves changes in land management practices. Due to the continued existence of the hydrology of a wetland area, the chances of success in restoration of the natural vegetation on the site are fairly good. This kind of mitigation requires consideration of all existing wetland functions in the mitigation. Special consideration is required for functions which are poorly correlated with vegetation. In recognition of the original functions and values of the wetland mitigation sites, the other characteristics of the areas, and the relative difficulty in enhancing wetland functions which are not related to vegetation; mitigation proposals for vegetative restoration will be reviewed using a 3:1 ratio as our guideline.

Additional Mitigation Measures -- This form of mitigation results in enhancement of the existing value of a wetland for one of the wetland's functions. The most common form of additional mitigation is improvement of habitat function. Due to the existence of a functioning wetland on the mitigation site, it will be relatively difficult to make large improvements of the existing wetland functions to provide compensatory mitigation for a project's impacts. Some wetland functions may be improved at the expense of others or the improvement may enhance some, but not all, of a wetland's functions. In recognition of this difficulty, and the relative difficulty in improving functions which are not related to habitat, mitigation ratios will be determined on a case-by-case basis after consideration of the initial wetland functions, probability of mitigation success, and other site specific factors.

In all cases, long-term management of the mitigation areas is required and mitigation should occur concurrently with project construction. In general, credit will not be given for improvements or other mitigation measures on Federal or other public lands unless it can be clearly shown that such mitigation measures would not otherwise occur during the life of the project as a result of existing or future management. Likewise, no credit will be given if the improvement could reasonably be accomplished via other regulatory or management mechanisms on any land, private or public.

Mitigation should be performed on-site, if possible, to replace the wetland functions lost or impacted by a proposed project. If no other options are available, off-site mitigation may be acceptable provided it is within an area of similar biological and physical characteristics. Due to the lesser or greater chances of success in replacing wetland functions or in the timing of achieving replacement of wetland functions, mitigation ratios may be adjusted. Distance from the impact site is one factor which will be considered in adjusting the mitigation ratios. Additional adjustments of the mitigation ratios may be made based upon case specific and site specific factors.

Mitigation measures must be identified and their beneficial and adverse impacts disclosed in the draft environmental impact document to meet the requirements of the National Environmental Policy Act (NEPA). Adverse impacts resulting from implementation of the mitigation plan may also need to be mitigated. The specific mitigation measures proposed for a project must be identified by the applicant through the 404 permit application process and the public notice should include any mitigation measures proposed by an applicant to provide the public with an opportunity to comment.

APPENDIX 4

CITY OF BOULDER OPEN SPACE BOARD OF TRUSTEES POLICY FOR "404" MITIGATION REQUESTS ON OPEN SPACE ADOPTED April 8, 1987

I. Introduction. This "404" mitigation policy is intended to be consistent with the primary purpose of the Open Space program, which is to preserve and protect Open Space land for the benefit of the public. Therefore, the policy does not favor the use of Open Space land for the financial benefit or convenience of private parties or public agencies. Any sale of Open Space land for this purpose is discouraged.

This policy provides a mechanism for Open Space Board of Trustees ("OSBT") to review plans to utilize Open Space lands for purposes of "404" mitigation. The federal "404" program (derived from the Clean Water Act, 33 U.S.C. §1344) prevents the destruction of most wetlands without a "404" permit issued by the Corps of Engineers. Such permits generally require mitigation by the Permittee. Typically, mitigation is achieved by the creation of new wetlands or other wildlife habitat.

Although the OSBT recognizes that the creation of wetlands on selected Open Space property may, under some circumstances, be beneficial, the OSBT is under no obligation to approve such use on Open Space lands. Each application will be individually reviewed, and the approval of any such application shall not constitute a precedent for decisions on future applications.

This policy is applicable to all persons, as defined in Section 1-2-1, B.R.C. 1981, including all city departments and other governmental entities.

II. Application Process. An applicant for either the purchase of Open Space property or an easement on Open Space property for wetlands mitigation must submit the following documents to the Department of Real Estate and Open Space ("staff") at least 30 days prior to the OSBT meeting, at which consideration of the request is sought:

A. A written statement describing the proposed project, the wetlands to be destroyed and their location, the work schedule for the entire project, and the mitigation that is proposed to be created on Open Space property in satisfaction of "404" mitigation requirements;

B. An environmental inventory of the Open Space property proposed to be used;

C. A map detailing the location and a schematic diagram of the proposed wetland location and also a map indicating the location of the wetland to be destroyed;

D. Complete plans for the establishment and maintenance of the wetland or habitat area on Open Space land, including the water source, grading, planting, and any additional maintenance such as water and weed control during establishment of the vegetation that would be required;

E. A statement explaining the need for the "404" mitigation, which includes the following information:

1. Alternative methods and alternative locations for the mitigation.

2. The cost to the applicant if the Open Space easement or purchase is granted.

3. The costs of alternative methods and locations.

4. Any benefits perceived by the applicant to accrue to a broader group or to the public as a whole by virtue of the granting of the request.

F. Any other items reasonably requested by the staff.

G. If the request is for an easement, the applicant must also satisfy the City of Boulder Open Space Board of Trustees' Policy for Easement Requests on Open Space dated November 13, 1985.

H. Any items submitted in an application may be retained by the City of Boulder.

III. Referral to the Open Space Board of Trustees. The application to utilize Open Space land for the purposes of satisfying "404" mitigation requirements, will be referred to and considered by the OSBT if the following criteria have been met:

A. All required documents have been timely received; and

B. The Open Space Board Chair and the Director of the Real Estate and Open Space Department concur that the proposal will benefit Open Space land. If the Board Chair and Director do not agree, the applicant may appeal that decision to the OSBT within 30 days of the denial, and the OSBT must hear the matter at its first meeting thereafter. The OSBT also has the authority to call up an item for review on their own motion.

IV. Consideration by the Open Space Board of Trustees. The OSBT will consider, at a public meeting, all applications that meet the criteria in Paragraph III. The OSBT will consider the following factors in determining whether or not to recommend to City Council that an easement or any other interest be granted on Open Space land for the purposes of "404" mitigation:

A. Whether there is sufficient need for the use of Open Space land for mitigation. In determining that such need exists, the Board will consider, without limitation, any alternatives available to the applicant, the cost of such alternatives, and the purposes for which the easement or sale is requested;

B. The degree to which the proposed mitigation will change the appearance and condition of the Open Space land;

C. Whether the proposed use of the mitigation interferes with use of the land for Open Space purposes;

D. Whether the proposed mitigation is consistent with the goals of the Open Space Program as set forth in Section 2-3-9(c), B.R.C. 1981;

E. Whether the entire ecosystem has been considered, and whether the existing use should be protected as opposed to allowing mitigation, which is a change of use of the property;

F. Loss of income due to the cancellation of existing leases or other such activities; and

G. Any other relevant factors.

V. Conditions.

A. Payment of money to the Open Space Fund. In determining how much money should be paid to the fund, the Board shall consider the following factors:

1. Whether the property will remain open to the public; and whether it will remain Open Space property.

2. Irrespective of any change in the value of the property as a result of mitigation, the OSBT reserves the right to charge full value for property.

3. All plans for work for wetlands mitigation activities on Open Space land shall be approved by the staff and the OSBT.

4. Applications for mitigation on Open Space land will be considered as a change of use and/or conveyance by the OSBT, and will thus be subject to approval by both the OSBT and the City Council;

5. Applicants are responsible for obtaining the "404" permit, and they remain responsible for the mitigation and all other requirements of their contract with the U.S. Army Corps of Engineers. Thus, after mitigation has occurred, and even if staff has agreed to maintain that property pursuant to paragraph V.6., the applicant remains ultimately responsible by contract or deed restriction for meeting the terms and conditions of the "404" permit;

6. After the completion of a "404" mitigation project, and after acceptance of that project by the staff, the staff will be responsible for the maintenance of that property, except in the case of absolute fee transfer of land to the applicant. However, should the mitigation area be destroyed for any

reason other than the negligence of the Open Space Department, the applicant will be responsible for any restoration, including restoration of physical works (berms, canals, etc.) that may be necessary in order to continue to fullfill the mitigation requirements of the "404" permit.

7. Staff time for work on wetlands mitigation projects shall be reimbursed. The minimum fee is $250.00, but should staff time (including other city employees) exceed that amount, then the fee shall be for the actual time spent on the project.

8. The applicant shall pay the cost of all mitigation efforts on Open Space property.

9. Any Open Space property disturbed as a result of construction activities associated with wetlands mitigation projects, shall be restored to a condition at least as good as prior to the disturbance. All restoration work must be to a standard and within a time frame acceptable to the staff.

10. Any other requirements necessary to assure minimum disturbance and maximum preservation of the Open Space land resource, and performance by the applicant of any obligation imposed as a condition of the approval of an easement or the sale of Open Space property.

11. The applicant shall indemnify and hold the City harmless for any losses, claims, and expenses, including reasonable attorneys' fees, incurred by the City as a result of any wetlands mitigation activities.

ADDENDUM

Staff requests that the Open Space Board of Trustees change its easement policy to require that reimbursement for staff time occur on all projects. That reimbursement shall be a minimum of $250.00 or the actual costs incurred by the Open Space staff or any other City employees that are involved in such project.

OS OS

WESTERN RESOURCE DEVELOPMENT CORP.

P.O. Box 467
711 Walnut Street
Boulder, Colorado 80306
(303) 449-9009

October 30, 1984

Jim Crain
Director, Real Estate/Open Space
City of Boulder
1877 Broadway, Suite 501
Boulder, CO 80302

Dear Mr. Crain:

Enclosed is the Western Resource Development (WRD) final report on mule deer in City of Boulder Open Space and Mountain Parks land and adjacent urban environs. The report describes study objectives and methods; discusses deer population size, movement patterns, and "high-risk" areas; and presents management alternatives that could be employed in response to the increasing number of complaints about deer damage and deer-vehicle collisions. A summary section also has been provided.

The study focused on the interface between natural habitats along the mountain front west of Boulder and nearby residential neighborhoods, because it is the free movement between these areas that has resulted in the present situation.

Management options are not presented as recommendations, because we recognize that policy decisions will have to include considerations other than ecology. However, we have tried to emphasize that (1) the increasing use by deer of urban habitats seemingly is related to a gradual change in behavior rather than overuse and degradation of natural habitats, and (2) the economic loss and nuisance suffered by some individuals should be viewed in the context of whether the presence of deer in town represents a problem or an amenity for the community as a whole.

This report represents fulfillment of our contractual obligations. We have enjoyed working with the City of Boulder on this interesting project.

Sincerely,

Allen B. Crockett

Allen B. Crockett, Ph.D., J.D.
Project Manager

ABC:ei
Enclosure

cc:
Ron Donahue, Parks and Recreation
Dick Lyman, Parks and Recreation
Gary Berlin, Colorado Division of Wildlife
Laurie Roe, Colorado Division of Wildlife

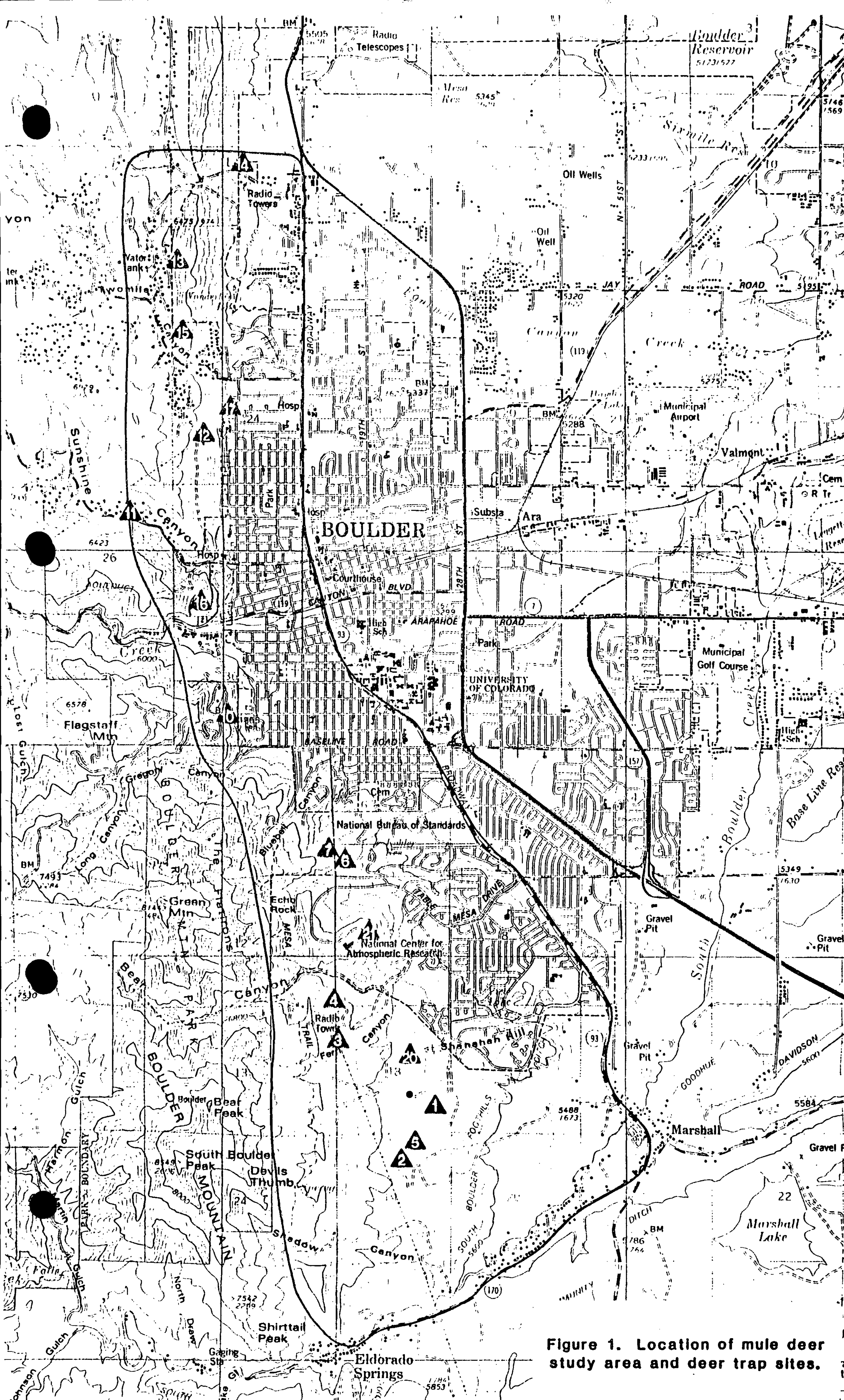

Figure 1. Location of mule deer study area and deer trap sites.

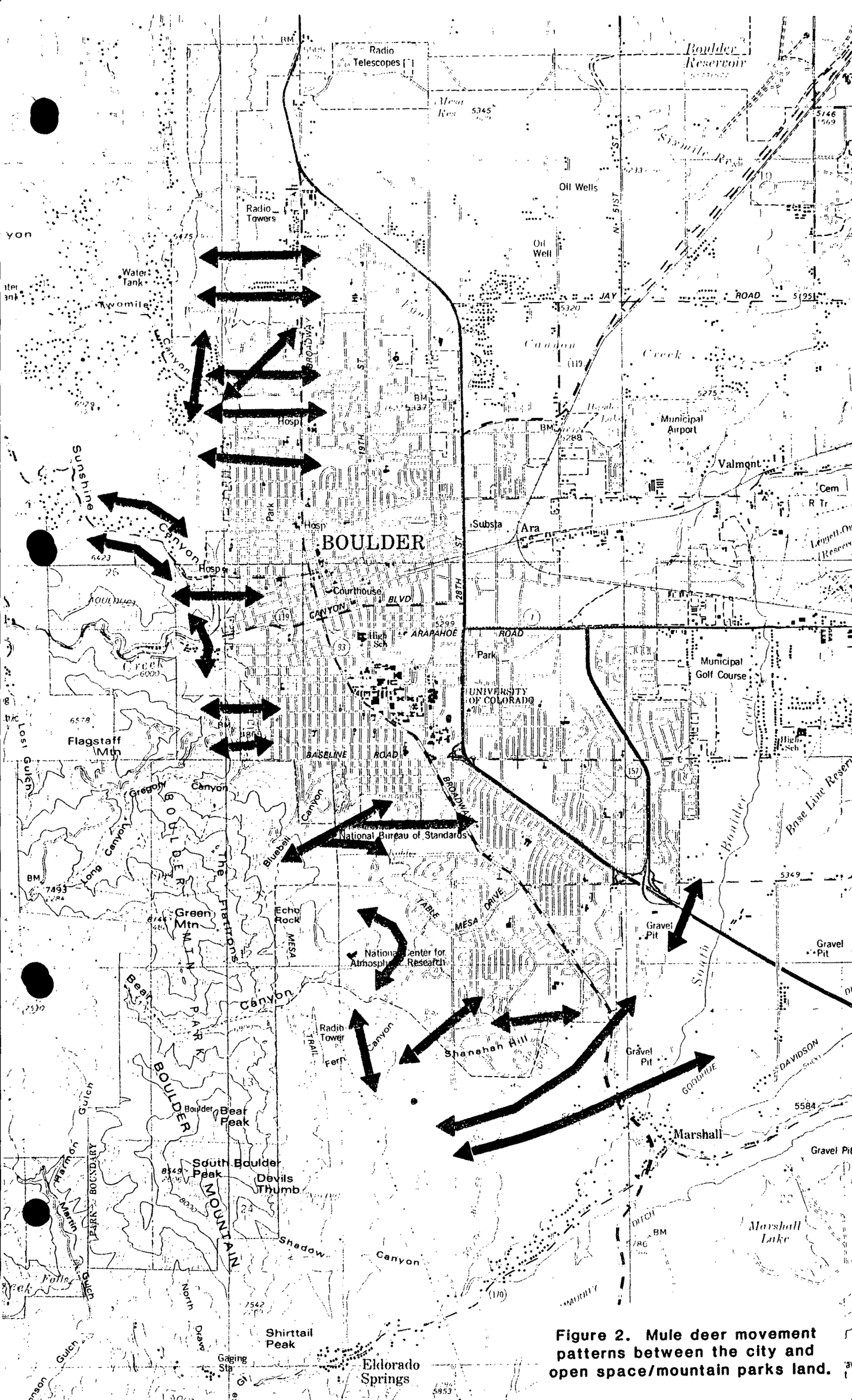

Figure 2. Mule deer movement patterns between the city and open space/mountain parks land.

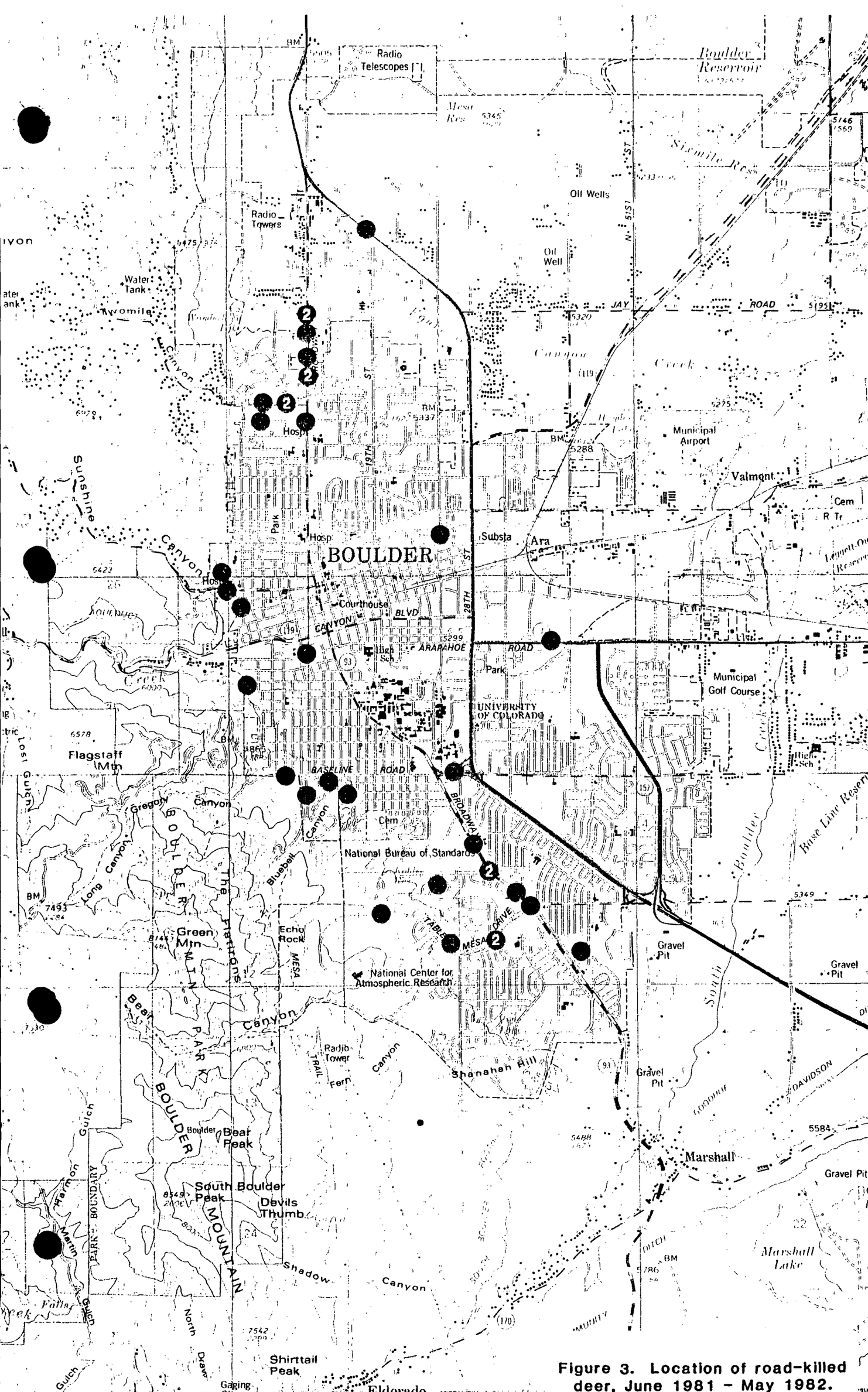

Figure 3. Location of road-killed deer, June 1981 - May 1982.

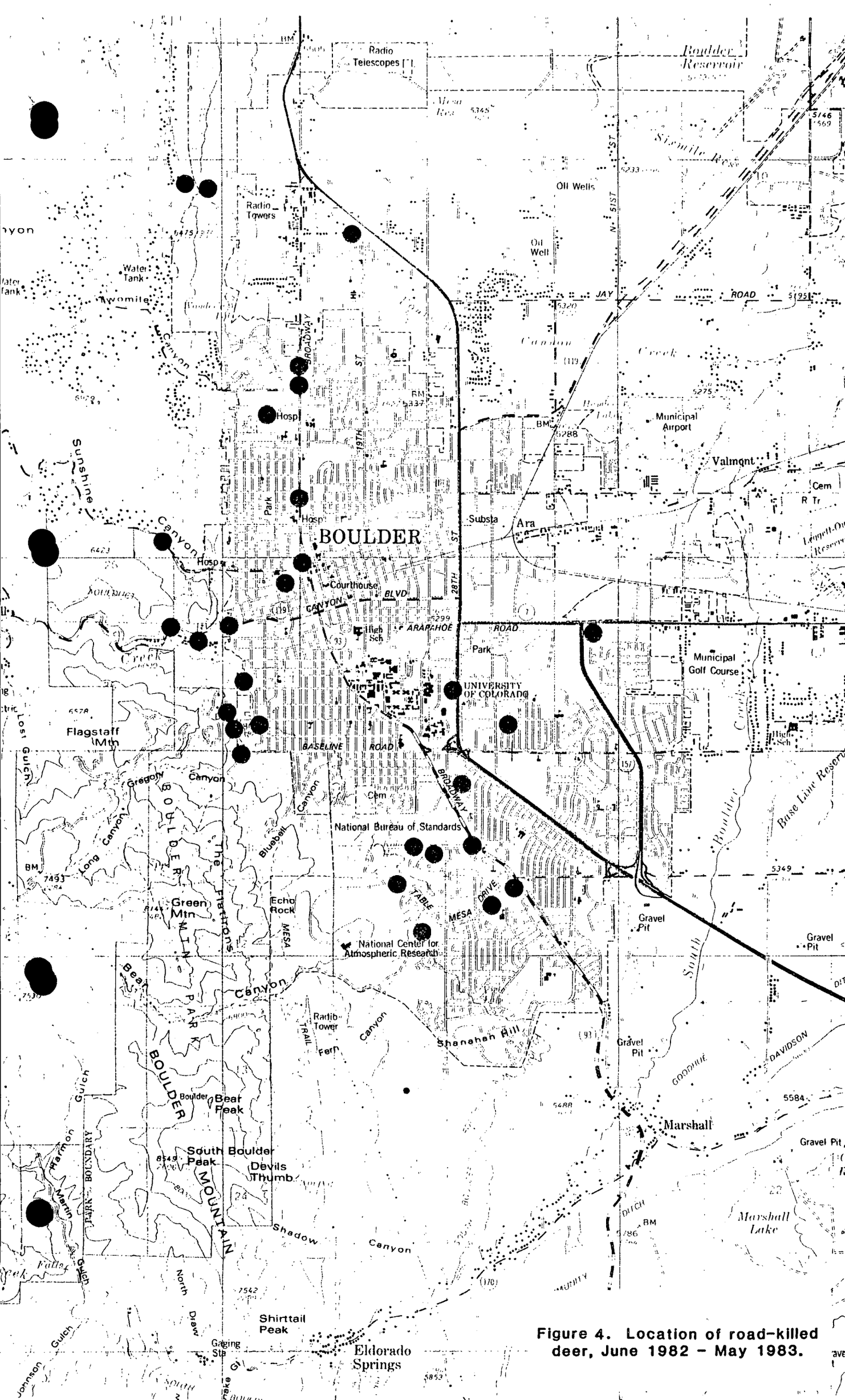

Figure 4. Location of road-killed deer, June 1982 – May 1983.

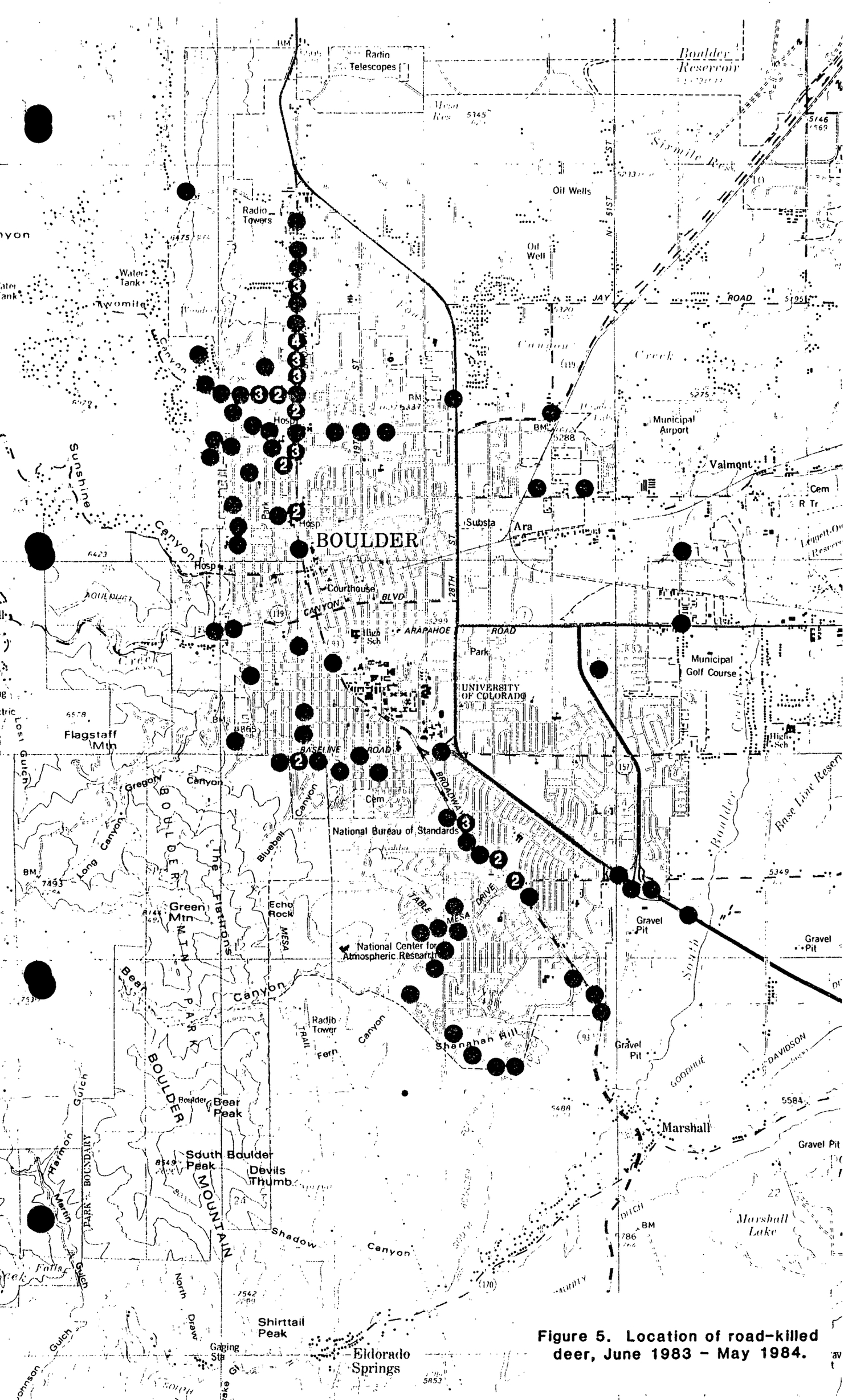

Figure 5. Location of road-killed deer, June 1983 – May 1984.