INITIAL MULE DEER HERD STUDY AT THE NEW MEXICO STATE UNIVERSITY CORONA RESEARCH RANCH

BY

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A Thesis submitted to the Graduate School
in partial fulfillment of the requirements
for the Degree
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Berry, R. J., and V. W. Howard Jr. 1992. Preliminary results from a fee-hunting operation in central New Mexico. Presented at the Joint Annual Meeting of the Arizona & New Mexico Chapters of The Wildlife Society. Thatcher, Arizona. Abstract.

ABSTRACT

INITIAL MULE DEER HERD STUDY AT THE NEW MEXICO STATE UNIVERSITY CORONA RESEARCH RANCH

BY

Randall Jay Berry, B.S.

Master of Science in Wildlife Science

New Mexico State University

Las Cruces, New Mexico, 1992

Dr. V.W. Howard, Jr., Chair

Study was initiated to estimate population density, home range size, age structure, sex ratio, and morphological characteristics of the mule deer herd. The data for this study were collected beginning in November 1989 to April 1992. This study is the initial phase of a 10-year project to examine the effects that livestock grazing and modifications to the pinyon-juniper habitat have on the mule deer population.

Density estimates were determined from pellet-group transects established primarily in the pinyon-juniper ecotone of the research area. Fall/winter usage was determined from the April pellet-group counts while spring/summer usage was determined from the October pellet-group counts. Vegetation transects were

established to determine vegetative characteristics of mule deer habitat. The line-point method was employed to estimate ground and tree cover and composition. Cluster analysis was used to examine vegetative similarities between sampled areas.

Mule deer densities ranged from 23 deer/259 ha (640 ac) for the 1990 spring/summer period to 28 deer/259 ha for the 1991 spring/summer period; however, there was no statistically significant difference between the four sampling periods.

An incisor (I_1) was removed from most male deer harvested on the research area during the 1989, 1990, and 1991 hunting seasons. Cementum annuli analysis was used to determine age. Six body measurements and 8 antler measurements also were taken from each of the harvested deer.

Three-year-olds were the dominate age class comprising 48% of the deer taken. There was a trend towards larger antler and body measurements with age. Hunting success rates for the 1989, 1990, and 1991 hunting seasons were 85%, 95%, and 92%, respectively.

Sex ratios of the population, as determined from an observation/trend route, were 100:75:68 (doe:fawn:buck). Summer home range sizes of the 4 does examined for this study were significantly larger than winter home range sizes. Summer home range size ranged from 2.95/sq km to 1.58/sq km and winter home range size ranged from 2.45/ sq km to 0.74/sq km.

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INTRODUCTION

The 11,264 ha (28,160 ac) New Mexico State University Research Ranch, near Corona, New Mexico, was purchased in 1988 to replace the Fort Stanton Research Area. Long-term research goals for the research area include examining ecological changes in the Colorado pinyon pine (Pinus edulis)-one-seed juniper (Juniperus monosperma) forest and the blue grama (Bouteloua gracilis) rangeland habitats, analyzing livestock and wildlife responses to these changes, and examining the interactions between livestock grazing and wildlife.

Pinyon (Pinus spp.)-juniper (Juniperus spp.) woodlands dominate approximately 31 million ha (76 million acres) in western North America, being the largest woodland type in the world (Box et al. 1966). Mule deer (Odocoileus hemionus) and other vertebrate species depend heavily on this woodland ecosystem for their survival, particularly during the critical winter months. Large-scale conversion of pinyon-juniper woodlands to grasslands began in the 1950s with 1.2 million ha (3 million ac) being converted in the U.S.A. between 1950 and 1964 (Box et al. 1966). By 1986, about 223,000 ha (548,000 ac) of pinyon-juniper were converted in Arizona and New Mexico (Dalen and Snyder 1986).

The long-term impact that these large-scale conversion projects are having on the pinyon-juniper ecosystem, and the wildlife that depends on it, has been very poorly documented (Terrel 1973). The economic importance of mule deer to New Mexico is high. The state sold 95,497 mule deer licenses during the 1991-92 hunting season for a total revenue of $1.8 million dollars[1]. Wildlife managers and ranchers have a vested interest in knowing how pinyon-juniper clearing to enhance livestock production affects mule deer populations and what types of treatments might be mutually beneficial to mule deer and livestock.

This study is the initial phase of a 10 year project whose main objective is to document the effects that livestock grazing and modifications of the pinyon-juniper habitat have on the mule deer population that inhabits the NMSU Corona Research Ranch. The main objective of this phase of the study is to gather a data base for future projects. The compilation of this data base will be achieved through the following objectives:

1. Determine the population density/259 ha for the spring/summer and fall/winter periods.
2. Determine vegetative composition of the mule deer habitat.'

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[1]Pete Pena, [Personal communication]. New Mexico Department of Game and Fish, Santa Fe, N.M.

3. Determine if a relationship exists between population density and vegetative composition.
4. Document winter and summer home range sizes of radio-collared females.
5. Estimate the sex ratio of the population.
6. Estimate the age structure of males from harvested deer.
7. Document morphological trends of males from antler and body measurements taken from harvested deer.
8. Document the success rates from the fee-hunting operation that has been in existence on the ranch since 1989.

Funding was provided from the McIntire-Stennis program and the New Mexico Agricultural Experiment Station. The principal investigator for this study was Dr. V.W. Howard Jr., Professor, Department of Fishery and Wildlife Sciences, New Mexico State University.

STUDY AREA

The 11,264 ha (28,160 ac) New Mexico State University Research Ranch (Figure 1) is located

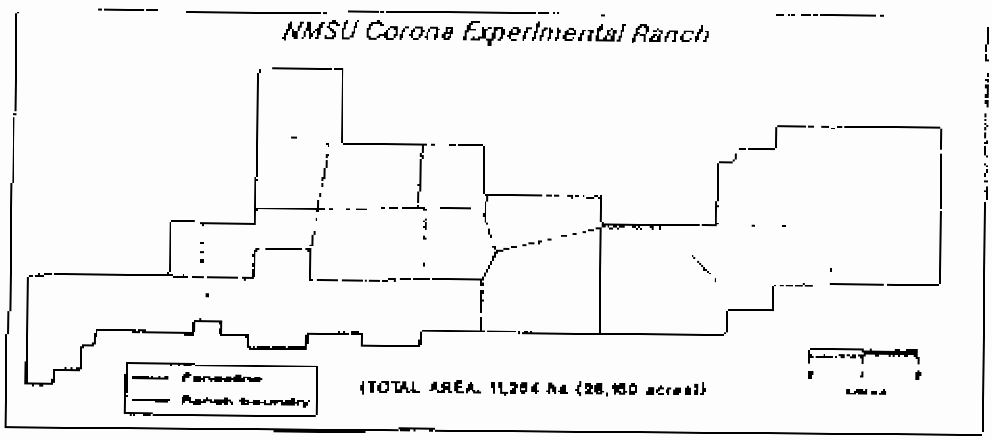

Figure 1. Area of the New Mexico State University Research Ranch near Corona, New Mexico.

approximately 22.5 km (14 miles) east of Corona, New Mexico along the borders of Lincoln and Torrance counties (Figure 2). In the past, both cattle and sheep have been grazed on the research area by previous owners. Presently, the NMSU Department of Animal and Range Sciences is conducting research on plant species and ecology, manipulation of vegetational communities, and grazing by cattle and sheep.

Modifications of the pinyon-juniper overstory were done by previous owners in an attempt to encourage the production of grasses and forbs for their livestock. The modification techniques included pushing, piling, and

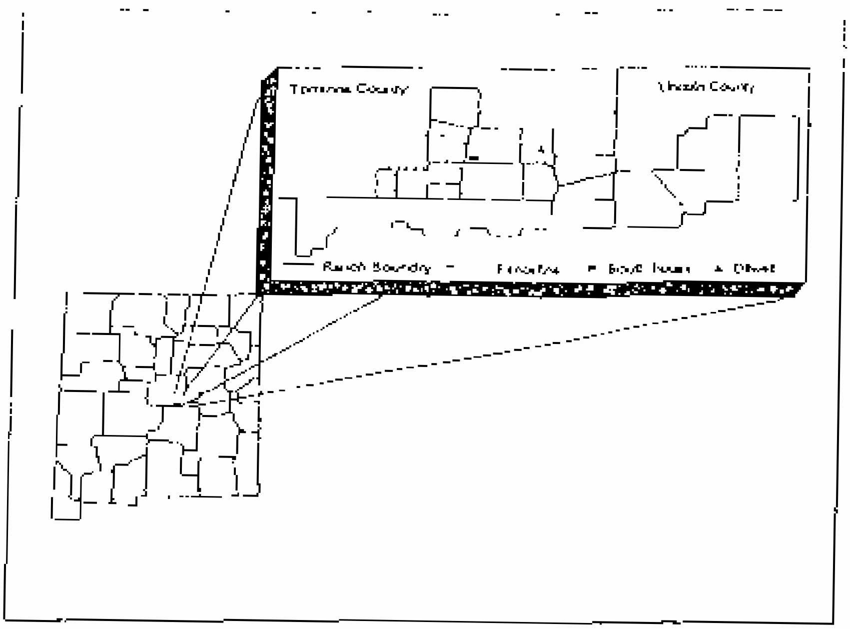

Figure 2. Location of the NMSU Corona Research Ranch in Lincoln and Torrance counties, New Mexico.

burning trees; two-way cabling and prescribed burns. The Department of Animal and Range Sciences is planning similar modifications in designated areas of the research ranch.

The climate of the area experiences extreme fluctuations from year to year but is primarily semi-arid. Temperatures range from a low monthly mean of -0.93°C in January to a mean monthly high of 21°C in July. The mean monthly precipitation that falls on the area ranges from 8 mm (0.31 in) to 78 mm (3.07 in) (NOAA 1981-1990). April is typically the driest month while highest precipitation usually occurs in July or August in the form of convectional thunderstorms (Berry 1992). Figure 3 displays the temperature means and precipitation amounts that occurred on the research area from October 1990 to September 1991 (Hart 1992).

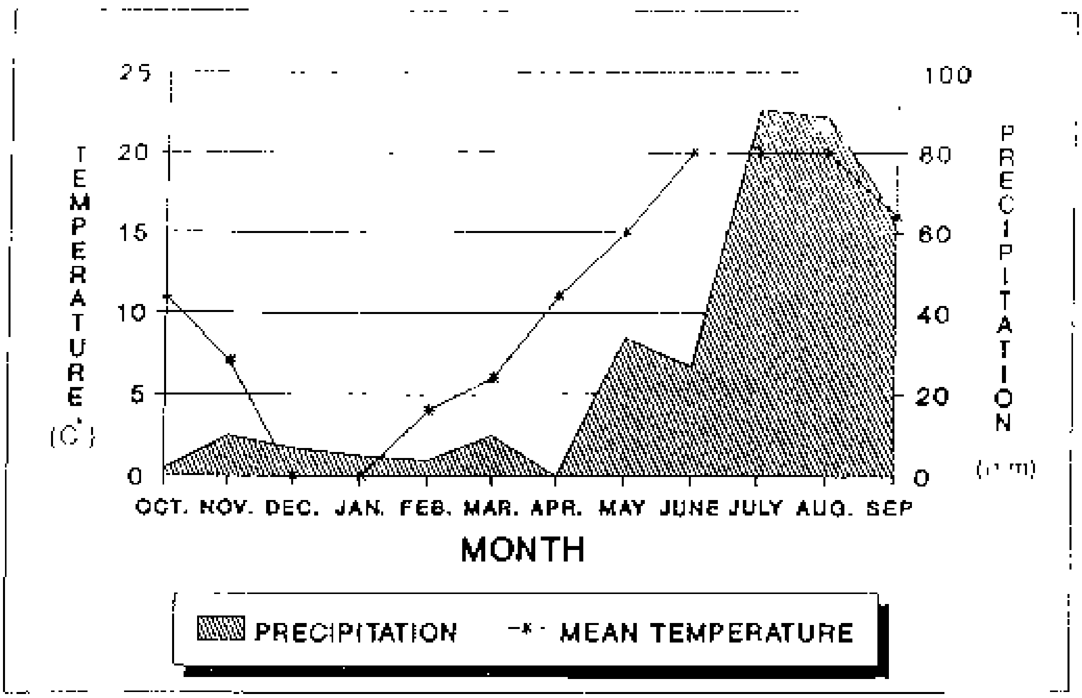

Figure 3. Temperature means and precipitation amounts recorded from October 1990 to September 1991 on the NMSU Corona Research Ranch (Hart 1992).

Vegetation on the ranch can be classified into 2 major types, grassland and pinyon-juniper woodland. Harrington (1992) identified 5 main ground vegetation communities on the research ranch (Table 1). Major grass species include blue grama (Bouteloua gracilis), sand dropseed (Sporobolus cryptandrus), wolftail (Lycurus phleoides), galleta (Hilaria jamesii), and several threeawns (Aristida spp.). The dominant woody species are one-seed juniper and pinyon pine.

Table 1. Five main ground vegetation communities identified on the NMSU Corona Research Ranch by Harrington (1992).

Community	Dominant vegetation type(s)
Bogr	Blue grama (72%)
BoArGu	Blue grama (32%) Purple threeawn (15%) Broom snakeweed (20%)
Lyph	Wolftail (54%) Blue grama (12%)
Bocu	Sideoats grama (43%) Wolftail (9%) New Mexico feathergrass (9%)
Stne	New Mexico feathergrass (54%) Sideoats grama (11%)

(Approximately 10-259 ha sections, located in the SW region of the research ranch, were not included in this study)

Soils of the sampled areas consist primarily of Penistaja fine sandy loam with 1 to 6% slope and Pinon channery loam with 3 to 20% slope (USDA 1970). Penistaja fine sandy loam occurs on upland piedmont fans and is classified as a friable sandy loam that has been leached of lime with a surface layer about 13 cm (5 in) thick grading into a subsoil about 61 cm (24 in) thick. Pinon channery loam occurs on crests and side slopes of ridges. It is classified as a brown, friable, limy channery loam with moderate granular structure. It has a surface layer about 15 cm (6 in) thick grading into a subsoil about 10 cm (4 in) thick.

The research area is part of the Great Plains Province whose topography typically consist of gently rolling hills and flat plains. Limestone sinkholes are found throughout the ranch, ranging in size from a few meters in diameter to sinkholes that occupy several hectares. Steep rocky outcrops, mesas, and sand dunes also can be found on the research area. The mean elevation of the area is 1860 m (6100 ft).

No natural permanent water sources are known to exist within the boundaries of the research area. The porous soil of the area does not allow for surface accumulation of water except during extremely heavy periods of precipitation when ephemeral pools of water form in the limestone sinkholes. Stock tanks used to supply the cattle herd with water are the only permanent water supply on the research area.

Pellet-Group Transects

Seventeen pellet-group transects were established during May 1990, 1 transect was established in October 1990 and 10 transects were established in June 1991 for a total of 28 pellet-group transects (Figure 4). Twenty-five of these transects were established in pinyon-juniper forest while only 3 transects were established in the blue grama rangeland.

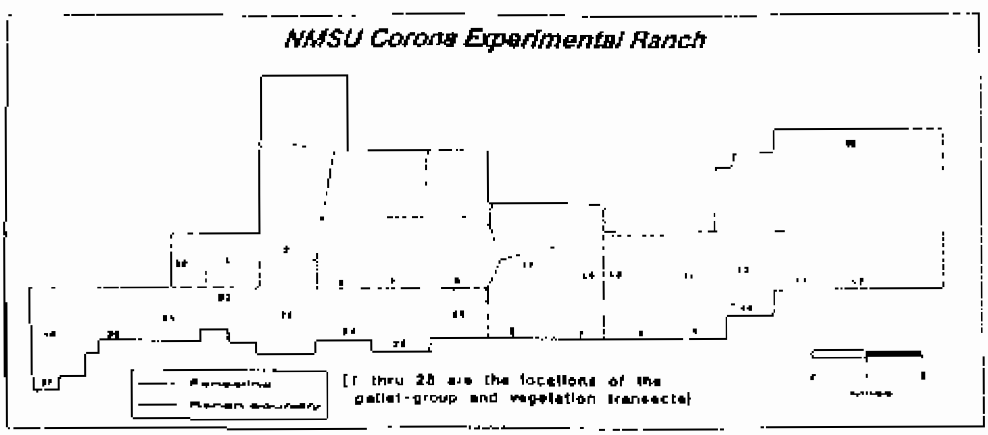

Figure 4. Locations of the pellet-group and vegetation transects established on the NMSU Corona Research Ranch between May 1990 and September 1991.

Data from transects were used to estimate densities of deer/259 ha (640 ac) for spring/summer and fall/winter periods. Densities from each transect were compiled and an overall mean deer/259 ha estimate for the sampled areas only was determined for each sampling period.

The starting point for each transect was established at least 30.5 m (100 ft) from the nearest road and 1.61 km (1 mile) from the nearest transect whenever possible. A 0.95 cm (3/8 in) diameter rebar stake 45.7 cm (18 in) in length, representing the transect starting point as well as the location of the first plot, was hammered into the ground at this point. A metal tag identifying the transect and plot number was attached to the stake which was spray-painted orange.

Directions of the transects were determined from the first stake by observing the direction of the sweep second hand of the installer's watch at the instant the installer's watch was observed. Directions were excluded which would cause the transect to leave the area being investigated. Nine additional stakes were installed along the bearing at 30.5 m (100 ft) intervals for a total of 10 plots for each transect.

Plot boundaries were delineated by the use of a 3.7 m (11' 9") chain representing the plot radius. A metal ring attached to the end of the chain was placed over the stake of each plot along a transect so that the extended chain circumscribed a 0.004 ha (0.01 ac) area for each plot. The plots were read by 1 observer walking along the edge of the plot, at the end of the extended chain, while the another observer positioned himself at the midpoint between the stake and the end of the chain. Both observers walked in a clockwise direction.

Pellet-groups on the transects were counted each October and April from October 1990 to April 1992. The number of pellet-groups counted in October were an index of mule deer densities during the spring/summer period. April pellet-group numbers were an index of the density for the fall/winter period. During counting, pellet-groups were painted with Nel-spot orange tree marking paint (Nelson Paint Co., Montgomery, Alabama) to "clear" groups from the plot and to prevent double counting. A minimum of at least 15 pellets was required to be considered a group. Additionally, at least one-half of the pellets in a group had to be within a plot to be counted.

Deer densities for each section were estimated using the standard formula derived by Rogers et al. (1958) (Figure 5). A defecation rate of 13 pellet groups per day was chosen as the average daily defecation rate (Neff 1968, Smith 1964). Standard errors and confidence intervals were also calculated from the pellet-group data (Lentner 1972).

DEER/SECTION FORMULA

$$N = \frac{(G)\ (x)\ (640)}{(d)\ \ (p)}$$ where:

N = deer per section d = defecation rate (13/day)

G = pellet groups per sample unit

x = reciprocal of the fraction of an area in the sample area.

640 = number of acres per section

p = period of pellet group accumulation (days)

Figure 5. Estimating the number of deer/section using a formula derived by Rogers et al. (1958)

Vegetation Transects

Vegetation transects were installed in September 1991. Two vegetation transects were installed at each of the 28 pellet-group transects by randomly selecting 2 of the 10 pellet-group plots on each transect. Plots 2 and 7 were used on each transect as determined from a random number table.

Random bearings on which transects would be established were selected using the installer's watch. A rebar stake representing the transect starting point was hammered into the ground on the bearing at a distance of 3.7 m (12 ft) from the pellet-group plot center. This distance was used to avoid any interference with the pellet-group plot. A metal tag that identified the transect was placed on the first stake. A second stake representing the transect end point was placed 30.5 m (100 ft) from the starting point on the bearing. Both stakes were painted orange. This was done at both plots yielding a total vegetation transect length of 61 m (200 ft) for each of the 28 transects.

The vegetation transects were read during September 1991. The line-point method devised by Pieper (1978) was used with an apparatus similar to that used by Howard (1966). The apparatus consisted of 2 conduit poles equipped with a snap swivel on the end of 1 and a gate spring and leather shoelace on the end of the other. The device was used to attach the ends of a 30.5 m (100 ft) steel tape, representing the transect, to the transect starting and end points. Points were marked at 30.5 cm (1 ft) intervals on the tape.

To record the plant species along each transect, an observer walked along the extended tape and called out to a recorder what lay beneath each point. The basal area of the plant lying below the tape had to intersect a line projected vertically through a transect point to be considered a "hit." Hits were recorded as a plant species, litter, or bare ground. Aerial cover also was determined at each point along the transect. Heights of trees and shrubs intersecting points along the transect were estimated to the nearest 15.24 cm (0.5 ft) and recorded.

Vegetation data were summarized, from the 56 vegetation transects examined (5600 points), into percent composition and percent cover by species and then vegetative group. Plant nomenclature followed Benson and Darrow (1954), Earle (1963), and Hitchcock (1971).

Observation/Trend Route

A 21.73 km (13.5 miles) observation/trend route (Figure 6) was established on the research ranch for deer

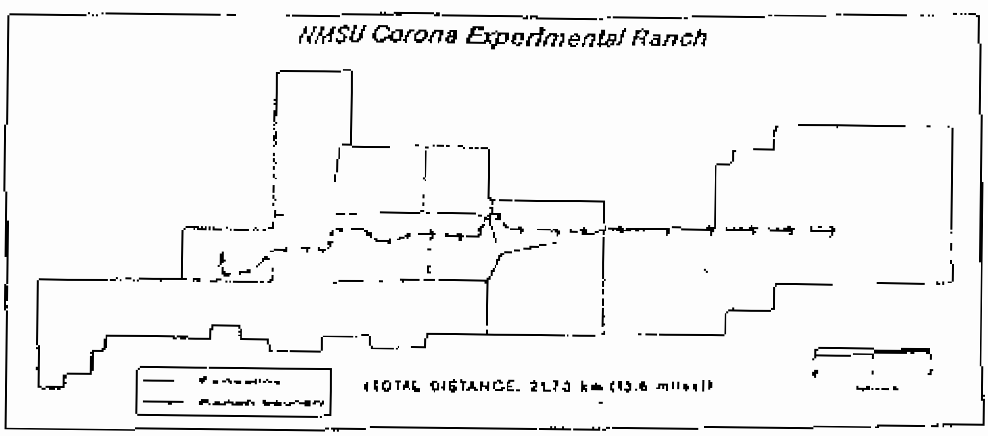

Figure 6. The observation/trend route established on the NMSU Corona Research Ranch in 1990.

observation purposes. The route chosen passes through each type of habitat identified on the research area. The purpose of the route is to observe the deer population during the breeding season, when male deer are most visible, in order to estimate sex ratio of the mule deer population. Dasmann and Taber (1956) reported that sex and age-class counts were most accurate during the mating season when deer are in family groups and no single age-class or sex is unusually conspicuous or retiring. Bowden et al. (1984) also found the mating season to be the only time of the year when an accurate count could be taken.

The route was driven during the early morning and late evening hours when mule deer are most active and visible. The route was driven at a slow rate of speed, approximately 32 kph (20 mph), to maximize the possibility of observing all deer located along the route. Deer were observed with the naked eye or with 10 X 50 Tasco wide angle binoculars when the classification of the observed deer was uncertain. The sex, age (adult or fawn), and location of each deer observed was recorded. The route was driven 4 times, 2 evening and 2 morning routes, for both mating seasons that occurred during this study. A prehunt and posthunt survey was not deemed necessary for this study due to the minimal hunting pressure on the study area population. Observations were compiled from both seasons and a simple doe:fawn:buck ratio was determined.

Home Range

Ten adult female mule deer were trapped using modified Clover traps (Howard and Engelking 1974) or immobilized by darts, injecting succinylcholine chloride (Sucostrine, Sqibb), shot from a pneumatic dart gun, and radio-collared; however, the summer and winter home range sizes of only 4 of these does were determined for this study due to time limitations. Dosage rates were similar to those recommended by Jacobsen et al. (1976) and Miller (1968). Modified Clover traps were set-up on several sites (Figure 7) in an attempt to radio-collar does from

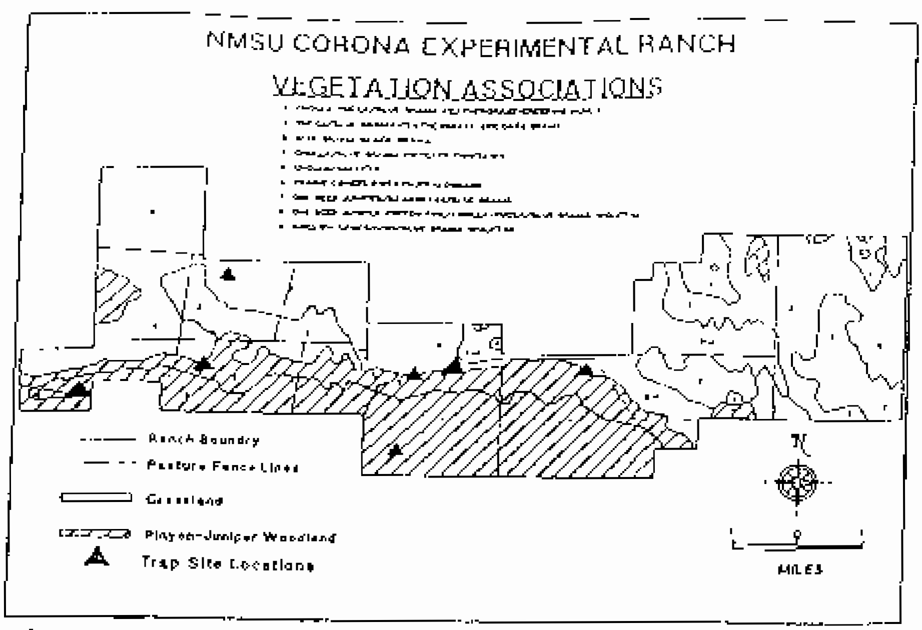

Figure 7. Locations of the sites selected to trap deer on the NMSU Corona Research Ranch during the 1991 trapping season (March to May) and the 1992 trapping season (March).

all habitats located on the research area.

All 10 does were equipped with pulsed signal transmitters (Telonics model MOD-500) with a life span of 27 months. Transmitters were attached to a composite collar that was fitted around the neck of the deer. Each deer also was fitted with an ear tag inscribed with an identification number. Bucks caught in the modified Clover traps were equipped with an ear tag and released or simply released.

The 4 does used for this study were located a minimum of 24 times each during the summer period, June through September, as well as the winter period, January through March. At least 1 location was recorded for each hour of the 24-hour cycle. A light-weight Telonics receiver (model TR-2E), a hand held-antenna, and Silva compass were used to determine bearings from positions that could be identified on a topographic map and the Universal Transverse Mercator (UTM) coordinates for those positions was determined as well. All positions were located a minimum of .80 km (0.5 miles) apart. Telemetry precision and accuracy was not determined since the focus of this study was to estimate home range size and not to identify specific habitat use.

Two readings were used to calculate a single position. Three readings were not used for this study due to the problems associated with the use of error polygons (Nams and Boutin 1991). Only those positions taken from readings that were separated by at least 30 degrees were used to estimate home range size.

A program written by White and Garrott (1990) with the computer software SAS was used to estimate locations of does using the bearings and the UTM coordinates of the positions from which the bearings were derived. The locations estimated for each deer were then applied to the computer software McPaal (Stuwe 1988) used for the analysis of animal locations and home range size. McPaal allows the user to choose from 4 types of home range size estimates: (a) minimum convex polygon, (b) concave polygon, (c) 95% ellipse, and (d) harmonic mean transformation.

The harmonic mean transformation method of estimating home range size (Dixon and Chapman 1980) was chosen over the minimum convex polygon method because of its ability to eliminate outlying points that can result in an overestimate of an animal's home range size. The harmonic mean method also identifies high use activity areas that cannot be identified using the minimum convex polygon method.

Summer and winter home range sizes from radio-collared does were statistically compared to determine if significant differences existed between summer and winter home range sizes.

Age and Morphological Characteristics

A fee-hunting operation has been in existence on the NMSU Research Ranch since 1989. Harvested deer are brought through a check station where an incisor (I_1) is removed and body and antler measurements are taken. A total of 52 deer were processed for this study.

Aging

Counting the number of cementum annuli from an incisor of each harvested deer was the method used to determine the age of each animal. Thomas and Bandy (1973) and Erickson and Seliger (1969) found this method to be reliable for determining the age of black-tailed deer and mule deer, respectively.

This method consists of cutting 3 thin layers, 0.2 mm (0.008 in) thick, from each incisor using an Isomet low-speed saw (Buehler Ltd., Evanston, Illinois). Tooth sections were then processed by soaking them in xylene for 5 minutes to remove or dissolve chemical residue remaining on the sections. Sections were then soaked in a 70% solution of formic acid for 10 minutes for decalcification, rinsed in distilled water, and passed through 2 solutions of 70% isopropyl alcohol for dehydration purposes. Sections were checked for any remaining residues.

Sections were stained in a solution of toluidine blue dye. Excess dye was removed by dipping each section first in isopropyl alcohol and then into distilled water. Stained sections were placed on a microscope slide with 2 drops of water and a cover slip placed over them. Sections were viewed under a Olympus BH2 10 X 20L power light microscope and the cementum annuli counted.

Since the first incisor (I_1) in mule deer becomes permanent at 1 year of age, deer ages were determined by adding 1 to the number of annuli counted.

Body and Antler Measurements

Body and antler measurements were taken from each of the harvested deer. The body measurements recorded consisted of total length, body length, shoulder height, neck circumference, chest girth, and hind foot length. Antler measurements consisted of right and left antler basal circumference, the number of points on the right and left antlers, right and left antler height, tip to tip distance, and inside main beam distance.

A mean for each measurement according to age-class was determined. Correlation analysis was used to determine if relationships existed between age and antler and body measurements.

Statistical Analysis

Deer/259 ha estimates were determined for each transect for each sampling period. These estimates were then summarized for each sampling period and an overall deer/259 ha estimate was determined for the areas sampled. The mean deer/259 ha estimate was multiplied by the number of transects read to estimate population size for the sampled areas.

Mean deer/259 ha estimates for the sampled areas were used to evaluate the hypothesis that fall/winter densities are different from spring/summer densities. An Analysis of Variance (ANOVA) (Lentner 1972) was conducted on the deer densities to determine if differences exist between the means of the 4 sampling periods. The statistic used to determine how different the densities were was p, the probability that a detected significant difference was, in reality not different. A p value less than 0.05 indicated a significant difference.

An exploratoy multiple regression was conducted to determine if a relationship exists between deer density and vegetative composition (bare ground, litter, grasses, forbs, cacti, shrubs, and canopy cover). A t-test was conducted on each vegetation variable using the Univariate procedure in SAS ($p < 0.05$).

The complete linkage clustering method (Romesburg 1984) was used to analyze vegetative similarities across the sampled areas. The cluster analysis grouped transects according to their vegetative composition. An Analysis of Variance (ANOVA) was then used to determine if differences exist between the means of each vegetation variable within the resulting clusters ($p < 0.05$).

A t-test ($p < 0.05$) was used to test the hypothesis that summer and winter home range sizes are different. Relationships between age and antler and body measurements were examined using Pearson correlation coefficients (Neter et al. 1989).

RESULTS AND DISCUSSION

Pellet-Group Transects

Pellet-group data were collected from 17 transects in October 1990, 18 transects from April 1991, and 28 transects in October 1991 and April 1992 (Table 2).

Table 2. Deer densities/259 ha for the 1990 & 1991 spring /summer sampling periods and the 1991 & 1992 fall/winter sampling periods on the NMSU Corona Research Ranch.

Date	n	est. deer/ 259 ha*	95% conf. interval	est. popn.*	95% conf. interval
10/90	17	23	14 to 33	398	235 to 561
4/91	18	27	19 to 36	491	338 to 644
10/91	28	32	22 to 43	901	603 to 1199
(excluding trans. No. 12)	27	28	20 to 37	777	540 to 999
4/92	28	27	20 to 33	742	570 to 914

*Estimates are for sampled areas only. They do not represent the entire research area.

The overall deer/259 ha estimate excluding transect 12 for the October 1991 reading was used due to a natural occurrence that resulted in an overestimate of the number of deer for the section where transect 12 is located. The first 4 plots of transect 12 are located in the bottom of a natural depression. The unusually heavy rainfall that the area received, during the spring and summer period of

1991, washed pellets from the surrounding hillsides into the depression where the first 4 plots are located.

This resulted in 38 pellet-groups being counted on the first 4 plots while the remaining 6 plots on the transect had no pellet-groups, new or old. The estimated number of deer for this 259 ha area during this period was 124. Using the estimate that excludes transect 12 results is a more reliable overall deer/259 ha estimate for this period.

Deer densities were slightly higher during the fall/winter period of 1990-91 (27 deer/259 ha) than the spring/summer period of 1990 (23 deer/259 ha). Density estimates from the 1991 spring/summer period and the 1991-92 fall/winter period were nearly identical with 28 deer/259 ha and 27 deer/259 ha, respectively. Deer/259 ha estimates for these 4 sampling periods were not significantly different ($p > 0.05$). The large increase in the estimated deer population for the last 2 sampling periods was a result of increasing the size of the sampled area from 4662 ha to 7252 ha.

The difference in densities between the 1990 spring/summer period and the 1990-91 fall/winter period could be the result of a winter migration, however; migration of deer onto the research site probably is not a reasonable explanation due to the areas somewhat isolated location from higher elevations of 2745 m (9000 ft) or higher.

The Capitan Mountains, the nearest mountain range to the research site, are located approximately 72 km (45 miles) south of the research area and it is unlikely that deer are migrating from this area to the research site. Mule deer migration studies done by Zalunardo (1965) and Bartmann and Steinert (1981) found that mean migration distances of mule deer in Colorado were 29.77 km (18.5 miles) and 33 km (21 miles), respectively.

Deer on the research area more than likely do not have a winter migration. Bartmann and Steinert (1981) found that Colorado mule deer that spend the summer in high elevations, 2745 m (9000 ft) or higher, tend to winter at elevations of 1675 to 2285 m (5550-7550 ft), while deer that spend the summer at the lower elevations do not normally migrate. The mean elevation of the research area is 1860 m (6100 ft).

Elevation of the research area and isolation from higher elevations are probably the best explanations for the absence of a winter migration, hence; the statistically insignificant change in population density between the 4 sampling periods.

Mule deer densities have not been determined for the grassland areas of the research ranch. Twenty-five of the 28 pellet-group transects are located in the pinyon-juniper ecotone. Exclusion of the grassland areas may be inflating or deflating the deer density estimates. Pellet-group transects need to be established in the grassland areas if a reliable deer/259 ha estimate is to be determined for the *entire* research area. Seasonal population shifts between the pinyon-juniper and grassland ecotones also can be determined when the deer densities of the grassland areas are examined.

Sources of Error

The pellet-group population estimate technique has certain discrepancies associated with it. Human error associated with plot size, fatigue, and vegetative cover all have an effect on pellet-group count results. Smith (1968) found that observer error decreased with smaller plot size and that statistical efficiency was directly related to plot size and shape. To minimize observer error, 2 observers were used when reading the transect plots and observations stopped when 1 or both observers became fatigued. Two observers can efficiently cover the .004 ha (.01 ac) plot used for this study. The use of 2 observers also minimized any error due to vegetative cover.

Other types of human error associated with pellet-group transect readings include counting old pellet groups missed from previous readings, counting groups previously painted from which the paint had disappeared, counting groups that may have been moved into the plot from outside, and not counting groups which were deposited inside but were moved outside the plot (Mello 1977).

Ferguson (1955) stressed the importance of pellet-group destruction by biological agents, particularly insect activity. The extent of this kind of destruction for this study could not be determined, however field observations indicated that this type of loss was minimal.

Defecation rates also can have an effect on deer density estimates. Sex, age, season of the year, and type of vegetation consumed can have an effect on the number of pellet-groups a mule deer will defecate in a 24-hour period. Dasmann and Taber (1955) found that defecation rates changed for black-tailed deer in California during different seasons of the year due to the type of herbaceous forage available. Rogers et al. (1958) found that mule deer defecation rates also changed during different seasons of the year. Smith (1964) found that defecation rates of fawns were much higher than those of yearlings and adults.

Vegetation Transects

The 5600 points examined along the 56 vegetation transects resulted in the identification of 15 grass species, 28 forb species, 5 cactus species, 6 shrub species, and 2 tree species (Refer to Appendix A for a complete list of common and scientific names). The dominant grasses and forbs are listed in Table 3.

Bare ground and litter made up 66% of the ground cover composition (Figure 8) illustrating the sparse distribution of the ground cover vegetation found throughout most of the research area. Bare ground and litter made up as much as 83% of the ground cover composition of transects located in areas with dense stands of pinyon-juniper. Strait (1991) found similar bare ground percentages in dense stands of pinyon-juniper on study sites in the Gila National Forest. Pinyon and juniper trees are capable of reducing or eliminating understory production through mechanisms including shade, phytotoxic root exudates, litter, and precipitation interception (Jameson 1966).

Table 3. Percent composition of grasses and forbs identified from September 1991 readings of the vegetation transects on the NMSU Corona Research Ranch.

COMMON NAME	% composition of overall ground cover	% composition within specific vegetation category
Grasses		
Blue grama	7%	34%
Wolftail	7%	31%
Sideoats grama	2%	8%
Hairy grama	2%	8%
Black grama	1%	7%
Three awn	1%	6%
Sand dropseed	0.5%	3%
(8 other species combined)	0.5%	3%
Total	21%	100%
Forbs		
Spurge	4%	38%
Lemonweed	1%	16%
Greenthread	0.5%	6%
Broom snakeweed	0.5%	6%
Prairie sunflower	0.4%	5%
Trailing four o'clock	0.3%	4%
(22 other species combined)	3.3%	25%
Total	10%	100%

Canopy cover occurred on 896 of the 5600 points examined for an overall canopy cover of 16% for the sampled areas. Canopy cover was as high as 40% for the transects located in the dense stands of one-seed juniper. The mean tree heights for one-seed juniper and pinyon pine were 3.35 m (11 ft) and 2.90 m (9.5 ft), respectively. One-seed juniper was the dominant tree

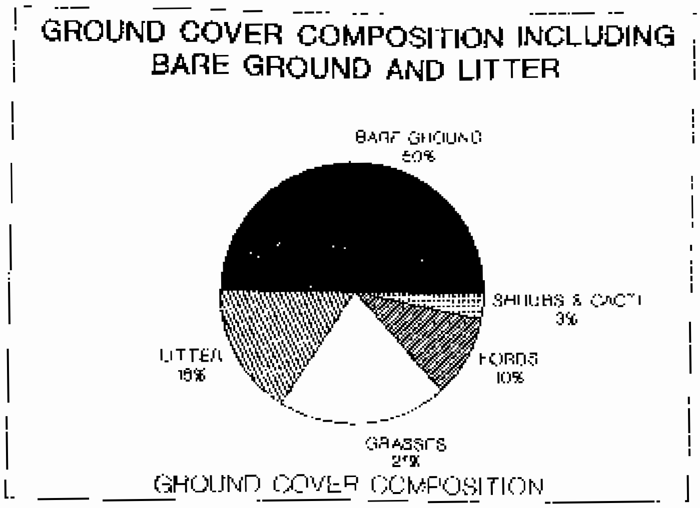

Figure 8. Ground cover composition determined from the 1991 readings of the vegetation transects on the NMSU Corona Research Ranch.

species while pinyon pine made up only a small percentage.

Total vegetative cover, canopy cover and ground cover vegetation combined, was 50%. Grasses were the dominant vegetative category at 41% with trees, forbs, cacti, and shrubs at 31%, 20%, 6%, and 2%, respectively (Table 4). The dominant cactus species were banana yucca (Yucca baccata) and prickly pear (Opuntia spp.). Shrub species consisted primarily of Gambel's oak (Quercus gambelii) and range ratany (Krameria parvifolia).

Table 4. Percent composition of each vegetative category determined from 1991 readings of the vegetation transects on the NMSU Corona Research Ranch.

CATEGORY	% of total vegetative cover	% composition of 5600 points examined
Grass	41%	21%
Trees (canopy cover)	31%	16%
Forbs	20%	10%
Cactus	6%	3%
Shrubs	2%	1%

Statistical Analysis of Vegetation and Mule Deer Densities

No relationship was found between mule deer densities and vegetative composition ($R^2 = 0.30$, $p > .05$) (Appendix C). However, 6 of the 7 independent variables had p values of 0.08 or less indicating that each variable, except canopy cover ($p > 0.10$), was not independent in the presence of the other variables. Therefore, independent t-tests were conducted on each vegetation variable resulting in p values of less than 0.05 for all 7 variables (bare ground, litter, grasses, forbs, shrubs, cacti, and canopy cover).

These results suggest that even though the regression model is not useful in predicting mule deer densities, relationships may exist between the different vegetative components of the pinyon-juniper ecotone. These relationships more than likely do have an effect on deer densities, but continued research is needed to determine how these relationships effect the mule deer population. The model is also being effected by the bias created by sampling primarily the pinyon-juniper ecotone within the research area. Relationships between deer density and vegetative composition can be correctly modeled only when all vegetative types on the research area are examined. Future research projects must include the open grassland areas of the research area.

Results from the Pearson correlation coefficient analysis (Appendix C) revealed a strong positive correlation ($r = 0.92$) between canopy cover and litter, and a strong negative correlation ($r = -0.71$) between grass and litter and between grass and canopy cover ($r = -0.66$). Litter and canopy cover also were negatively correlated with the additional vegetative categories as well. These relationships indicate that as canopy cover increases ground cover decreases. These relationships are typical of a pinyon-juniper ecotone. Strait (1991) and Cosper (1989) found similar results in pinyon-juniper habitats examined in the Gila National Forest.

Cluster analysis (Appendix C) placed the 28 transects into 1 of 3 distinct categories (Table 5). Trees were the dominant vegetative type of the 13

Table 5. Cluster analysis of the vegetative composition of the 28 transects, from the 1991 readings, on the NMSU Corona Research Ranch. Transects were placed into 3 distinct categories according to their vegetative composition.

CLUSTER 1

Transect*	Bare	Litter	Grass	Forb	Shrub	Cactus	Tree
1	.58	.21	.14	.07	0.00	0.00	.35
9	.54	.29	.01	.13	0.00	.01	.31
3	.47	.40	.10	.02	0.00	.01	.39
8	.47	.34	.13	.05	0.00	.01	.37
27	.47	.30	.15	.06	0.00	.02	.40
6	.36	.33	.21	.10	0.00	0.00	.36
14	.45	.29	.18	.04	.04	0.00	.29
17	.41	.28	.10	.14	0.00	.07	.30
5	.46	.28	.13	.09	0.00	.04	.17
16	.49	.27	.17	.06	.01	0.00	.20
23	.51	.16	.24	.08	.01	0.00	.20
24	.49	.21	.26	.02	0.00	.02	.19
15	.27	.24	.22	.18	.01	.08	.27

CLUSTER 2

Transect*	Bare	Litter	Grass	Forb	Shrub	Cactus	Tree
4	.41	.09	.20	.28	.01	.01	.09
7	.42	.12	.13	.33	0.00	0.00	.01
26	.49	.04	.21	.25	0.00	.01	0.00

CLUSTER 3

Transect*	Bare	Litter	Grass	Forb	Shrub	Cactus	Tree
10	.55	.05	.36	.01	.01	.02	.04
21	.51	.05	.37	.06	.01	0.00	0.00
19	.51	.10	.31	.05	0.00	.03	.04
13	.58	.01	.30	.02	.01	.08	0.00
22	.60	.05	.31	.04	0.00	0.00	.04
20	.45	.09	.36	.09	.01	0.00	.08
11	.62	.09	.20	.07	0.00	.02	.12
25	.58	.10	.22	.10	0.00	0.00	.10
18	.58	.08	.17	.07	.02	.08	.07
12	.55	.01	.26	.18	0.00	0.00	0.00
28	.49	.03	.27	.18	.01	.02	0.00
2	.43	.09	.27	.19	.01	.01	.09

MEANS

	Bare	Litter	Grass	Forb	Shrub	Cactus	Tree
Cluster 1	.47	.28	.16	.08	.005	.01	.29
Cluster 2	.44	.08	.18	.29	.004	.006	.03
Cluster 3	.55	.06	.29	.08	.007	.02	.04

* total cover may exceed 100% due to the inclusion of ground and canopy cover.

transects placed in cluster 1. Bare ground and litter made up as much as 83% of the ground cover on the transects placed in cluster 1. Forbs were the dominant vegetation type of the 3 transects in cluster 2. These transects had very little canopy cover and bare ground and litter made up approximately 52% of the ground cover. Grasses were the dominant vegetation type of the 12 transects placed in cluster 3. These transects had very little canopy cover and bare ground and litter made up 52 to 71% of the ground cover.

The results of the ANOVA found bare ground, litter, grasses, forbs, and trees all to be significantly different between the 3 clusters ($p < 0.05$). Shrubs and cactus were not significantly different between the 3 clusters ($p > 0.05$).

Multiple comparisons of the cluster means were made using the Least Squared Mean procedure in SAS. The presence of trees is the reason for the difference in the amount of litter present on the transects in cluster 1 as compared to clusters 2 and 3 ($p < 0.001$). As canopy cover increases, so does the amount of litter. The high percentage of forbs in cluster 2 is the result of disturbances to these 3 transects. Each of these areas were disturbed by burning or clearing of the pinyon-juniper overstory. The high percentage of grasses found on the transects in cluster 3 as compared to clusters 1 and 2 ($p < 0.001$) is due to the small percentage of litter and trees found on these transects. Grasses were negatively correlated with trees ($r = -0.66$) and litter ($r = -0.71$).

Observation/Trend Route

A total of 273 (approximately 35% of the estimated population) deer were observed along the observation/trend route during the 1990-91 breeding season. The herd composition was 41% does (112), 28% bucks (76), and 31% fawns (84). The ratio of fawns and bucks per 100 does observed was 100:75:68 (does:fawns:bucks). These ratios are probably not affected by seasonal fluctuations since migration into and out of the area appeared to be minimal or nonexistent.

The doe-fawn ratio (1:0.75) indicates a fawn crop of 75% was surviving during early winter. The 1991 doe:fawn:buck ratio for state unit 38, which includes the research area, is much lower at 100:64:24, indicating a fawn crop of 64%[2]. The differences in the doe:buck ratios can be attributed to the minimal amount of hunting

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[2]D. Waybright, [Personal communication]. New Mexico Department of Game and Fish, Santa Fe, N.M.

pressure that the research ranch population experiences. The mule deer population in the Sacramento Mountains which is heavily hunted had a post-hunt doe:buck ratio of 100:16 or 6 does for every buck (Mello 1977). Doe:buck ratios of 14:1 have been observed from heavily hunted mule deer populations where few or no does are taken (Taylor 1961).

Only 127 deer were observed during the 1991-92 mating season with a herd composition of 46% does (58), 32% fawns (41), and 22% bucks (28). The number of fawns and bucks per 100 does was 100:71:48 (does:fawns:bucks). However, these numbers are given only as a reference since the sample size was deemed inadequate to make a reliable estimate.

Home Range

Twenty-five deer were captured during the first trapping season (March 1991 to May 1991) while 12 were captured during the second trapping season (March 1992) for a total of 37 deer. Only 6 (16%) of the 37 deer trapped were does. The reason for the high percentage of bucks (84%) being trapped as opposed to does is not known. Out of 256 mule deer captured by Garrott and White (1982) using modified Clover traps with altered door heights and different baiting strategies 64% were does and 36% bucks. Five of the 31 bucks that were captured were fitted with a colored ear tag and released, the other 26 were simply set free.

Four does were immobilized with succinylcholine chloride injected by an automatic projectile syringe shot from a pneumatic dart gun. Animals collapsed within 4 to 7 minutes after being injected. Recovery times were determined for 3 of the does injected and averaged 40 ± 5 minutes.

Table 6 contains summer and winter home range

Table 6. 1991 summer and 1992 winter home range sizes of 4 does on the NMSU Corona Research Ranch.

DEER IDENTIFICATION	SUMMER	WINTER
ONE-RED	2.95 sq km	2.45 sq km
TWO-BLACK	2.96 sq km	1.89 sq km
THREE-RED/GREEN	1.37 sq km	0.74 sq km
FOUR-BLACK/WHITE	1.58 sq km	0.98 sq km

(COLOR DESIGNATION DENOTES COLOR OF RADIO-COLLAR)

sizes of the 4 does examined for this study. Summer home range size was significantly larger than winter home range size ($t = 5.54$, $df = 3$, $P < 0.05$) although it must be stressed that sample size was small ($n = 4$).

Summer home range sizes for individual does ranged from a high of 2.96 sq km (296 ha) to a low of 1.37 sq km (137 ha). Winter home range sizes ranged from a high of 2.45 sq km (245 ha) to a low of 0.74 sq km (74 ha) (Appendix B). Winter home range sizes were 17% to 46%

smaller than summer home range sizes. Kufeld (et al. 1988) found that summer and winter home range sizes of mule deer in Colorado, found at an elevation of approximately 1646m (5400 ft), ranged from 1.17 sq km (117 ha) to 3.23 sq km (323 ha).

Summer and winter home ranges overlapped for all 4 does (Appendix B). Fifty to 80% of the winter home range was contained within the boundaries of the summer home range. This illustrates the strong affinity does have for a particular area that obviously meets all their survival requirements.

Age and Morphological Characteristics

Age Structure

The age structure of 52 male mule deer that were harvested during the 1989, 1990, and 1991 hunting seasons, determined by cementum annuli analysis, was dominated by 3 year-olds that comprised 48% (n = 25) of the deer taken (Figure 9). One (n = 2) and 2 (n = 10) year-olds made up 23% of the deer harvested with 4 (n = 8), 5 (n = 4), 6 (n = 2), and 8 (n = 1) year-olds making up the remaining 29%.

Three through 8 year-olds made up 77% of the deer harvested suggesting that the age structure of the male deer are dominated by the older age classes. However, the

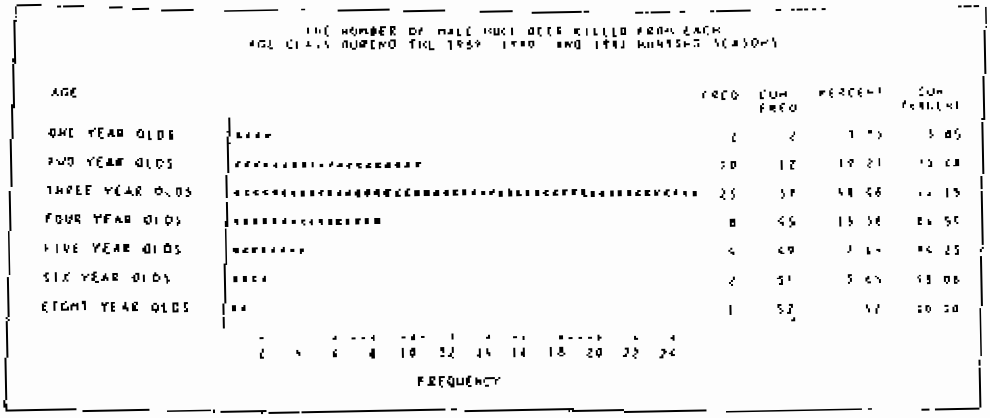

Figure 9. Frequency and percent of each age class harvested from the 1989, 1990, and 1991 hunting seasons on the NMSU Corona Research Ranch.

small number of 1 and 2 year-olds should not be misinterpreted as an indication of the size of these age classes. Hunters were allowed to take only those deer that had at least one forked antler. This regulation and the fact that these hunters were hunting in an area with high deer and low hunter densities allowed for larger antlered (older) bucks to be harvested. Also, the doe:fawn ratio of 100:75 suggest that production on the research area is high. A larger data base is needed before any trends or conclusions can be made about the male age structure of this population.

Body and Antler Measurements

Mean body and antler measurements for each age class are given in Tables 7 and 8. Antler and body measurements appear to increase with age; however, the trend towards

Table 7. Means of the six body measurements taken from hunter killed deer during the 1989, 1990, and 1991 hunting seasons on the NMSU Corona Research Ranch.

AGE (years)	N	($\bar{X}$) Total Length	($\bar{X}$) Body Length	($\bar{X}$) Shoulder Height	($\bar{X}$) Neck Cir.	($\bar{X}$) Chest Girth	($\bar{X}$) Hind Ft. Length
1989							
1	2	66.52	61.25	35.07	15.13	35.88	18.63
2	3	69.22	62.58	37.21	15.54	36.68	18.72
3	4	68.94	62.63	37.25	15.45	35.41	18.75
4	2	70.25	65.39	37.50	16.13	39.39	19.13
5	3	67.13	62.33	36.81	17.43	38.38	17.84
6*	1	68.00	60.25	40.50	17.00	39.25	19.00
Total	15						
1990							
2	5	69.24	63.60	37.35	17.53	38.48	19.03
3	9	74.72	68.14	37.88	18.99	39.83	19.29
4*	1	77.00	71.00	38.25	21.75	43.00	19.25
Total	15						
1991							
2	2	64.38	58.13	33.38	18.91	38.50	16.13
3	9	78.03	71.69	42.35	21.75	43.52	21.25
4	5	67.53	61.25	39.03	20.23	40.38	18.46
5*	1	57.00	52.00	33.65	15.25	33.25	17.75
6*	1	71.00	66.00	40.50	17.25	40.91	19.00
8*	1	74.5	67.00	39.50	21.50	39.50	17.50
Total	19						

* - Indicates a sample size of one. Does not represent a mean.

Table 8. Means of the 8 antler measurements taken from hunter killed deer during the 1989, 1990, and 1991 hunting seasons on the NMSU Corona Research Ranch.

AGE (years)	N	($\bar{X}$) Rt. Ant. Cir. (in.)	($\bar{X}$) Lt. Ant. Cir. (in.)	($\bar{X}$) Rt. Ant. Points	($\bar{X}$) Lt. Ant. Points	($\bar{X}$) Inside M. Beam	($\bar{X}$) Tip to Tip	($\bar{X}$) Rt. Ant. Height	($\bar{X}$) Lt. Ant. Height
1989									
1	2	2.82	2.89	3.50	3.50	12.89	10.00	13.07	12.57
2	3	3.43	3.30	3.00	3.67	16.59	13.42	14.58	14.71
3	4	3.01	2.98	3.00	3.25	13.42	11.41	12.54	12.89
4	2	3.45	3.32	3.00	3.50	19.00	18.00	15.00	15.33
5	3	3.88	3.93	4.67	4.67	20.00	17.46	17.75	17.79
6*	1	4.00	4.13	5.00	5.00	18.00	12.65	16.25	16.13
Total	15								
1990									
2	5	3.20	3.16	4.00	3.40	14.53	13.63	13.90	14.13
3	9	3.61	3.59	4.44	4.11	16.75	14.58	16.36	16.23
4*	1	4.00	4.00	4.00	4.00	18.50	16.25	16.50	15.00
Total	15								
1991									
2	2	3.38	3.39	3.50	4.00	17.94	17.94	13.33	13.02
3	9	4.26	4.23	4.67	4.56	18.26	16.68	18.60	18.81
4	5	4.29	4.18	4.80	4.20	19.55	16.03	18.98	18.92
5*	1	3.00	2.91	3.00	2.00	16.75	13.50	13.75	14.50
6*	1	3.75	3.91	4.00	5.00	17.13	16.25	15.50	15.75
8*	1	5.25	5.00	5.00	4.00	21.00	13.50	19.25	19.75
Total	19								

* - Indicates sample size of one. Values do not represent a mean.

larger body measurements is not as obvious as the trend towards larger antler measurements.

The Pearson correlation coefficients between age, antler and body measurements are listed in Table 9. The data from all 3 years were combined for each age class. Moderate to high correlation values, ranging from r = 0.36 to r = 0.79, existed between neck circumference and all eight antler measurements. Chest girth and shoulder height also was highly correlated with antler size. Right and left antler circumference was highly correlated to age (r = 0.70). These correlations suggest that antler size is increasing with age and body size.

These results should be viewed as preliminary results only since the sample size for this study was extremely small (n = 49). Also, when working with hunter harvested-deer, bias is most certainly introduced into the sample. Much more data is needed before any conclusions or predictions can be made about the morphological trends of males in this population.

Table 9. Pearson correlation coefficients for age, antler and body measurements taken from deer harvested during the 1989, 1990, and 1991 hunting seasons on the NMSU Corona Research Ranch.

	AGE	TL	BL	SH	NC	CG	HFL	RAC	LAC	RAP	LAP	IMB	TTT	RAH	LAH
AGE	1.00	.09	.05	.42	.28	.19	.13	.70	.69	.49	.31	.63	.21	.55	.62
TL		1.00	.99	.74	.67	.81	.62	.56	.57	.45	.49	.30	.03	.53	.44
BL			1.00	.70	.63	.81	.65	.49	.51	.39	.46	.28	.10	.50	.41
SH				1.00	.51	.73	.71	.66	.70	.65	.63	.40	.004	.68	.67
NC					1.00	.81	.19	.79	.79	.68	.38	.66	.36	.76	.66
CG						1.00	.49	.65	.69	.62	.67	.57	.44	.68	.56
HFL							1.00	.08	.10	.19	.16	.05	.13	.27	.23
RAC								1.00	.99	.78	.53	.84	.26	.91	.89
LAC									1.00	.84	.64	.80	.23	.90	.57
RAP										1.00	.68	.58	.08	.84	.79
LAP											1.00	.42	.19	.52	.45
IMB												1.00	.68	.53	.82
TTT													1.00	.32	.31
RAH														1.00	.97
LAH															1.00

<u>LEGEND</u>

AGE- AGE CLASSES
TL- BODY LENGTH AND TAIL
BL- BODY LENGTH
TTT- TIP TO TIP
SH- SHOULDER HEIGHT
NC- NECK CIR.
CG- CHEST GIRTH
RAH- RT. ANT. HEIGHT
HFL- HIND FOOT LENGTH
RAC- RIGHT ANT. CIR.
LAC- LEFT ANT. CIR.
LAH- LEFT ANT. HEIGHT
RAP- RIGHT ANT. LENGTH
LAP- LEFT ANT. LENGTH
IMB- INSIDE MAIN BEAM

Fee-Hunting Operation

Hunter success rate for the three hunting seasons ranged from a low of 85% (17/20) in 1989 to a high of 95% (19/20) in 1990 (Figure 10). Overall success rate for the

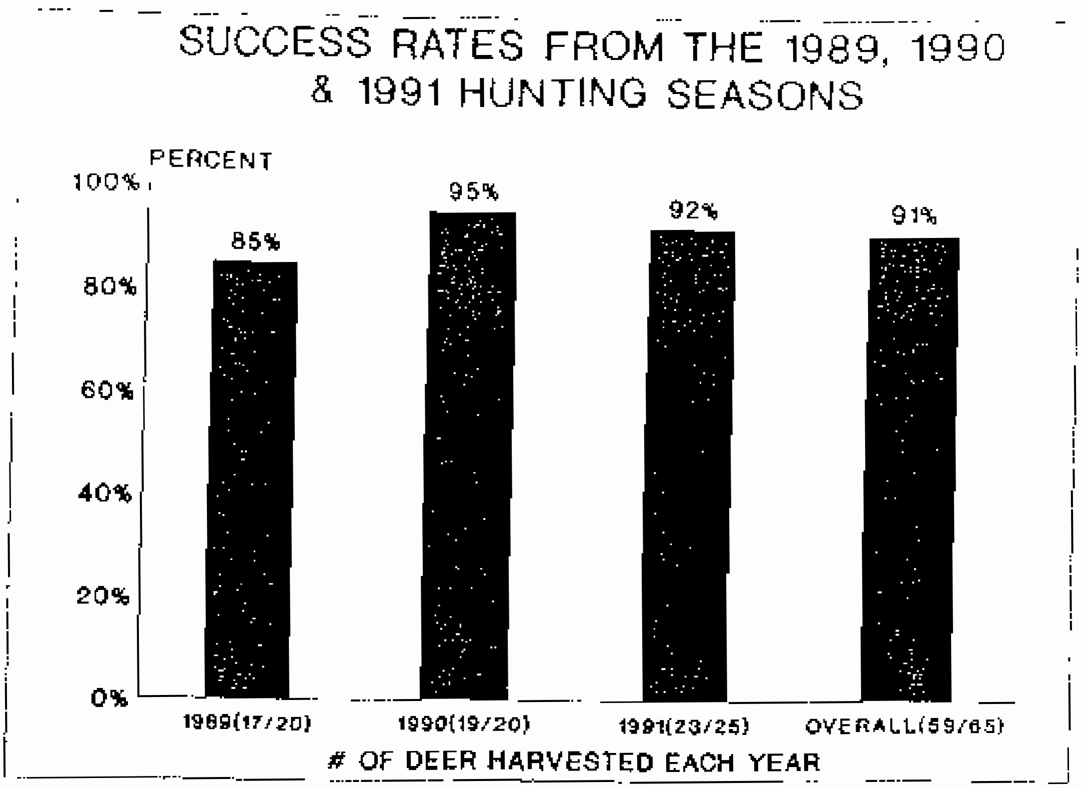

Figure 10. Hunter success rates and number of deer taken from the 1989, 1990, and 1991 hunting seasons on the NMSU Corona Research Ranch.

three seasons was 91% (59/65). These success rates are well above the highest overall state success rate, for three seasons, of 29% for the 1989 hunting season (New Mexico Game and Fish Dept 1989).

Twenty permits were sold in 1989 and 1990 and increased to 25 permits in 1991. Hunters paid $600.00 per permit resulting in $12,000 of income generated in 1989 and 1990 and $15,000 generated in the 1991 season. Total income generated from the fee-hunting operation to date is $39,000.

RECOMMENDATIONS

It can not be overemphasized that the main objective of this study was to create a data base for future research projects. No solid conclusions can be made from the data collected thus far, but recommendations as to the direction of future research needs, other than those already scheduled, and management practices can be made from the results of this study.

To determine if the effects of modifications to the pinyon-juniper habitat are detrimental or beneficial to the mule deer population, research efforts by the Fishery and Wildlife Sciences Department and the Animal and Range Sciences Department must be coordinated. The research ranch represents a unique opportunity to conduct research that can be used to develop a pinyon-juniper habitat modification model for private landowners, as well as government agencies, who want to increase their income by harvesting deer and improving grazing conditions on their land.

Research is needed to determine the effects that different stocking levels of cattle have on the deer population. Intense cattle grazing can have negative effects on deer populations through competition for forage species and social incompatibility (Skovlin et al. 1968). Bowyer and Bleich (1984) found that intense cattle grazing reduced or eliminated important forage species used by mule deer and reduced dense patches of vegetation used as cover during the fawning period.

The effects that water development projects, currently taking place on the research site, will have on the mule deer population need to be documented. These projects will more than likely have a positive effect on the deer population, but research is needed to support this. Deer densities on the Fort Stanton Research Area increased when permanent water sources were developed in areas which had little or no free water (Wood et al. 1970).

If a sustainable management plan is to be developed for the mule deer population, relationships between deer densities and vegetation must be determined. These relationships can only be determined when all of the vegetation types found on the research area are sampled. Presently, only 3 (11%) of the pellet-group transects are located in the grassland areas of the research ranch. Pellet-group transects need to be established in the remaining grassland areas of the research ranch. The GIS data base created by the Animal and Range Sciences Department for the research area can be used with wildlife data to determine habitat preference and composition.

Research projects planned for the future will help create a sustainable management plan for the mule deer population, but it is important that research projects for other wildlife species that exist on the research area be developed. Habitat modifications must take into consideration other wildlife species besides mule deer. Species of interest include hognose skunk (Conepatus leuconotus), gray fox (Urocyon cinereoargenteus), badger (Taxidea taxus), and wild turkey (Meleagris gallopavo). The revenue from the fee-hunting operation can be used to fund research projects for these and other wildlife species.

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APPENDIX A

LIST OF COMMON AND SCIENTIFIC NAMES OF GRASSES, FORBS, SHRUBS, CACTI, AND TREES

Scientific Name	Common Name
GRASSES	
Bouteloua gracilis	Blue grama
Bouteloua eriopoda	Black grama
Bouteloua hirsuta	Hairy grama
Bouteloua curtipendula	Sideoats grama
Lycurus phleoides	Wolftail
Sporobolus cryptandrus	Sand dropseed
Sitanion jubatum	Big squirrel tail
Muhlenbergia richardsonis	Mat muhly
Panicum obtusum	Vine mesquite
Muhlenbergia torreyi	Ring muhly
Muhlenbergia eludens	Fine muhly
Hilaria jamesii	Galleta
Munroa squarrosa	False buffalo grass
Muhlenbergia montana	Mountain muhly
Aristida spp.	Three awn
FORBS	
Argemone squarrosa	Prickly poppy
Amaranthus hybridus	Pigweed
Chenopodium fremontii	Lamb's quarters
Pectis angustifolia	Lemon weed
Euphorbia spp.	Spurge
Salsola kali	Russian thistle
Helianthus petiolaris	Prairie sunflower
Solanum elaeagnifolium	White silver leaf night shade
Allionia incarnata	Trailing four o'clock
Physalis virginiana	Ground cherry
Urtica gracilis	Stinging nettle
Grindelia squarrosa	Curlycup gumweed
Psilostrophe tagentina	Paper daisy
Thelesperma megapotamicum	Greenthread
Sphaeralcea parvifolia	Globe mallow
Dithyrea wislizenii	Spectacle pod
Senecio longilobus	Threadleaf groundsel
Mentha arvensis	Mint
Carex filifolia	Threadleaf sedge
Lepidium montanum	Pepperweed
Ipomoea hirsutula	Wild morning glory
Ambrosia artemisiifolia	Ragweed
Heterotheca villosa	Hairy goldaster
Oxytropis lambertii	Locoweed
Zinnia grandiflora	Wild zinnia
Verbena ambrosifolia	Verbena

Scientific Name	Common Name
FORBS (cont'd)	
Ratibida columnifera	Prairie cone flower
Gutierrezia sarothrac	Broom snakeweed
SHRUBS	
Ribes cereum	Squaw currant
Krameria parvifolia	Range ratany
Fallugia paradoxa	Apache plume
Artemisia tridentata	Big sagebrush
Chrysothamnus nauseosus	Rubber rabbitbrush
Ceratoides lanata	Winter fat
Berberis fremontii	Algerita
Quercus gambelii	Gambel's oak
CACTUS	
Opuntia spp.	Prickly pear
Nolina microcarpa	Bear grass
Opuntia imbricata	Walking stick cholla
Yucca elata	Soaptree yucca
Yucca baccata	Banana yucca
TREES	
Juniperus monosperma	One-seed juniper
Pinus edulis	Pinyon pine
Pinus ponderosa	Ponderosa pine[1]

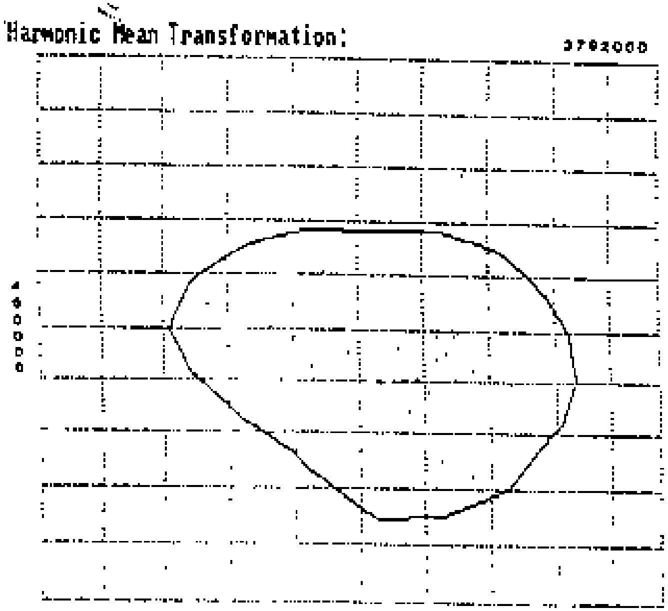
[1]Ponderosa pine was not identified on the vegetation transects but does exist on the research area.

APPENDIX B

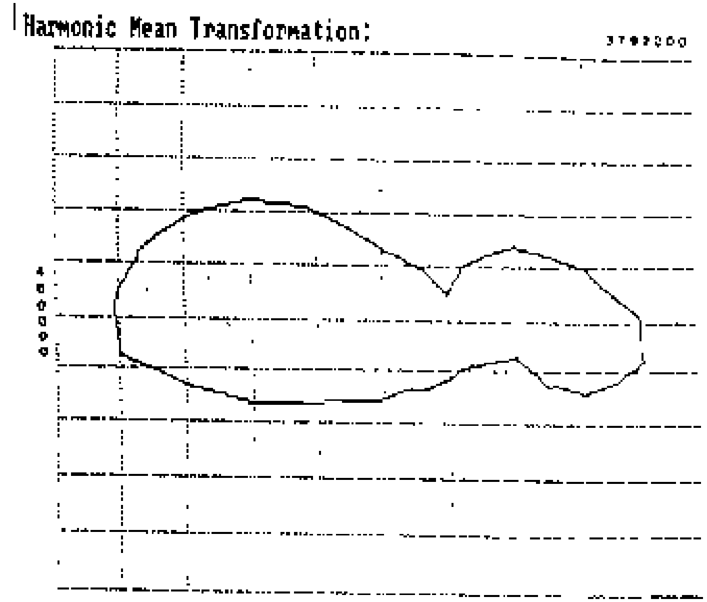
SUMMER AND WINTER HOME RANGE SIZES

SUMMER AND WINTER HOME RANGE SIZES OF THE RED/GREEN RADIOCOLLARED DOE

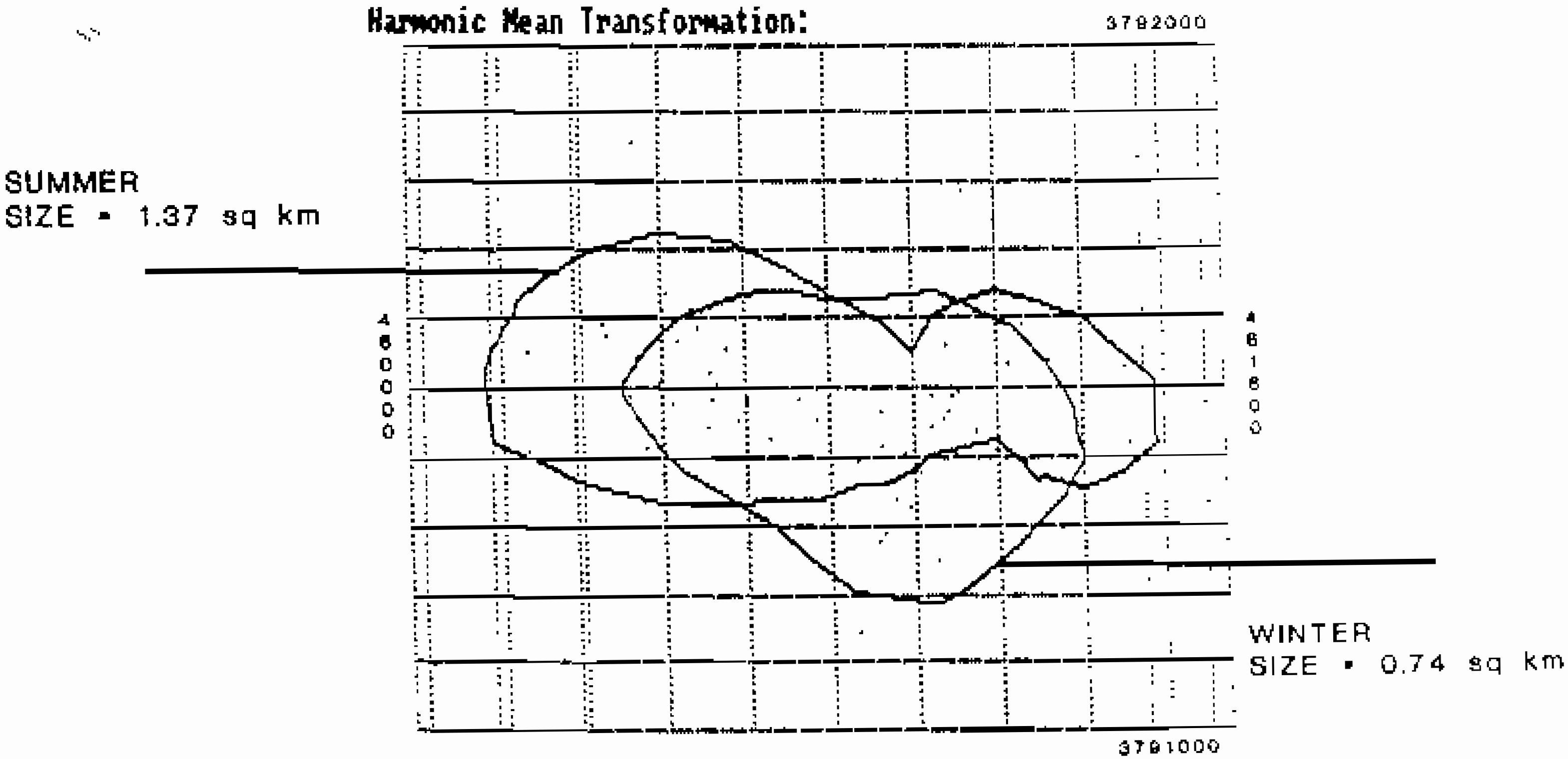
SUMMER



WINTER

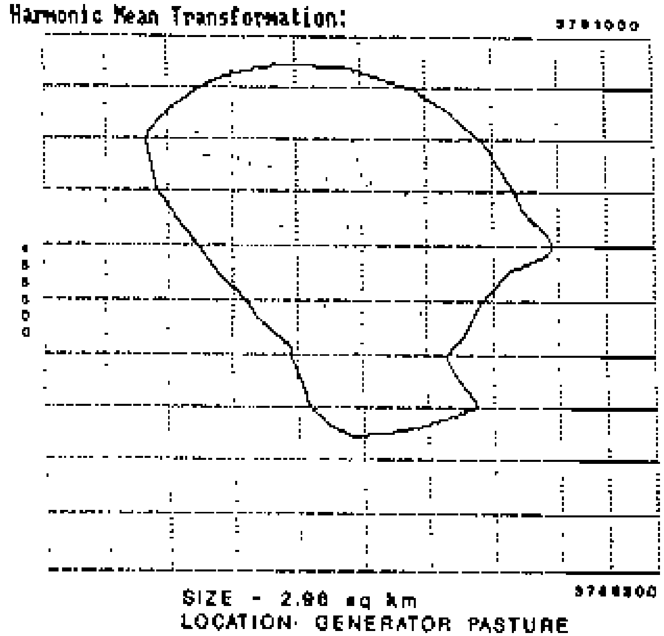


WINTER HOME RANGE OVERLAID ONTO SUMMER HOME RANGE OF RD/GRN RADIOCOLLARED DOE

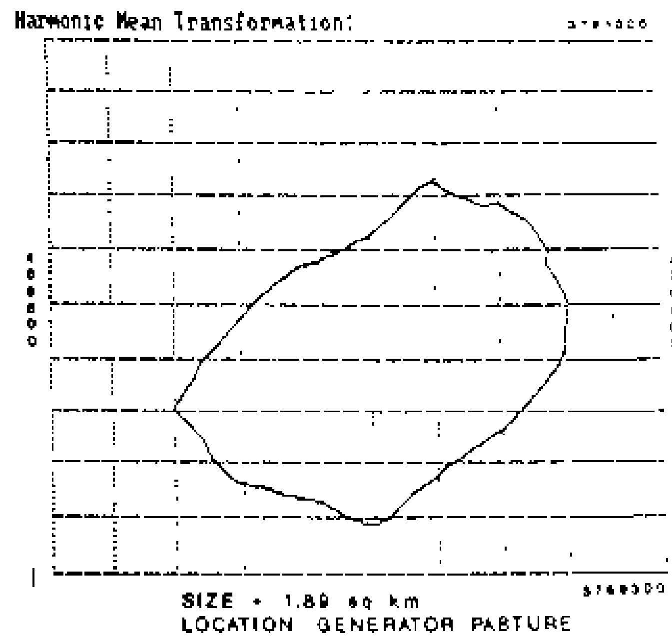


SUMMER AND WINTER HOME RANGE SIZES OF THE BLACK RADIOCOLLARED DOE

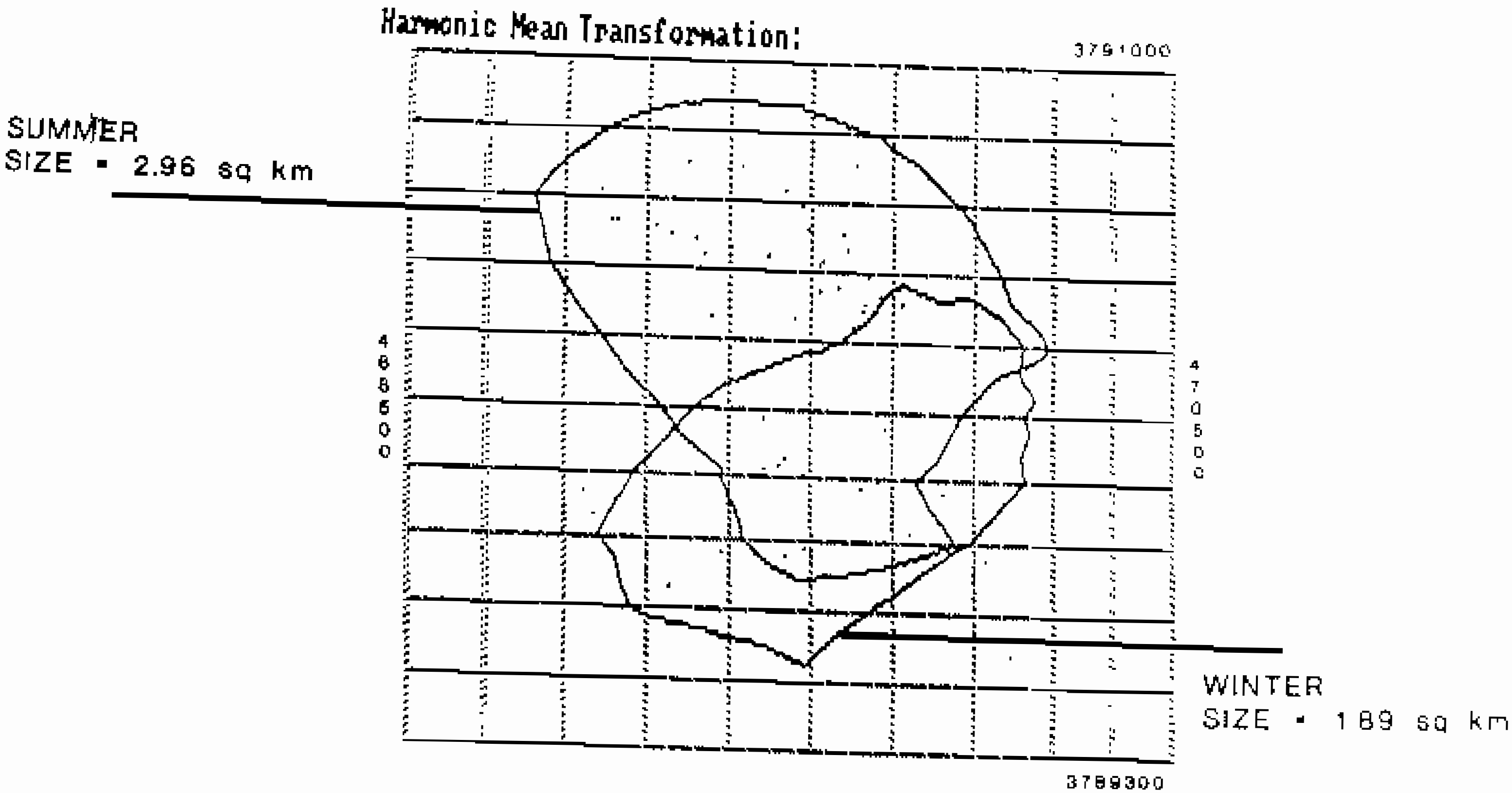
SUMMER



WINTER

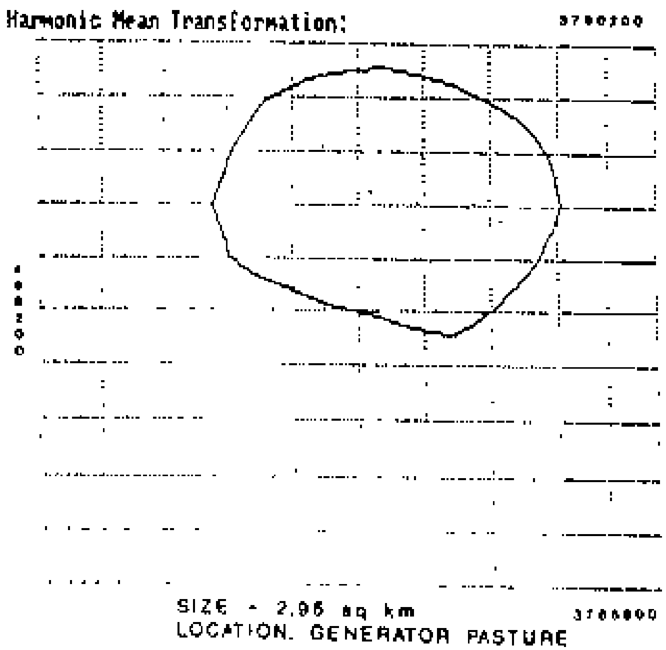


WINTER HOME RANGE OVERLAID ONTO SUMMER HOME RANGE OF BLACK RADIOCOLLARED DOE

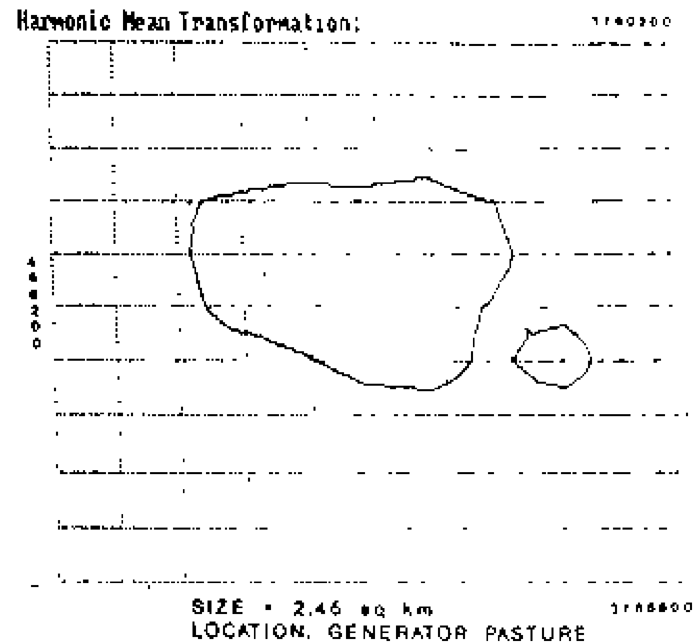


SUMMER AND WINTER HOME RANGE SIZES OF THE RED RADIOCOLLARED DOE

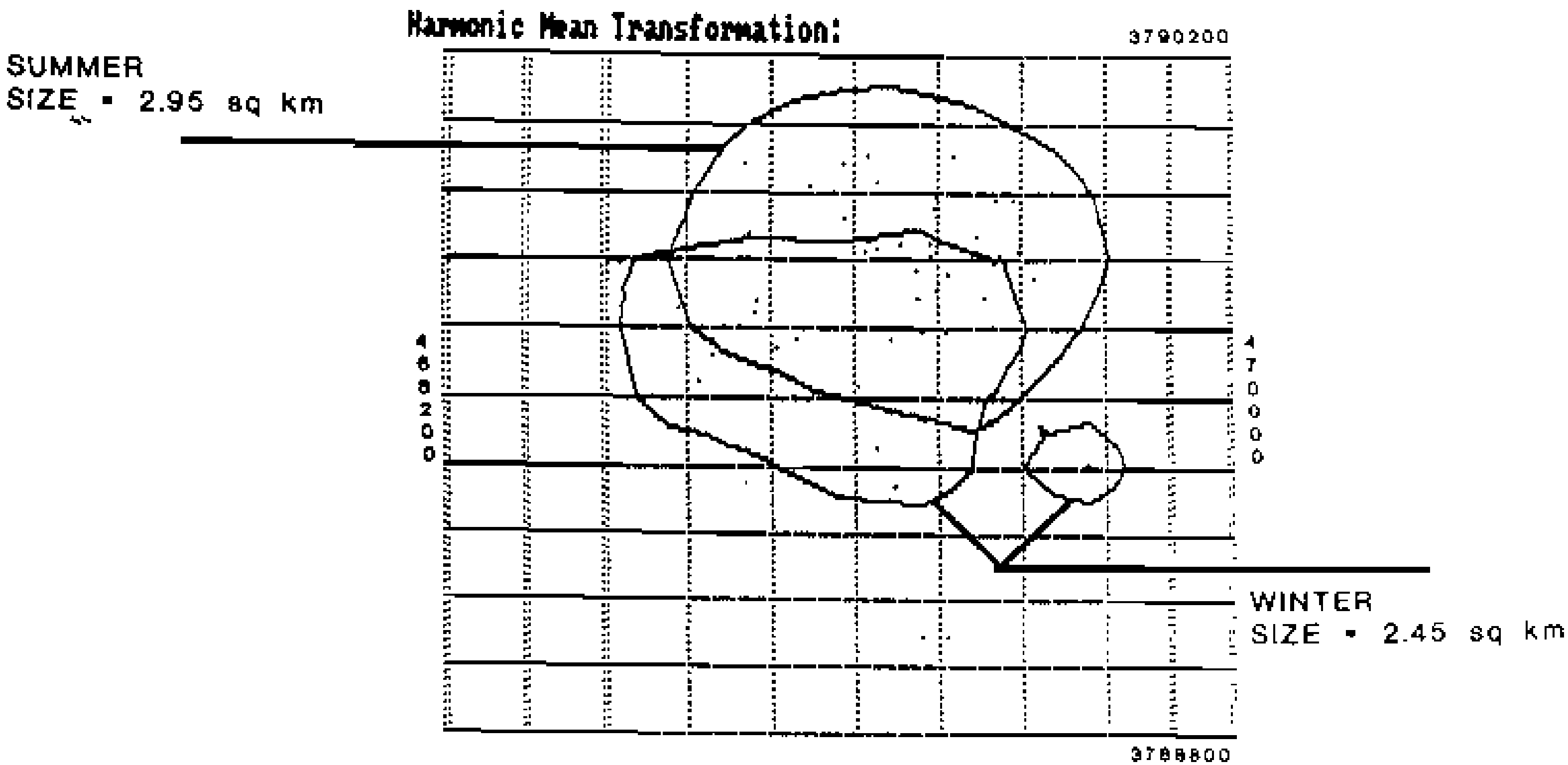
SUMMER



WINTER

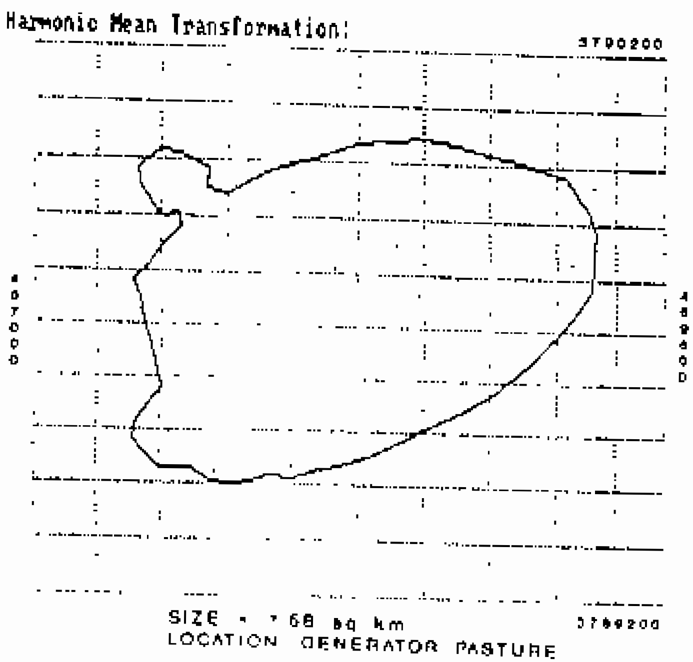


WINTER HOME RANGE OVERLAID ONTO SUMMER HOME RANGE OF RED RADIOCOLLARED DOE

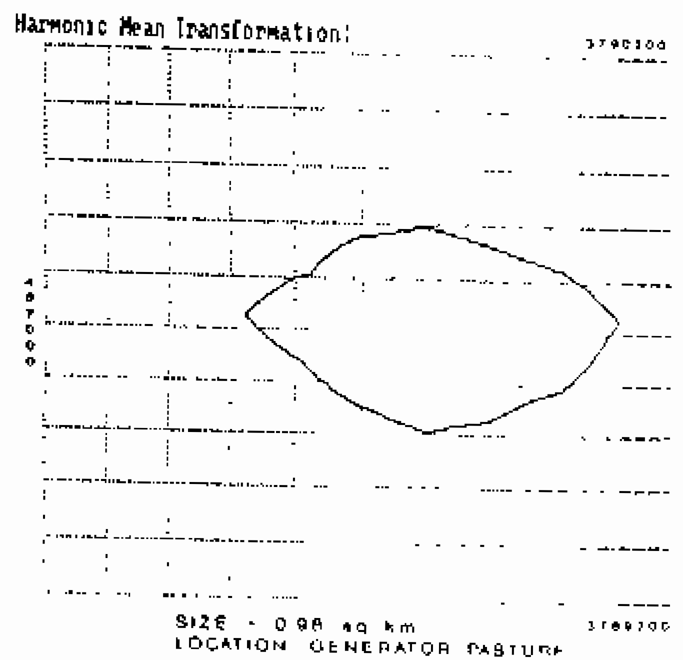


SUMMER AND WINTER HOME RANGE SIZES
OF THE BLACK/WHITE RADIOCOLLARED DOE

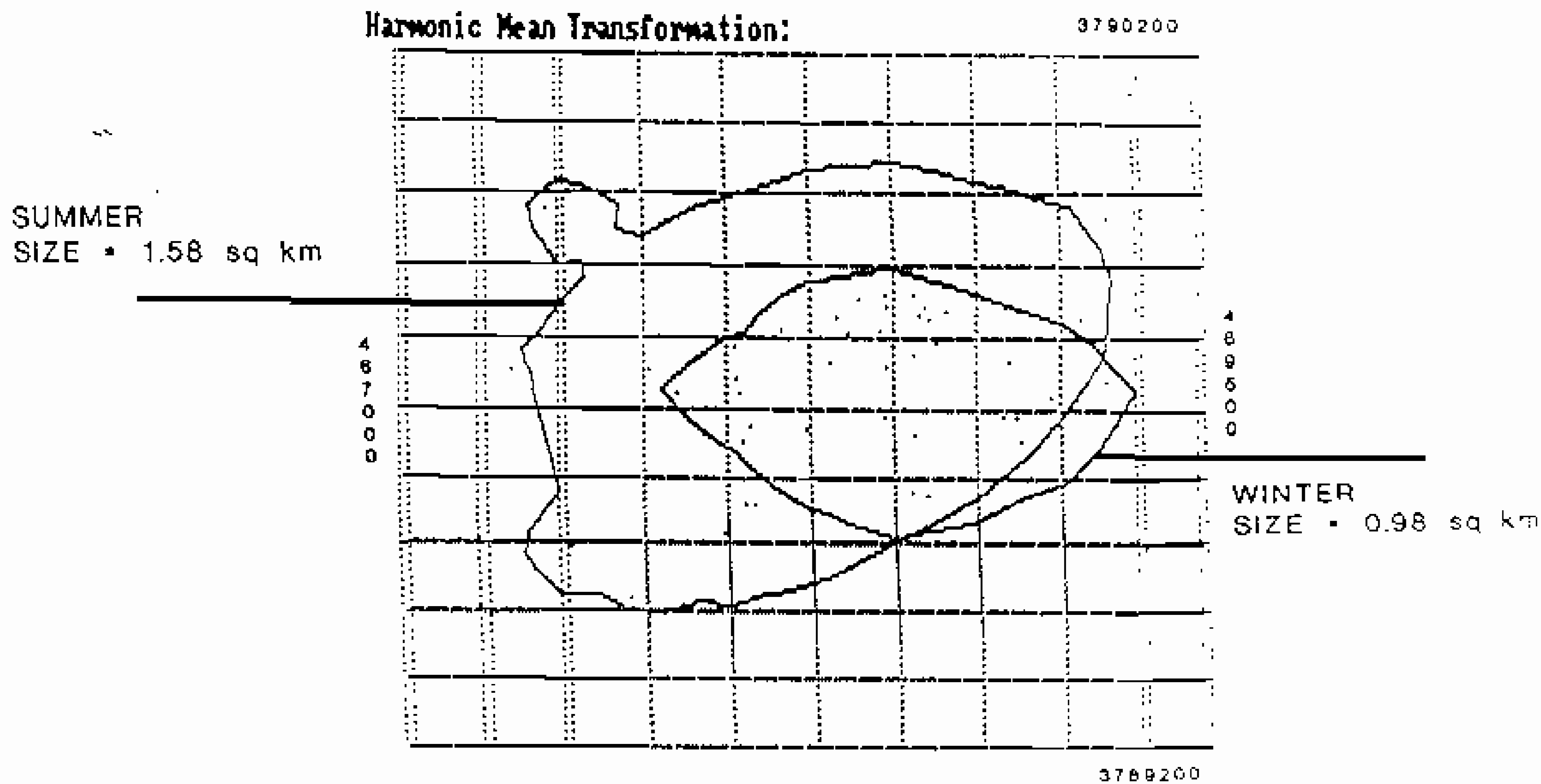
SUMMER



WINTER



WINTER HOME RANGE OVERLAID ONTO SUMMER HOME RANGE OF BLK/WHT RADIOCOLLARED DOE



APPENDIX C

RESULTS FROM MULTIPLE REGRESSION ANALYSIS, CLUSTER ANALYSIS, AND PEARSON CORRELATION COEFFICIENTS

PEARSON CORRELATION COEFFICIENTS FOR ALL
SEVEN VARIABLES FROM 1991 VEGETATION TRANSECT READINGS

VARIABLE	N	MEAN	STD DEV	SUM	MINIMUM	MAXIMUM
BARE	28	0.50071429	0.07892465	14.02000000	0.28000000	0.63000000
LITTER	28	0.16535714	0.11672957	4.63000000	0.01000000	0.40000000
GRASS	28	0.21428571	0.08608474	6.00000000	0.03000000	0.37000000
FORB	28	0.10571429	0.08261596	2.96000000	0.01000000	0.33000000
CACTUS	28	0.01928571	0.02637740	0.54000000	0.00000000	0.08000000
SHRUB	28	0.00571429	0.00878912	0.16000000	0.00000000	0.04000000
TREE	28	0.15892857	0.13668941	4.45000000	0.00000000	0.40000000

PEARSON CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / N = 28

	BARE	LITTER	GRASS	FORB	CACTUS	SHRUB	TREE
BARE	1.00000 0.0000	-0.45270 0.0156	0.15816 0.4215	-0.42268 0.0250	-0.12962 0.5109	-0.11823 0.5491	-0.34942 0.0684
LITTER	-0.45270 0.0156	1.00000 0.0000	-0.71151 0.0001	-0.23296 0.2329	-0.00833 0.9664	-0.12480 0.5269	0.92817 0.0001
GRASS	0.15816 0.4215	-0.71151 0.0001	1.00000 0.0000	-0.19209 0.3275	-0.07853 0.6912	0.19161 0.3287	-0.65838 0.0001
FORB	-0.42268 0.0250	-0.23296 0.2329	-0.19209 0.3275	1.00000 0.0000	-0.07794 0.6934	-0.12314 0.5324	-0.29133 0.1325
CACTUS	-0.12962 0.5109	-0.00833 0.9664	-0.07853 0.6912	-0.07794 0.6934	1.00000 0.0000	0.11411 0.5631	-0.02487 0.9000
SHRUB	-0.11823 0.5491	-0.12480 0.5269	0.19161 0.3287	-0.12314 0.5324	0.11411 0.5631	1.00000 0.0000	-0.08104 0.6819
TREE	-0.34942 0.0684	0.92817 0.0001	-0.65838 0.0001	-0.29133 0.1325	-0.02487 0.9000	-0.08104 0.6819	1.00000 0.0000

)EP VARIABLE: DEER

MULTIPLE REGRESSION USING ESTIMATED NUMBER OF DEER/SECTION
AND ALL SEVEN VARIABLES FROM 4/92 READINGS

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	7	2021.95081	288.85012	1.225	0.3352
ERROR	20	4716.72776	235.83639		
C TOTAL	27	6738.67857			

ROOT MSE	15.35697	R-SQUARE	0.3001
DEP MEAN	26.60714	ADJ R-SQ	0.0551
C.V.	57.71745		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	1032.76299	476.79372	2.166	0.0426
BARE	1	-1006.24205	471.75281	-2.133	0.0455
LITTER	1	-899.36643	475.62000	-1.891	0.0732
GRASS	1	-984.68193	472.53616	-2.084	0.0502
FORB	1	-949.03297	463.92475	-2.046	0.0542
CACTUS	1	-842.65049	419.57521	-2.008	0.0583
SHRUB	1	-1761.21160	874.20507	-2.015	0.0576
TREE	1	-100.38860	60.46887923	-1.660	0.1125

CLUSTER FUNCTION USING ALL SEVEN VARIABLES
TO DETERMINE IF CERTAIN TRANSECTS HAVE SIMILAR VEG COMP

COMPLETE LINKAGE CLUSTER ANALYSIS