<u>LINCOLN-PETERSON POPULATION</u>
<u>ESTIMATE</u> <u>ON</u> <u>THE</u> <u>DEER</u> <u>POPULATION</u>
<u>IN</u> <u>BOULDER,COLORADO</u>

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ABSTRACT

We conducted field observations on the Mule deer(Odocoileus hemionus)and White-tailed deer(Odocoileus virginianus)population in the foothills of Boulder,Colorado. Using observations of the deer that had been marked for the study in previous years and random samples taken on April 2,3,4 and 18 we used the Lincoln-Peterson formula to estimate the population size. Using a 95% confidence interval we came up with an estimated population size range of 1238 +/- 221,an increase from 1989. In addition to this,during the field observations,the locations of the deer were recorded in order to get an understanding of their movements and home ranges. We found that most of them were returning to the same area as previous years and using a small range.

INTRODUCTION

In 1983 Boulder Parks and Open Space began their long term study of the Mule deer(Odocoileus hemionus)population in the foothills and neighborhoods of Boulder. Making up a small portion of this population are some White-tailed deer(Odocoileus virginianus)as well as some hybrids. This study is conducted in the winter due to the deer´s movement west into the mountains during the warmer parts of the year. The goals of this study were to monitor the deer´s population numbers and trends,their home ranges,their movement patterns and the number of road kills. Data was collected by staff and interns from the University of Colorado,compiled in field books and then consolidated into manuscripts that contain all the information gathered during the years of study. The Lincoln-Peterson method of population estimation(see Seber,1982) and its associated capture,marking and

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recapture has been used since the beginning of the study in 1983. In the winter of 1989 the phase out of this method was begun and our field work of January-April 1990 is the end of this method. It has been phased out in favor of less costly methods such as pellet surveys as well as aerial and ground counts. It is also being phased out due to the growing skepticism concerning the reliability of the Lincoln-Peterson method(Hirth,1988).

METHODS

The study area consisted of the foothills and associated neighborhoods from Eldorado Springs Road to just south of Lee Hill Road in Boulder,Colorado(see Fig.1). This area was divided into four districts of approximately equal size: there were the North,North Central,South Central and South districts. On the topographic maps of these areas a North/South and East/West grid system was placed so that deer positions could be recorded accurately using directional coordinates. Starting in 1983 and ending on January 27,1989 deer were trapped in large live traps. Their age and sex were recorded and they were given an ear tag,one in each ear(ear tags normally used for cattle). Yellow tags were used on deer trapped in the two districts south of Baseline Road,the two south districts; orange tags were used for deer in the two north districts,north of Baseline Road. The field observation period for this years study was January 20 through April 1,1990. During this time the interns spent approximately ten hours a week in the field recording the date sighted and position,by coordinates and land marks,of any tagged deer observed. This data was recorded in the field book of the

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corresponding disrict. Each intern spent three weeks per district and was able to work in three of the four districts so that the different schedules of the interns allowed for the field observations to be carried out at different times of day.   These recorded observations gave a general picture of the deer movements and home ranges as well as which marked deer were still around.

On April 2,3,4 and 18 a comprehensive ground count was performed by staff and interns. For each day the total number of deer seen, marked and unmarked, as well as the number of marked deer were recorded. These counts were our random samples and the number of marked individuals seen in the field observations plus any additional individuals seen during the count was assumed to be the number of marked deer in the population. We applied these numbers to the Lincoln-Peterson formula for population estimation.   This formula is based on the assumption that if a certain number of deer in the population are marked then the ratio of marked to total deer should be the same in the random sample and the total population. The Lincoln-Peterson formula is $N = (M+1)(n+1)/(m+1) - 1$ where N = total population estimate, M = total marked deer assumed in population, n = total deer in sample and m = total marked deer in sample.   The count for each day was run through this formula and a mean was taken. The mean was then applied, with a standard error estimate, to a 95% confidence interval calculation and this gave us our population estimate.

RESULTS

Through our field observations and any additional sightings on the count days we assumed there to be 56 marked deer left in

the population and this is the number we used in the Lincoln-Peterson formula. The four count days yielded marked and total deer numbers respectively of 22\595 for day 1,26\503 for day 2, 18\461 for day 3 and 27\505 for day 4(Table 1). These are the random samples we used for the estimation. Using the formula the population estimations were 1476 for day 1,1063 for day 2,1385 for day 3 and 1029 for day 4; these resulted in a mean of 1238(Table 2). To partially account for the possible errors in this kind of estimation we calculated a standard error estimate,using the mean,of 112.8(Table 3). With this standard error estimate we were then able to calculate a 95% confidence interval. This gave us our final population estimate of 1238 +/- 221(Table 4). This calculation means that we are 95% sure that the population mean lies within this range. Table 5 lists the results from previous years for comparison.

Through our field observations we were also able to record the movements of the deer by plotting their locations on the map given for each deer in the field book for each district. Looking at the locations of the deer over time in the North Central district it appears that the deer are returning to the same area each year since they are most often seen within a short distance of the site where they were trapped. There were only two exceptions to this in the North Central district. The two deer with tags orange(O) 283 and 285 who were tagged in January of 1988 at the Cunningham trap site(near 4th and Kalmia)this year were seen spending much of their time in the Flagstaff area. This is approximately 2.5 miles away from their original trap

FIGURE 1
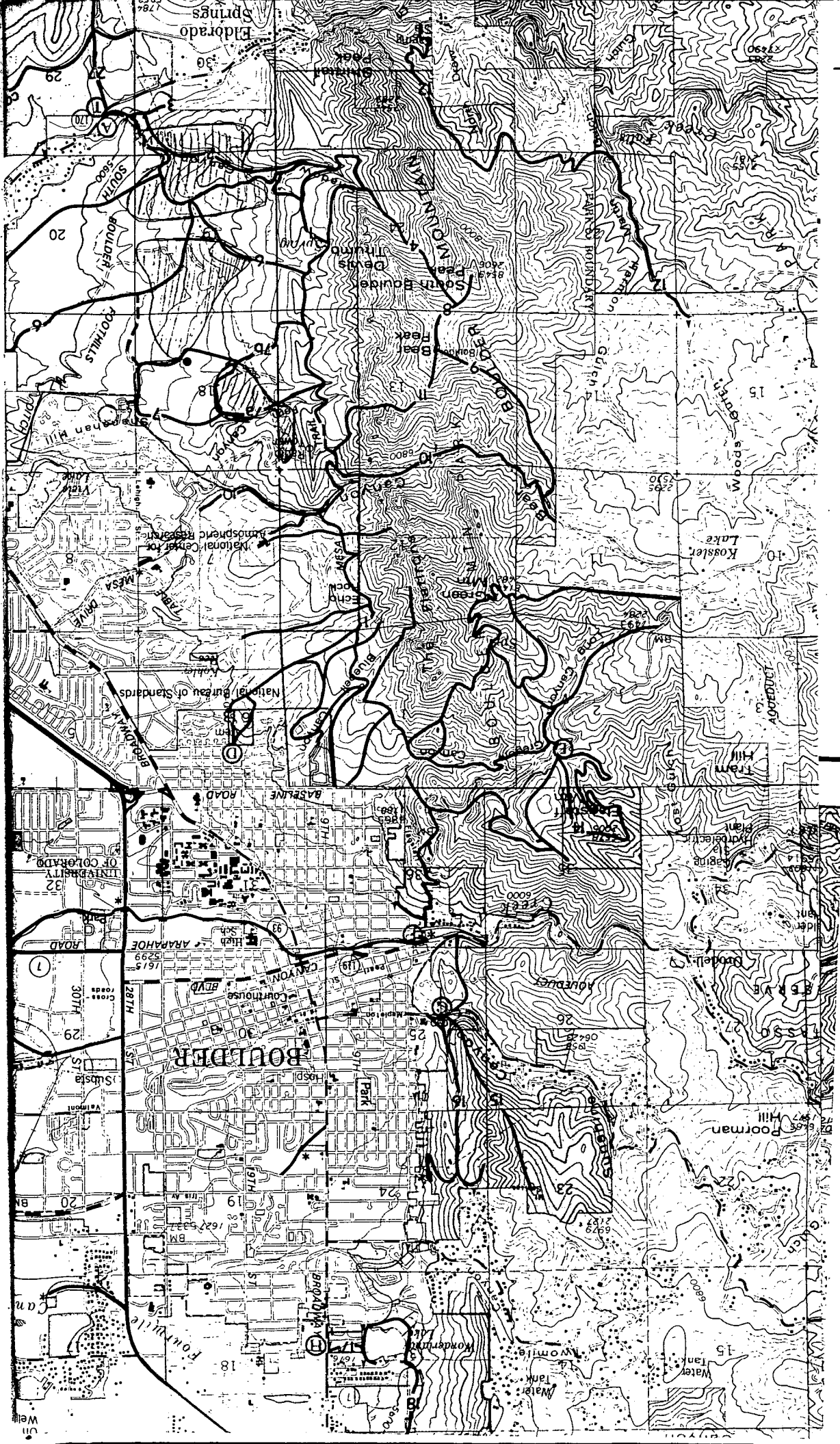
Figure 1

TABLES

TABLE 1: Figures obtained from count days

Day	Total deer	Marked deer
Count day 1 April 2	595	22
Count day 2 April 3	503	26
Count day 3 April 4	461	18
Count day 4 April 18	505	27

TABLE 2: LINCOLN-PETERSON POPULATION ESTIMATES FOR COUNT DAYS.

- 56 = number of deer assumed in population.

Count day 1: $\dfrac{(56+1)(595+1)}{(22+1)} - 1 = 1476$

Count day 2: $\dfrac{(56+1)(503+1)}{(26+1)} - 1 = 1063$

Count day 3: $\dfrac{(56+1)(461+1)}{(18+1)} - 1 = 1385$

Count day 4: $\dfrac{(56+1)(505+1)}{(27+1)} - 1 = 1029$

$$\text{Total} = 4953$$
$$(\hat{N})\ \text{Mean} = 1238$$

TABLE 3: STANDARD ERROR CALCULATION. (SE)

Day 1 $(1476 - 1238)^2 = 56,644$

Day 2 $(1063 - 1238)^2 = 30,625$

Day 3 $(1385 - 1238)^2 = 21,609$

Day 4 $(1029 - 1238)^2 = 43,681$

Total 152,559

Sum of squared deviations from the mean $\left(\sum_{i=1}^{K} (\hat{A}_i - \hat{N})^2 \right)$

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

where K = number of count days

$$= \sqrt{\tfrac{1}{4(4-1)} (152,559)}$$

$$= \underline{112.8}$$

TABLE 4:   95% CONFIDENCE INTERVAL

$$95\% \text{ CI} = \hat{N} \pm 1.96(SE)$$
$$= 1238 \pm 1.96(112.8)$$
$$= 1017 - 1459 \quad \underline{or} \quad \underline{1238 \pm 221} \longrightarrow \text{This is our population estimate}$$

TABLE 5:   Figures for past counts 1983 — 1989

YEAR	MEAN POPULATION ESTIMATE	STANDARD ERROR	95% CONFIDENCE INTERVAL	AVG. NO. OF DEER SEEN ON COUNT	ROAD KILLS
1983	783	21.9	740 - 826	296	119
1984	888	74.7	742 - 1034	312	133
1985	—	NO	SURVEY	DONE	113
1986	1073	86.8	903 - 1243	439	116
1987	1067	89.8	891 - 1243	546	188
1988	1116	40.7	1036 - 1196	446	214
1989	952	44.7	864 - 1040	536	—

FIGURE 2: Population trends over the years.

YEAR.

1990	1017 —— 1238 —— 1459
1989	864 — 952 — 1040
1988	1036 — 1116 — 1196
1987	891 — 1067 — 1243
1986	903 — 1073 — 1243
1985	— NO COUNT —
1984	742 — 838 — 1034
1983	740 — 783 — 826

700 800 900 1000 1100 1200 1300 1400 1500

POPULATION ESTIMATES.
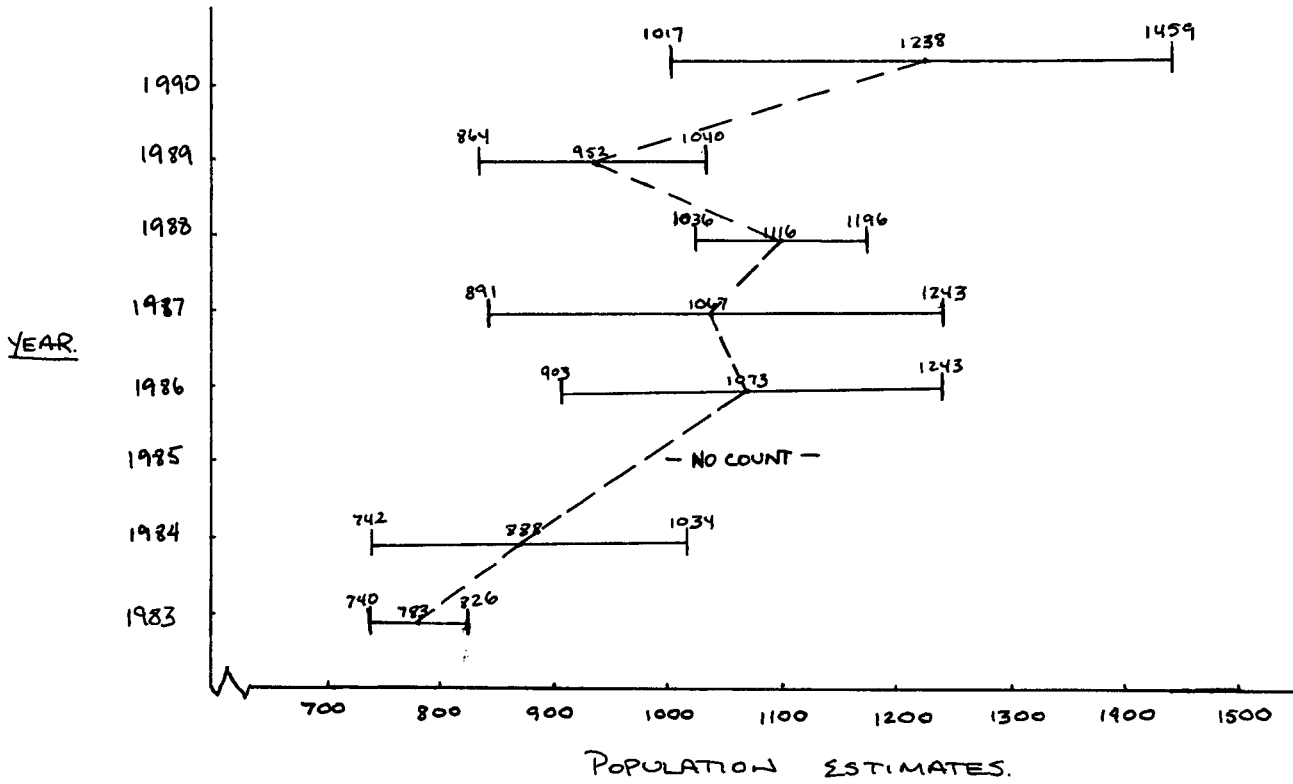
p. 25 — 3?
34
38
8·14
16 — 20
25 — 33

site. The deer also seem to use a very small area surrounding these trap sites indicating a small home range in these wintering grounds. The deer in the Flagstaff area and Sunshine Canyon moved around more than those in the Cedar Brook neighborhood. For example, many of the deer including 0151,0161 and 0169 all moved west small distances in late February. 0161 and 0169 also showed eastern and southern movement at the beginning of march. In contrast,two deer in the Cedar Brook area,0282 and 0293,showed practically no movement at all.

DISCUSSION

What this population estimate gives us is a general idea of how many deer are living in the study area. This number is not supposed to be thought of as exact for a couple of reasons. First,the "recapture" portion of this estimation model was based on the field observation of marked deer making it very possible that some of the more secretive deer that are marked were not seen. Second,the accuracy of the Lincoln-Peterson formula is less than definite and should not be taken as such(Hirth,1988). This estimation is,however,important because it not only gives an approximate range for the population size but can also be compared to past years to see trends in the population. Figure 2 shows the population estimates from 1983-1990 in relation to each other. There is a general increase in population size with only two small drops in size between 1986 and 1987 and between 1988 and 1989. The drop between 1988 and 1989 is probably linked to the increased number of road kills in 1988,214(Table 5),as well as the severe winter of 1988\89. Having a general idea of population size and the trends is necessary for the wildlife

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management policies of this area. This is especially true considering the high degree of interaction between the deer and the humans whose neighborhoods they enter. The increase in the population that is indicated by our estimation this year,from a mean of 952 in 1989 to 1238 in 1990,may indicate that the conflict between the foothill residents of Boulder and the deer may become worse and need to be considered in any future policies. This increase in deer may also be linked to another conflict that has become more prevalent in the last couple years and that is the apparent increase in the Mountain lion(Felis concolor)population. They may be attracted to the increasing food base in the area. More concrete information on the population of the Mountain lions(Felis concolor)is needed.

This study also gave us an indication of the movements of the deer in the area. In the North Central district I observed that many of the deer were spending much of their time near the site where they had been trapped(excluding the two exceptions). This is significant considering that many of these deer were tagged several years ago and are still returning to the same area. This makes it easier to predict where the deer are going to be from year to year when setting up further studies and management plans. With the phase out of Lincoln-Peterson method, this knowledge of the general areas where many of the deer prefer to spend the winter will help in the future aerial and ground counts that will take its place. It remains to be seen in the following years whether the use of new methods will yield significant differences in the population estimates.

LITERATURE CITED

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    related parameters,2d ed. Griffin,London.