FEMALE MULE DEER HOME RANGE USE ON THE CORONA RANGE AND LIVESTOCK RESEARCH RANCH

BY

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...and I thank God.

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ABSTRACT

FEMALE MULE DEER HOME RANGE USE ON THE CORONA RANGE AND LIVESTOCK RESEARCH RANCH

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Master of Science in Wildlife Science

New Mexico State University

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Dr. Volney W. Howard, Jr., Chair

Home ranges of 8 female mule deer were studied on the New Mexico State University Range and Livestock Research Ranch at Corona, New Mexico. The Research Ranch has two general habitat types, yucca-grassland and pinyon-juniper, with intergrade areas between these in some places, and in other areas a sharp contrast line exists from one habitat type to the other. Only slight topographic relief (~ 300m) occurs, eliminating any elevational migration. The Research Ranch supports a healthy population of mule deer that has been a source of investigation for a variety of graduate studies. In this study, deer were radio-collared and tracked for one year using ground triangulation. To minimize mapping error, all readings were taken from permanent receiver points established with G.P.S. The hypotheses being

tested were: (1) that non-migratory female mule deer will use their annual home range similarly from one season to another, (2) that home range size will not differ between the two habitat types, and (3) that home ranges do not differ, when using the same parameters, for the adaptive kernel and minimum convex polygon estimation methods.

Three time intervals based on temperature and precipitation fluctuations were used as the seasons. The sum of locations for three seasonal home ranges comprised the annual home range. To insure locations were representative of the 24-hour cycle, 25% of the locations for each deer came from each of the four categories in the 24-hour sampling period.

The Cool season home range was the smallest seasonal home range because of the necessity to minimize energy expenditure. The largest seasonal home ranges were observed during the Hot/Wet season mainly because does established a fawning area separate from previously used areas. There was no significant difference between the Cool season and the Hot/Dry season home ranges (P = 0.3992). There was a large variation in home range sizes between the Hot/Dry season and the Hot/Wet season, but these were not significant (P = 0.1124). A significant difference did occur between the Cool season and the Hot/Wet season home ranges (P = 0.0169). Home ranges were larger for deer that showed stronger fidelity for the grasslands (P = 0.0009) than were home ranges for deer using the more wooded areas. Finally, the home range estimate differed depending on which home range estimator was used (P = 0.0018).

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INTRODUCTION

The Corona Range and Livestock Research Ranch (CRLRR), owned and managed by New Mexico State University, has been a site of many research studies in the fields of Animal Science, Range Science, Wildlife Science and others. The principal focus of studies conducted on CRLRR have been to research methods of rangeland management that may be better economically and ecologically. The Research Ranch supports a healthy mule deer (*Odocoileus hemionus*) population as well as cattle and sheep. The two types of habitat available for these herbivores are the grassland areas and the pinyon-juniper (*Pinus edulis-Juniperus monosperma*) woodlands. In an ecosystem (pinyon-juniper and juniper woodlands) where research and management efforts have become accelerated due to recent recognition of its importance (Pieper 1983), the modification of these areas on CRLRR with the deer herd, provides an ideal site to study non-migratory mule deer.

Mule deer are one of New Mexico's most economically important big game species. Private land owners are beginning to see that wildlife, especially big game, may have monetary value. Mule deer have become a supplementary source of income for many landowners (Morrill 1988). Because fee hunting is often only a supplementary income, a balance depicting the land owner's desires must be found between the deer and the livestock. The CRLRR deer herd is harvested annually, generating a supplementary annual income and is subjected to management decisions based on improving livestock grazing.

There are many large gaps in our knowledge of mule deer behavior in pinyon-juniper habitats, about interactions between mule deer and livestock, and about the behavior of mule deer during hunting season on private land. Existing studies on the subject differ among deer populations and among habitat types. It has been long contended that range improvements for livestock inversely affect wildlife (Bernardo et al. 1994). It also has been argued that proper livestock grazing maintains or improves habitat for mule deer (Austin and Urness 1986). Clary et al. (1974) concluded that partial or complete removal of the trees can result in marked increases in production of grasses, forbs, and shrubs; demonstrable increases in livestock carrying capacity; and at least theoretical improvement of deer habitat. Inferred benefits to deer habitat of pinyon-juniper removal or suppression remain theoretical because of the lack of unequivocal proof that deer actually do benefit (Carpenter and Wallmo 1981). Originally, studies on the effects of mule deer in the pinyon-juniper habitat focused on the production of forage (Carpenter and Walmo 1981). Short et al. (1977) conducted a study in New Mexico on the effects of mule deer in the pinyon-juniper habitat following overstory removal and looked at the decrease in cover as a limiting factor. They concluded that the absence of cover reduced habitat quality enough to limit use by deer even though food quantity had actually increased after clearing. Howard et al. (1994) stated that because there are many factors involved which affect deer usage, each area planned for pinyon-juniper manipulation should be treated as a unique situation. This paralleled Carpenter and Wallmo's (1981) observation that habitat manipulation to benefit a particular deer population must be based on the individuals making up that population. Understanding behavioral responses of deer to hunting pressure is important to a land owner wanting to supplement his income with fee hunting. Wildlife habitat managers and livestock range managers need to understand how hunting pressure influences deer distribution and how they relate to vegetative cover when hunted so that suitable deer habitat can be provided (Kufeld et al. 1988).

Understanding the dynamics and interactions of the deer herd at the CRLRR is important because these deer do not migrate seasonally. The Research Ranch is both summer range and winter range for many of these deer, this population is hunted for additional income and pinyon-juniper manipulations are being tested. Therefore the CRLRR is an excellent place to study mutual benefits between livestock and deer.

This study was designed to provide a detailed analysis of the home ranges of the female deer on the Research Ranch in order to better understand how the deer use the habitat types available to them. The objectives for this study were to: 1) estimate seasonal and annual home ranges for non-migratory adult female mule deer in pinyon-juniper woodlands, 2) monitor changes in the home range by season, 3) investigate differences between home ranges in the woodland and grassland areas, and 4) compare two popular methods of estimating home ranges.

STUDY AREA

The New Mexico State University (NMSU) Corona Range and Livestock Research Ranch is located 18 km (11 mi.) east of Corona, New Mexico. The Research Ranch lies in northern Lincoln County and southeastern Torrance County (Fig. 1) where the plains mesa grasslands from the east meet the pinyon-juniper savannah in the west (Dick-Peddie 1993).

The 11,396 ha (28,160 ac) Research Ranch is predominately grassland. The pinyon-juniper woodland comprises approximately 15% of the ranch, which is mostly on the western and southwestern portions. The topography is described as gentle, rolling hills with elevations ranging from 1,740 m (5,710 ft) to 2,048 m (6,720 ft). The climate is semi-arid with a mean annual precipitation rate of 391.9 mm (15.43 in) based on a 47-year period (1931-1977) (Kunkel 1984).

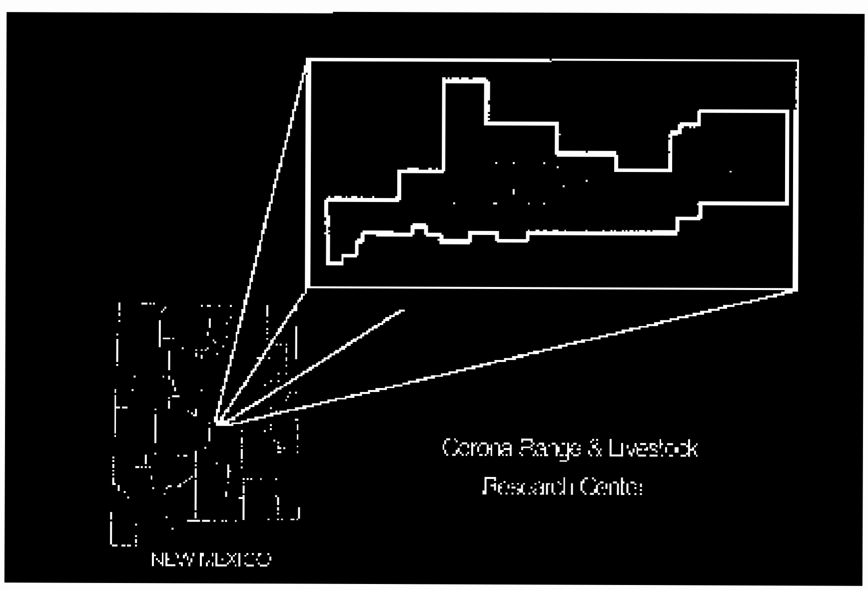


Figure 1. Location of NMSU's CRLRR.

MATERIALS AND METHODS

Capture and Collaring

Six collared adult female mule deer remained on the CRLRR (Smallidge 1997) when this study was initiated. Four additional adult female deer were added to the pre-existing population of collared does between September and December 1997. The criteria for selecting a deer were that they were adult females and that they were captured on the ranch. Avoidance of deer collared in clusters, in order to monitor deer in different habitats, was attempted but capture opportunities kept this consideration relatively lax. One doe's signal was lost early in the study and another doe died 5 months into the study leaving 8 collared deer (Appendix A).

Deer were chemically immobilized using powder charge dart rifles, 2 cc barbless darts, and 1.3 cc of succinylcholine chloride (succostrin) in a 10% solution in order to deliver .1ml/4.5 kg. Deer were blindfolded and their feet were bound immediately upon approach to prevent injury to deer or people. Once secured, a radio collar (Telonics® MOD-500) was fitted around the neck and an ear tag with an identification number was attached to the right ear.

Once the doe was fitted with a collar and ear tag, the collar (transmitter) was checked for signal presence. The blindfold and leg tie were then removed. The doe was monitored while recovering to ensure she got to her feet and appeared healthy.

Triangulation and Monitoring

Once deer were released permanent receiver stations were established at advantageous points (i.e. high and/or open) prior to data collection to provide line-of-sight reception (Loft and Kie 1988) and therefore, eliminate some bias that may occur when mapping. Receiver stations were recorded with a Global Positioning System (GPS) unit for higher mapping accuracy when plotting deer locations; see Smallidge (1997) for equipment and materials used.

Triangulation was done by standing over a receiver station with a Yagi antenna, Telonics® TR-2E receiver, and a compass. Triangulation bearings were taken from the GPS mapped receiving stations. A bearing was defined as the bisection of the arc of audible reception (Garrott et al. 1987) or from the direction of an obviously louder signal.

Certain criteria needed to be established for consistency control and low bias introduction when collecting location data. The time interval which elapses between relocations of instrumented animals (sampling interval) has a direct effect on the precision with which the timing of migratory or dispersal movements can be determined (White and Garrott 1990). This statement was applied on the level of the potential mobility of individual deer between consecutive locations. Lair (1987) suggested biological independence can be assumed if the sampling interval is long enough for an animal to move to any point within its home range. This study followed the suggestion of Moore (1994), of 4 hours minimum between consecutive locations. In order to eliminate error due to movement between readings while obtaining any single location, compass bearings from two receiver stations were taken within 10 minutes of each other. The angle of intersection between the two bearings had to be $30° \leq X \leq 150°$. Too small or too large of an angle introduces greater error (White and Garrott 1990). A fit to these criteria was determined at the second receiver station to avoid collecting unusable data.

Bearings recorded in the field were applied to a United States Geological Survey (U.S.G.S.) (1981) 1:24000 scale topographic map of the ranch and used to plot deer locations. Locations were indexed to a 100 m grid and then estimated to the 10 m range. Locations were recorded in Universal Transverse Mercator coordinates (U.T.M.s) and entered into the home range program.

Data gathering for individual doe locations was divided into 4 intervals during a 24-hour sampling period to help eliminate bias introduced into home range studies that have observations clustered in a certain time frame (Table 1). A 24-hour sampling period was categorized by 1) a.m. dark, 2) a.m. light, 3) p.m. light, and 4) p.m. dark. Twenty-five percent of the locations for each deer came from each category. In each season, 20 locations were gathered on each doe. The annual home range for each doe is simply a summation of her seasonal home ranges.

Table 1. Percentages and number of locations in the 24-hour sampling period by category for individual deer on CRLRR.

CATEGORY	%LOCATIONS	SEASONAL	ANNUAL
a.m. dark	25%	5	15
a.m. light	25%	5	15
p.m. light	25%	5	15
p.m. dark	25%	5	15
total	100%	20	60

Garrott et al. (1987) concluded that the seasonal movements of migratory mule deer in the intermountain west are driven and controlled by seasonal changes in energetic needs of the animals and by the quantity and quality of forage available within the year-round range of the animals. Del Frate (1990) developed a set of seasons based on the Chihuahuan Desert's annual precipitational variation, which coincides biologically with local wildlife patterns. He divided the year into 3 periods. April, May, and June are characterized by hot, dry and windy conditions. July through October is when 50% or more of the precipitation occurs. From November through March the climate is generally characterized by cool, dry weather with a slight peak in precipitation in December. The three seasons he identified were 1) Hot/Dry, 2) Hot/Wet, and 3) Cool. These seasons fit the precipitation regime on the CRLRR (Fig. 2).

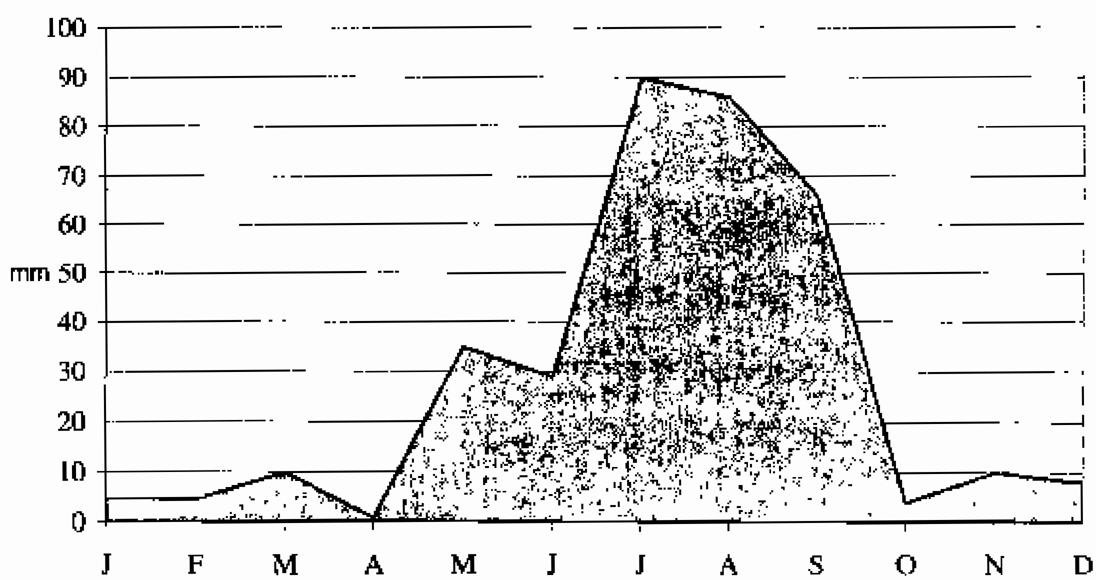


Figure 2. Precipitation amounts recorded from Oct. 1990 to Sept. 1991 on CRLRR (Hart 1992).

Home Ranges

Home ranges of the mule deer on the CRLRR have been studied during parts of the year (Berry 1992, Moore 1994, Smallidge 1997). Because these were preliminary studies of the CRLRR mule deer herd, none looked at the mule deer's home range over the course of an entire year. This study was focused on the home range throughout the entire year. The 3 previously mentioned studies also used different methods for determining home range size. This investigation compared one method (adaptive kernel) used in the previous study (Smallidge 1997) and one method not yet used at CRLRR (minimum convex polygon).

Burt (1943) defined home range as the area traversed by the individual in its normal activities of food gathering, mating and caring for young; therefore, excursions outside its normal area should not be considered part of the home range. This poses a problem in determining the home range because of the subjectivity involved in deciding what is normal. White and Garrott (1990) proposed that objective criteria with a biological basis are needed to select movements that are normal and repeatable, and therefore objective. A 95% utilization distribution (Jennrich and Turner 1969) is objective and repeatable, but arbitrary. White and Garrott (1990) stated that for the sake of comparison among studies, 95% meets the criterion.

Differentiating habitats was done by recording which type of habitat each location was in when mapping. This method avoids the problem of determining which habitat type to select when an error polygon overlaps more than one habitat. A location within 50 m of a change in habitat was given a neutral value. This eliminated the need for error polygons. Home ranges with ≥75% of locations being in a particular habitat were categorized in that habitat. Home ranges where the percentage of locations fell between 75% and 25% were not categorized. All deer in this study fit the categorization criteria for one of the two habitat types.

This study analyzed home ranges on CRLRR by using the adaptive kernel and minimum convex polygon methods. Both methods were executed through the CALHOME (CALifornia HOME Range) program.

Adaptive kernel method

The adaptive kernel method is a non-parametric estimation procedure that requires that a grid structure be overlaid on the data points. Adaptive kernel assigns value to the home range area by the percentage of locations that fall in specific grid cells. This study used the maximum grid size of 50 x 50. This implies that a grid of 50 x 50 cells is laid on top of all the locations entered for the home range. Unlike the harmonic mean estimator, a difference in the number of grid cells has little influence on the size of the home range (Worton 1995, Kie et al. 1996). Rather, adaptive kernel is more sensitive to the value of the bandwidth (Harris et al. 1990) which has been called the "smoothing parameter" (Worton 1989). CALHOME uses a least-squares cross-validation (LSCV) score to choose an appropriate smoothing parameter (Lawson and Rodgers 1997). This is a goodness of fit measure between the bandwidth and the data.

Minimum convex polygon method

The minimum convex polygon (MCP) method is an early example of biologists seeking methods to describe an animal's use of 2-dimensional space (Mohr

1947). In this method the outermost set of data points representing an animal's locations is connected to form a polygon with no concave sides (Kie et al. 1996). MCP is often considered a relatively more comparable home range estimate among different studies and different home range programs (Harris et al. 1990). In Calhome, a MCP using 100% of the locations is the starting point and then each point along the border of the MCP is excluded one-at-a-time until the desired percentage (95) is reached (Kie et al. 1994). Garrott and White (1987) mentioned that a major limitation to the MCP was that as the number of locations increases, so does the area computing home range. It can be argued that if the home range keeps expanding with new locations, then not enough locations had been gathered.

Statistical Procedures

The Statistical Analysis System (SAS 1989) was used for all major analysis. The general linear models procedure was used to test variances between home range estimator methods and between home range sizes compared to seasons. Experimental design was completely random with a factorial arrangement with the factors being method and season. To test home range sizes between the habitat types, a completely random one-way analysis of variance was used.

Means and ranges were computed from all seasonal home ranges. Likewise, the mean and range were computed for the size of annual home ranges between the habitat types and for the difference in annual home ranges for two home range estimation methods.

The CALHOME program delivers with its graphs, X and Y maximum and minimum values in U.T.M. coordinates. The program gives a mean distance between locations for each home range (Appendices B and C).

Appropriate statistical procedures for calculating the sample size needed to gain reasonable statistical power and/or precision (White and Garrott 1990) were not done because of constraints on the number of collars that were available for use.

RESULTS and DISCUSSION

Seasonal Home Ranges

The seasonal home ranges with the least area, by both methods, was the Cool season defined by the months November – March (Table 2). The mean areas for all 8 deer in the Cool season reported by minimum convex polygon (MCP) at a 95% utilization distribution (u.d.) was 92.8 ha and ranged from 20.5 to 242.8 ha (Table 2). The Cool season mean reported by adaptive kernel (AK) at a 95% u.d. was 178.1 ha and ranged from 51.3 to 494.1 ha (Table 2).

Table 2. Cool season home range areas (95%) on CRLRR, 1997-98.

Deer ID	MCP (ha)	AK (ha)
# 1	61.4	118.3
# 2	112.8	198.9
# 3	242.8	494.1
# 4	77.3	125.2
# 5	35.0	58.7
# 6	20.5	51.3
# 7	75.6	197 7
# 8	116.8	180.4
$\bar{X}$ =	**92.8**	**178.1**

The season with intermediate home range sizes, for both MCP and AK, across all 8 deer was the Hot/Dry season which is defined by the months April- June (Table 3). The mean area for the Hot/Dry seasonal home ranges reported by MCP with a 95% u.d. was 136.0 ha (range 31.2 to 426.0 ha). The mean area reported by AK with a 95% u.d. for the Hot/Dry season was 247.8 ha (range 55.2 to 712.3 ha).

Table 3. Hot/Dry seasonal home range areas (95%) on CRLRR, 1998.

Deer ID	MCP (ha)	AK (ha)
# 1	84.6	137.4
# 2	82.1	205.9
# 3	426.0	712.3
# 4	105.9	176.0
# 5	53.6	109.8
# 6	31.2	55.2
# 7	104.2	242.7
# 8	148.7	342.7
$\bar{X}$ =	**136.0**	**178.1**

The largest seasonal home ranges for all 8 deer and for both MCP and AK methods with a 95% u.d. were in the Hot/Wet season, defined by the months July – October (Table 4). The mean area for the MCP method was 205.0 ha (range 93.0 to 483.4 ha). The mean area for AK in the Hot/Wet season for all deer was 418.7 ha (range 198.8 to 954.4 ha).

Table 4. Hot/Wet seasonal home range areas (95%) on CRLRR, 1998.

Deer ID	MCP (ha)	AK (ha)
# 1	108.8	153.2
# 2	120.3	254.1
# 3	483.4	954.4
# 4	119.4	325.1
# 5	168.2	385.5
# 6	93.0	198.8
# 7	279.2	515.3
# 8	267.7	563.2
$\bar{X}$ =	**205.0**	**418.7**

The smallest seasonal home ranges occurred in the Cool season as calculated by both estimators. They were not significantly different from the next larger season, the Hot/Dry season (P = 0.3992). However, the Cool season showed a highly significant difference (P = 0.0169) when compared to the largest seasonal home range, the Hot/Wet season.

One reason the Cool season was not significantly different from the Hot/Dry

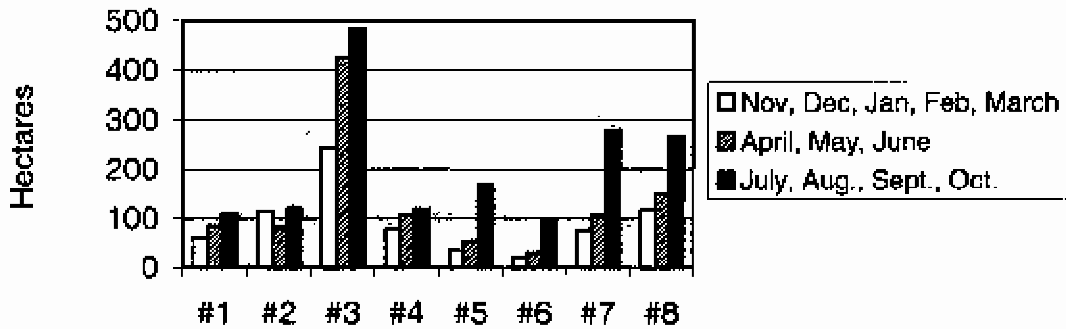


Figure 3. Individual seasonal home range sizes, 95% MCP.

season may be attributed to deer #2 (Figure 3). This doe was the only one in the population with a discrepancy in the ascension of home range sizes. Except for deer # 2, all deer, by both estimators, had a smallest home range in the Cool season and a largest home range in the Hot/Wet season. Deer #2's smallest seasonal home range was in the Hot/Dry season and her intermediate sized home range was in the Cool season. She did remain consistent with the other deer in respect to the Hot/Wet season, which was her largest seasonal home range (Figure 3).

This one discrepancy may be attributed to insufficient sample size. It appears that if more deer were radio collared, the trend to have larger seasonal home ranges ascending from the Cool season to the Hot/Wet season may have been smoothed over. One aspect, which must be considered when designing radio-tracking studies, is sample size and intensity. White and Garrott (1990) stated that the intensive fieldwork required to collect data limits the number of animals that can be tracked and the frequency that data can be collected. Therefore, another possibility for deer # 2's discrepancy, may be that 20 locations during each season were not enough to draw conclusions about a home range. However, the former possibility appears more reasonable.

The reason for the Cool season's smaller mean home range size (Figure 4) appears to be because of the lack of available forage diversity during this time. Therefore, the energy expended to search farther for food is avoided. Joseph (1995) stated of the CRLRR deer, that the high ingestion of browse during winter was because forbs and grasses were dry and new regrowth had not begun. During winter forage quality is reduced through plant senescence (Short et al. 1966, Wallmo et al. 1977). This factor, combined with increased energetic costs to maintain homeostasis in a cold environment, subject deer to a negative energy balance for several months of the year (Garrott et al. 1987). Therefore, deer must strive to reduce the severity of the negative energy balance by minimizing energy expenditures and effectively using forage resources. Joseph (1995) found that deer diets on the CRLRR were 85.5% to 95.5% browse during the fall and winter with *Juniperus monosperma* being approximately 67% of the browse species This places a high level of dependence on the juniper woodlands for food during the Cool season. In addition, the CRLRR deer population is non-migratory, and makes the deer dependent on the woodlands for cover from the harsher Cool season weather.

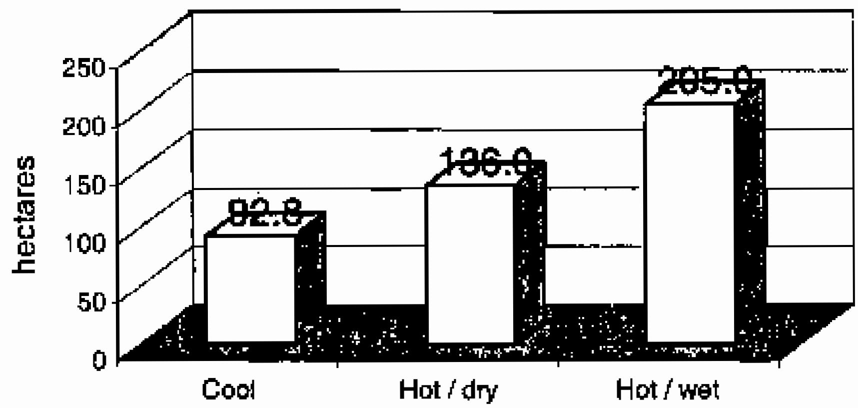


Figure 4. Mean seasonal home range sizes, 95% MCP.

The previous study conducted on the CRLRR mule deer herd (Smallidge 1997) supports this conclusion with the findings from analysis of pellet transects. Loft and Kie (1988) compared pellet-group transects and radio triangulation locations as indicators of habitat use on a seasonal basis. Leopold et al. (1984) and Loft and Kie (1988) concluded that the rankings of habitat use by mule deer determined from pellet-group deposition and direct observation methods were similar, and that pellet-group information was of value in determining overall ranks of habitat use. Smallidge (1997) reported higher population estimates during the fall and winter seasons compared to spring and summer. This increase in number was attributed to the fact that some neighboring ranches have converted sections of pinyon-juniper woodlands to grasslands and that CRLRR has deer that only have a small portion of their home range on the Research Ranch which is utilized more during the colder months for the cover and food benefits.

The largest seasonal home range on the CRLRR was the Hot/Wet season reported by both estimator methods across all 8 deer (Figure 4). A difference was observed in the means by 95% MCP between the Hot/Wet seasonal home ranges (X = 205.0 ha) and the second largest seasonal home ranges where X = 136.0 ha, respectively. However, this difference was not quite significant (P = 0.1124). A significant difference between the Hot/Wet seasonal home ranges and Cool seasonal home ranges was shown (P = 0.0169).

The reason for the excessive size of the Hot/Wet seasonal home ranges is attributed to fawning. I observed that all of the does began using previously unused portions of the home range near the second week in July, near the onset of fawning, and through the rest of the month. Observations from this study support Wallmo (1973) in that fawning coincides most favorably with new plant growth to promote lactation in postpartum deer in New Mexico, which is an area of summer rainfall. Mule deer at CRLRR used a small, but new area for fawning, then returned to the area used during the Hot/Dry season and the Cool season. Jackson et al. (1972) and Ozoga et al. (1982) both report on small, isolated areas used for fawning. Riley and Dodd (1984) found similar areas in their study and that these areas were not used for the remainder of the summer. Mackie (1970) and Steerey (1979) observed that does temporarily re-located their home ranges during the fawning season.

Woodland and Grassland Home Ranges

For comparing home ranges associated with habitat, the annual home ranges were used. The annual home range for each deer is simply a sum of the 20 locations gathered in her 3 seasonal home ranges, therefore N = 60. The sizes of the areas reported are from 95% MCP analysis. Loft et al. (1991) used the 95% MCP method for estimating habitat availability. Bekoff and Mech (1984) concluded that when ≥ 50 locations were used to calculate a 95% MCP the coefficient of variation was < 10%.

Radio-telemetry triangulation can provide unbiased point samples of habitat use over time (Loft and Kie 1988). Among the 8 deer in this study, 5 were classified in the woodland habitat and 3 were classified in the grassland habitat. The mean annual home range size for deer in the woodland habitat was 133.0 ha (range 84.6 – 185.9 ha), (Figure 5). The mean home range size for deer in the grassland habitat was 291.0 ha (range 274.2 – 561.0 ha).

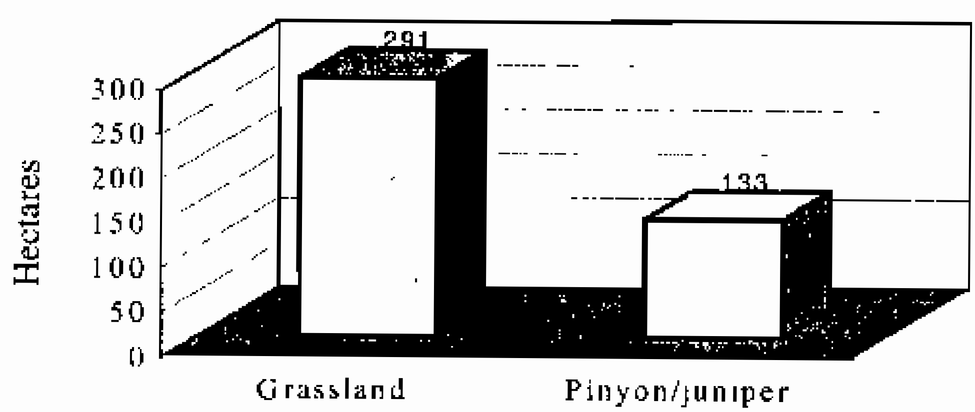


Figure 5. Annual home range sizes of 2 habitats on CRLRR, 1997-98.

There was a highly significant difference in the home range sizes between the habitat types (P = 0.0009). The primary reason for the large difference in the home range sizes between habitats can be attributed mostly to Deer #'s 3, 7 and 8. The two latter deer did not have significantly large Cool season or Hot/Dry season home ranges. The Hot/Wet seasonal home ranges for #'s 7 and 8 were much larger than the other two seasonal home ranges. Deer # 3 was the other contributor to the significantly larger grassland home ranges. All of deer # 3's seasonal home ranges were large. Deer # 3 utilized a large open area surrounded by woodlands. She would bed just inside the tree line, but appeared to use the open area for most of her active periods. A reason for # 3's considerably large home range is that the open area was large, almost her entire 561.0 ha range, and she would move all the way across it to wooded edge on the other side as weather would dictate which side would offer the most protection. Also, she would use the grassland habitat from sundown to mid morning. The woodlands would be used during the middle of the day. Deer #'s 7 and 8 also followed a similar pattern.

Methods of Home Range Estimation

The MCP and AK methods of home range estimation were compared to see if there was a difference between them (Appendix B). There was a significant difference (P = 0.0018) between the MCP and AK methods for each of the 8 does in this study with the AK method providing larger ranges. This study would suggest that the results of the two methods would not be comparable. Means between the two methods differed greatly among the seasonal home ranges with only 20 total locations to an even greater difference among the annual home ranges where 60 locations were gathered (Figure 6).

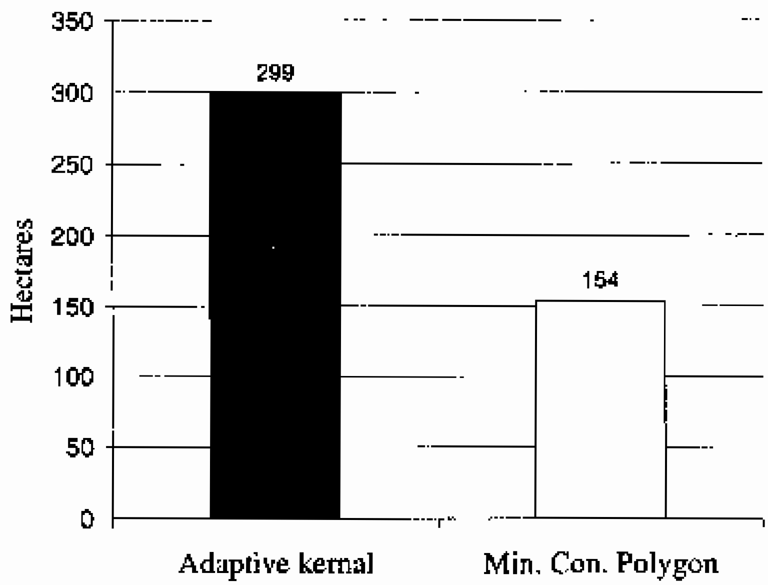


Figure 6. Comparison of mean annual home range sizes between 2 estimation methods.

This may reflect on the area, habitat, topography, or population that is investigated. Loft et al. (1991) used the same estimators as this study and found that the AK and MCP did not have a significant difference. They state that they used the 95% MCP because of its agreement with their AK estimates. However, Loft et al. (1991) did not state what grid cell size they used or in which program they were working. Lawson and Rodgers (1997) strongly caution that comparing home ranges among different research studies can be misleading unless researchers report choices for software program, home range estimators, user-selected options and input values of required parameters.

For each home range analyzed in this study (32), the adaptive kernel estimate was considerably larger than the minimum convex polygon estimator. The AK method had tendencies to round and smooth home ranges into open areas that a particular deer did not appear to use. This is rather subjective since the deer were not monitored constantly, but I observed that deer would reach certain edges or corners of their home range (i.e. one location), and have turned around and be heading back toward the center of her range at the next location 4 hours later. Therefore, the MCP method for estimating home ranges on the CRLRR appears more accurate.

CONCLUSIONS

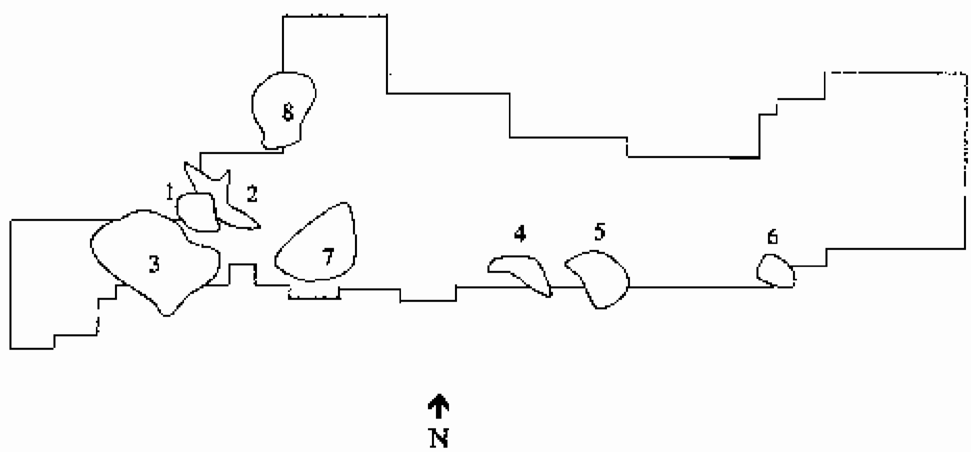
Mule deer home range dynamics were studied on the CRLRR using seasonal telemetry locations and home range estimators. The need for better understanding of how mule deer use their home ranges in relation to their habitat and the changing seasons because mule deer have become a common way for landowners to supplement income and mule deer are the primary big game species of the pinyon-juniper habitat (Carpenter and Wallmo 1981). Most of these landowners are livestock ranchers, therefore the CRLRR is an excellent site for this study because it is a livestock operation, a fee hunting program and contains large pinyon-juniper woodlands.

The findings in this study support Joseph (1995) and Smallidge (1997). All three studies show evidence that the CRLRR mule deer are dependent upon stands of pinyon-juniper in the winter. Credibility is given to this statement because each of these studies came to that conclusion from a different approach.

There are issues that may warrant further investigation into this deer herd. A study that carefully examines the interactions between cattle and deer is needed for the CRLRR. An investigator could look at the movements of the deer in reference to the stocking and rotation rates of the livestock . A multi-year study similar to this one could reveal the fidelity levels of deer to their seasonal home ranges. There are several studies in the literature on how forage quality affects sex ratios at birth in fawns. Pederson and Harper (1984) cite numerous sources showing considerable evidence that nutrition may influence the sex ratio of offspring born to a variety of cervids, especially mule deer. It appears that deer densities decline when the fawn ratio is skewed toward males. A practical and well compensated effort for obtaining critical insight into the CRLRR deer herd has been the data from the pellet transects over the years. Continued monitoring of these transects would allow the managers to keep up with current deer population trends, especially when coupled with current age class and sex ratios. Also, the telemetry work done on the CRLRR has provided information in areas not easily reached by other inexpensive means. The knowledge of how these deer use their home range from season to season was previously unknown. This study also aided by supporting other studies done on the CRLRR in the requirements deer need from the pinyon-juniper woodlands. A final suggestion in the event that further telemetry studies are done on the CRLRR; it would be wise to be consistent with methodologies so that studies are compatible and can be compared with each other on the fine points.

APPENDIX A

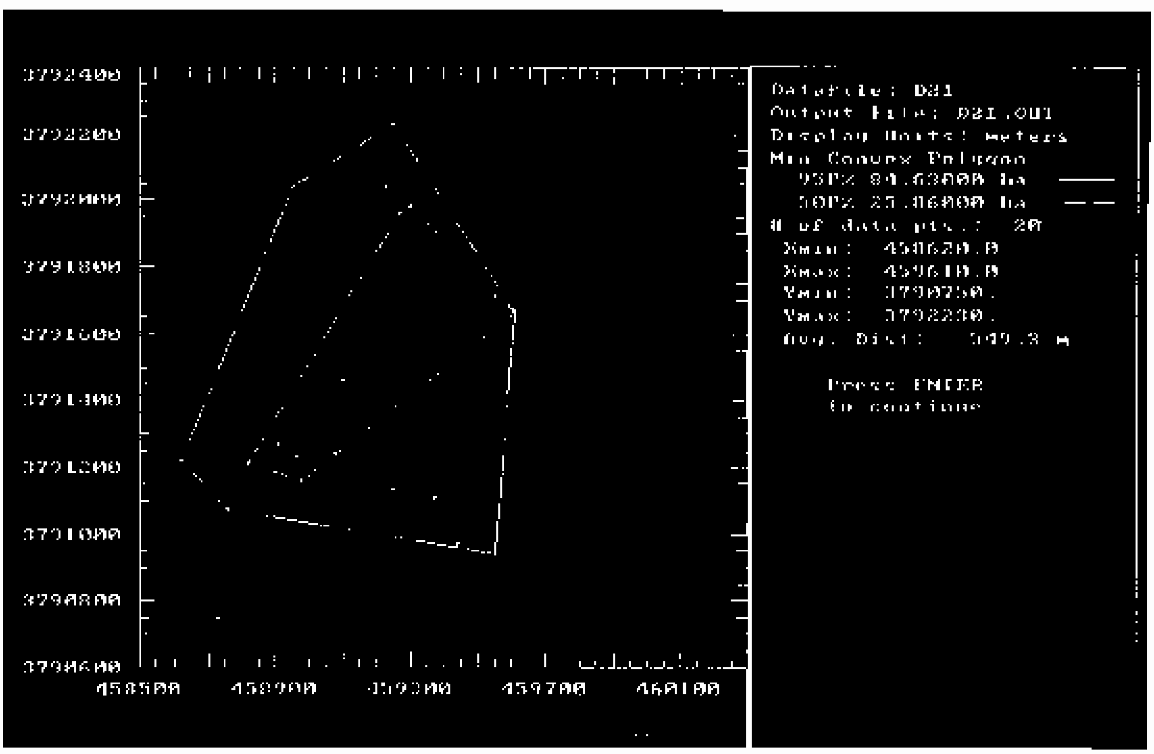
COLLARED DEER LOCATIONS ON CRLRR, 1998.



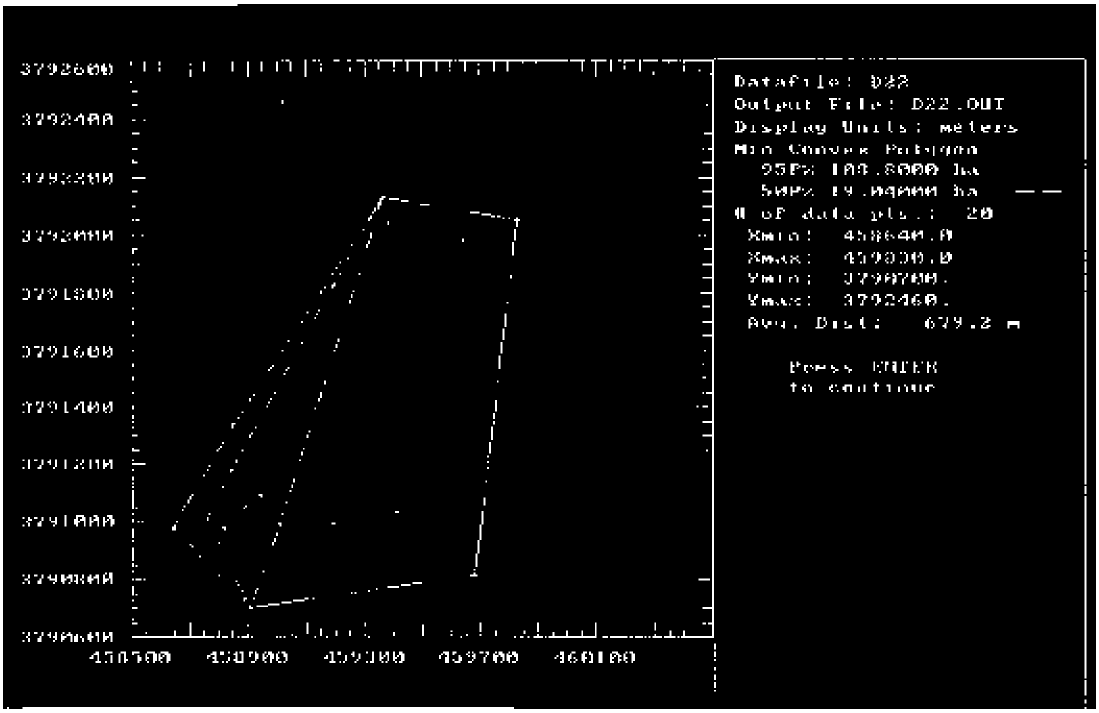
APPENDIX B

MINIMUM CONVEX POLYGON SEASONAL HOME RANGES FOR 8 FEMALE MULE DEER ON CRLRR

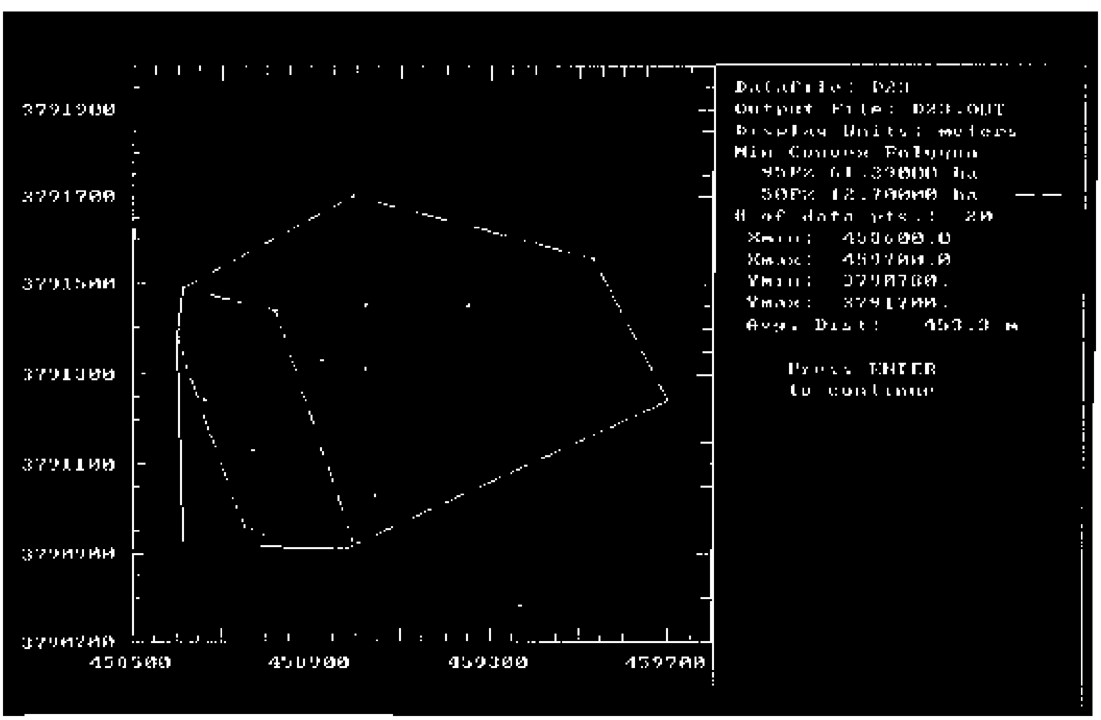
Deer #1, 50% and 95% MCP Hot/Dry seasonal home range on CRLRR, 1998.



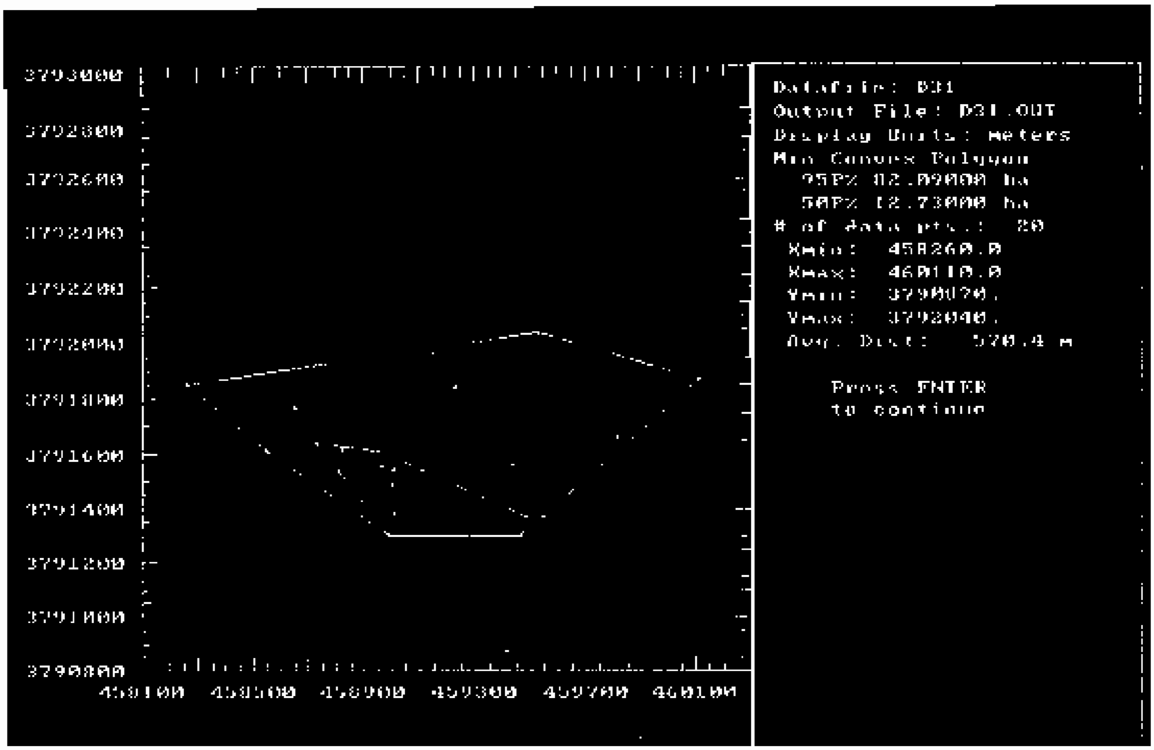
Deer #1, 50% and 95% MCP Hot/Wet seasonal home range on CRLRR, 1998.



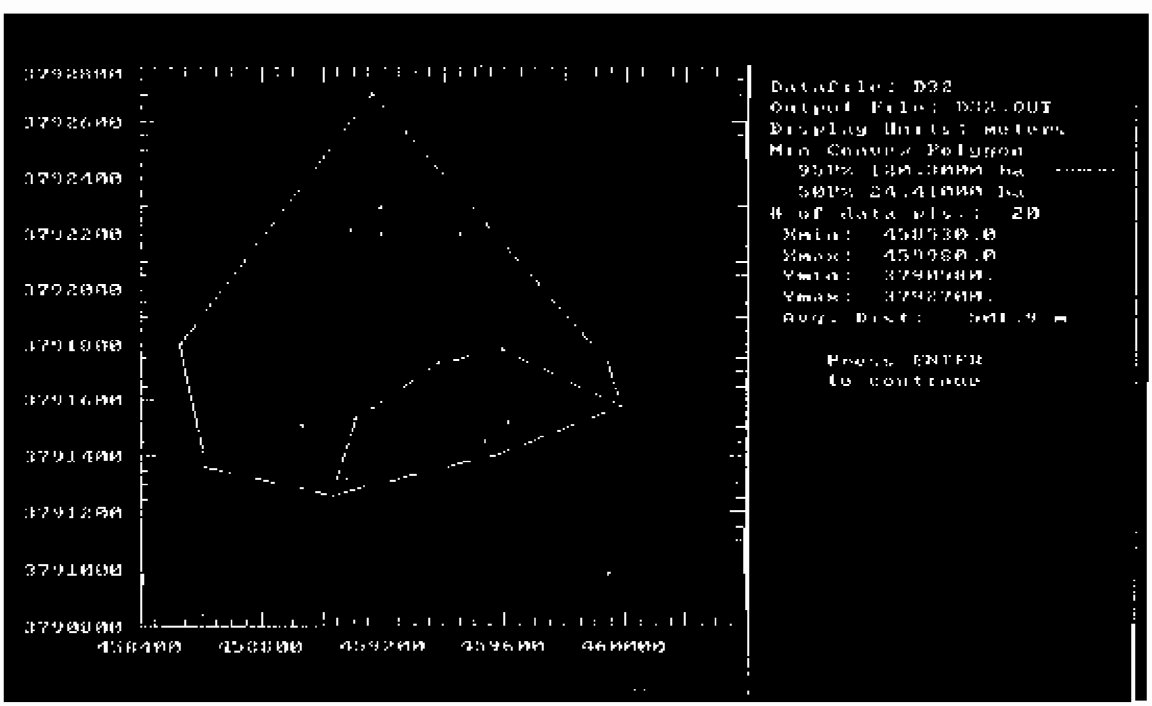
Deer #1, 50% and 95% MCP Cool seasonal home range on CRLRR, 1997-98.



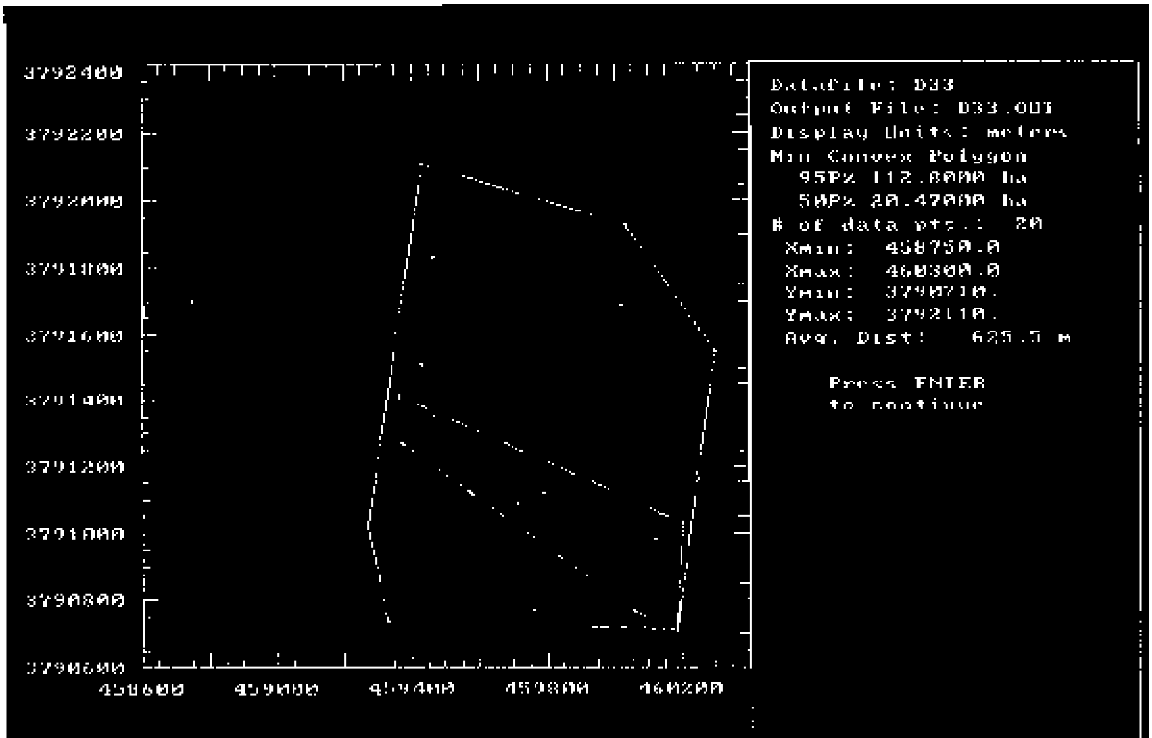
Deer # 2, 50% and 95% MCP Hot/Dry seasonal home range on CRLRR, 1998.



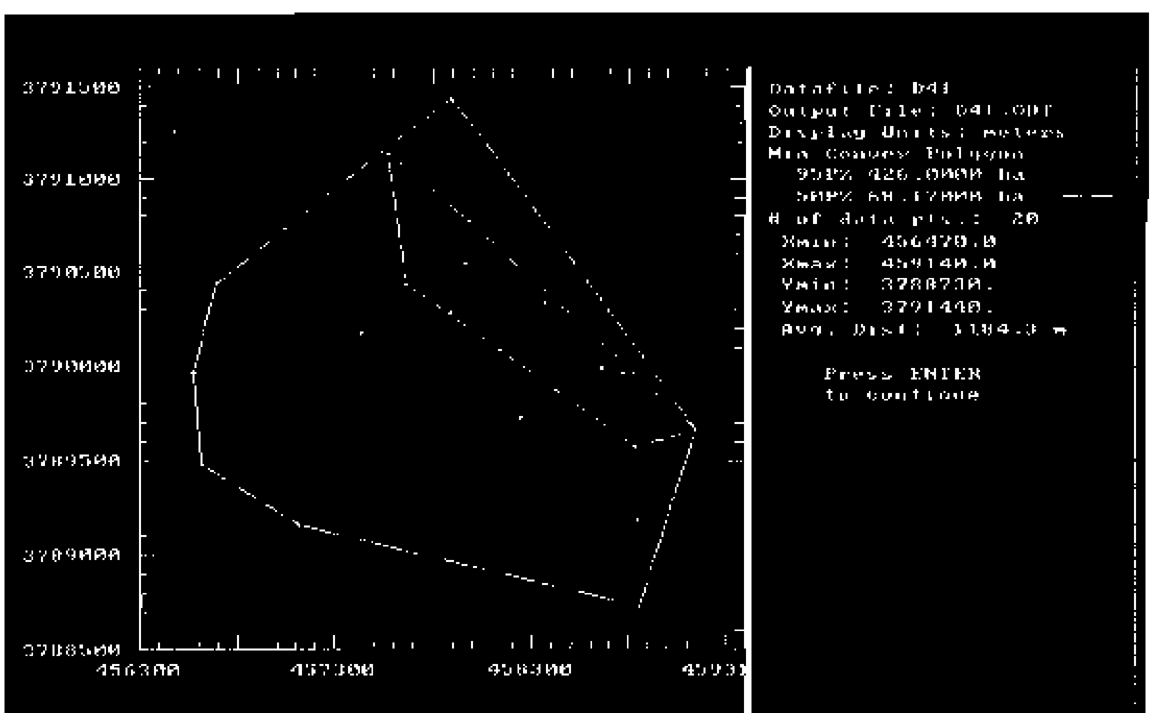
Deer #2, 50% and 95% MCP Hot/Wet seasonal home range on CRLRR, 1998.



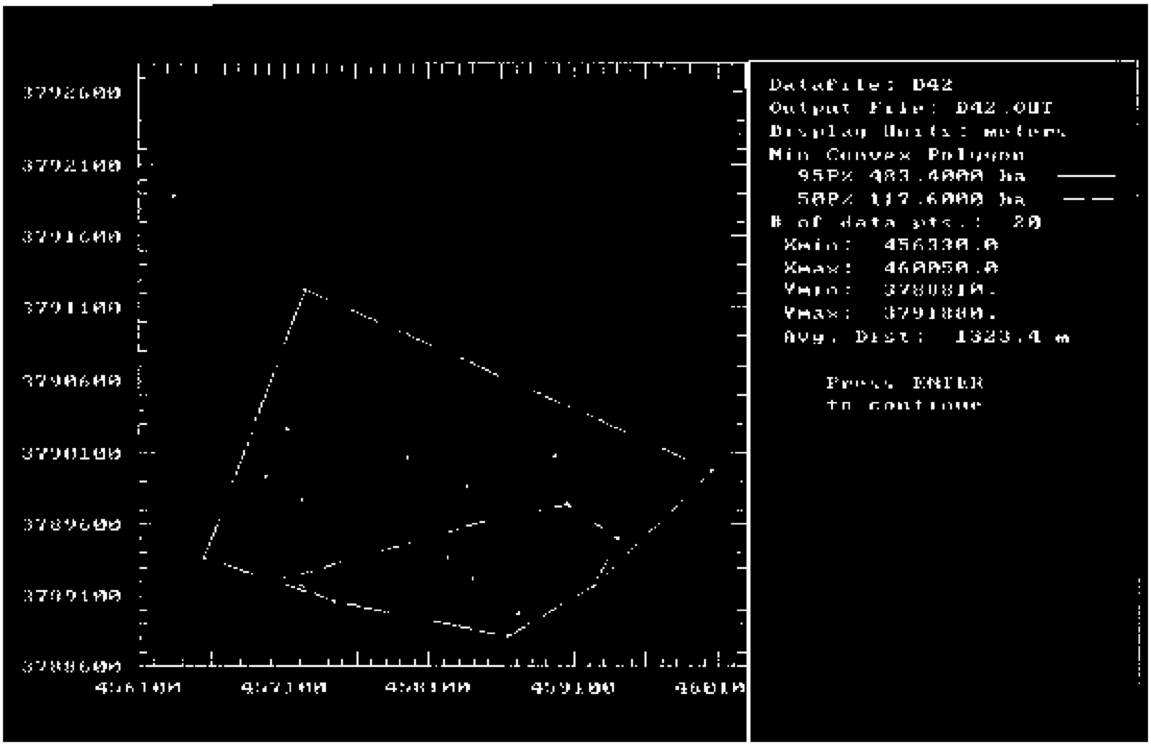
Deer #2, 50% and 95% MCP Cool seasonal home range on CRLRR, 1997-98.



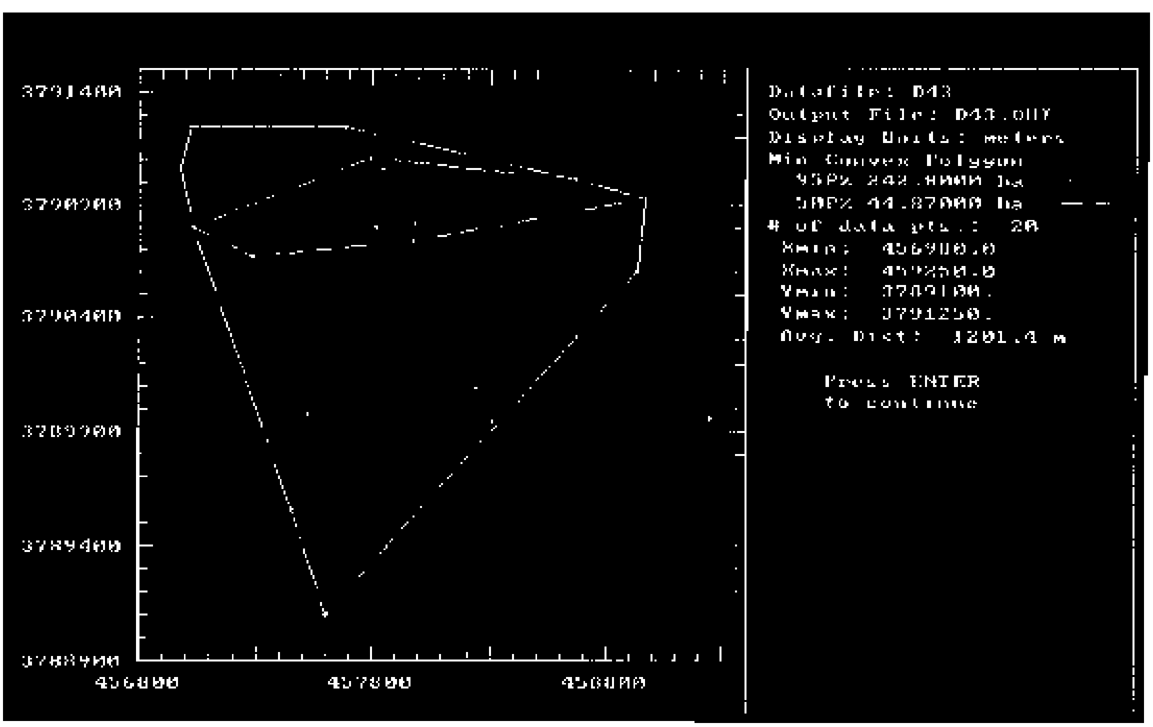
Deer #3, 50% and 95% MCP Hot/Dry seasonal home range on CRLRR, 1998.



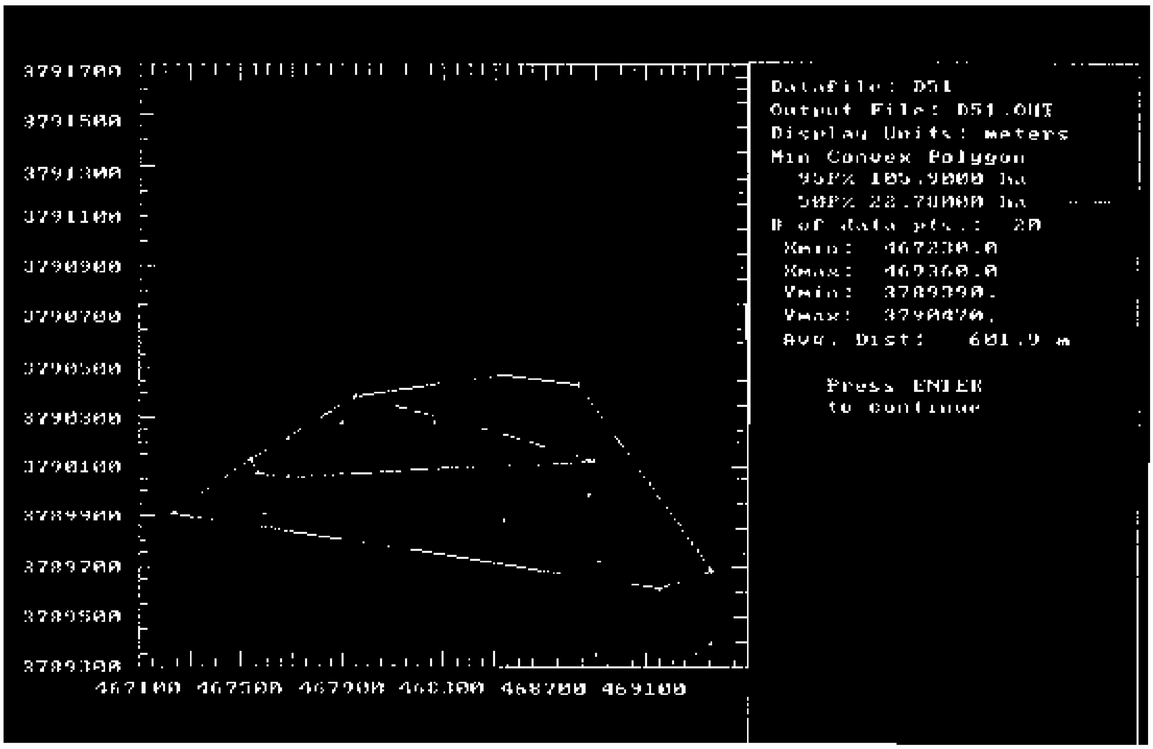
Deer #3, 50% and 95% MCP Hot /Wet seasonal home range on CRLRR, 1998.



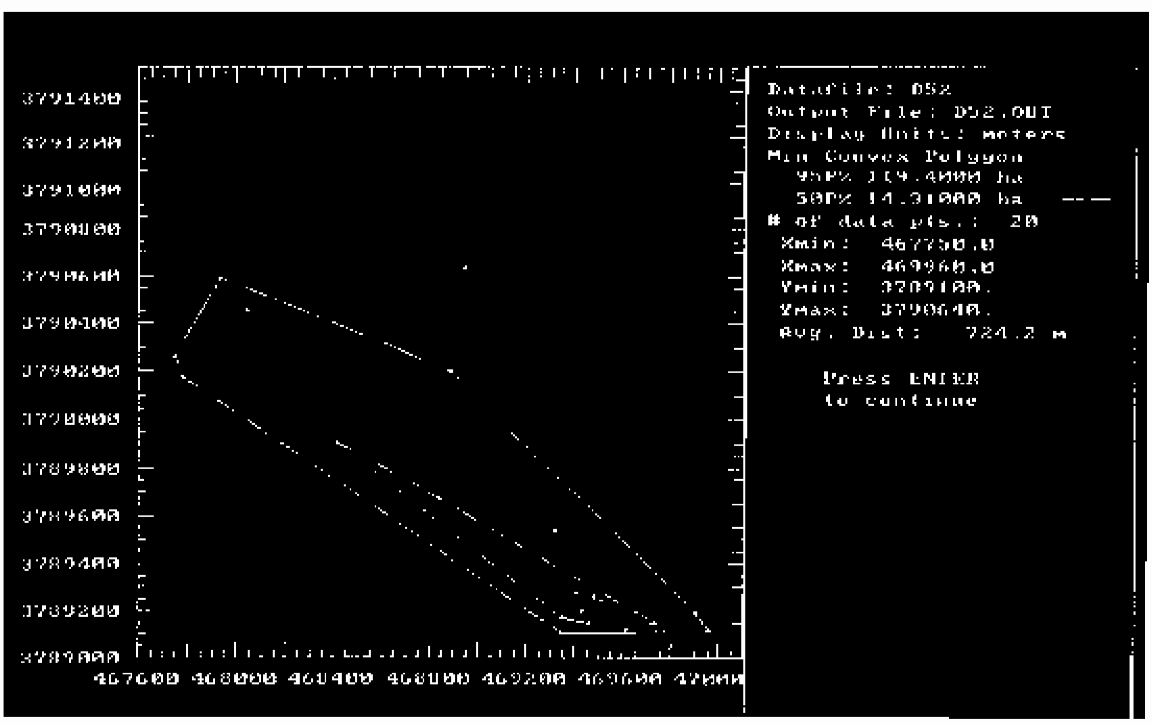
Deer #3, 50% and 95% MCP Cool seasonal home range on CRLRR, 1997-98.



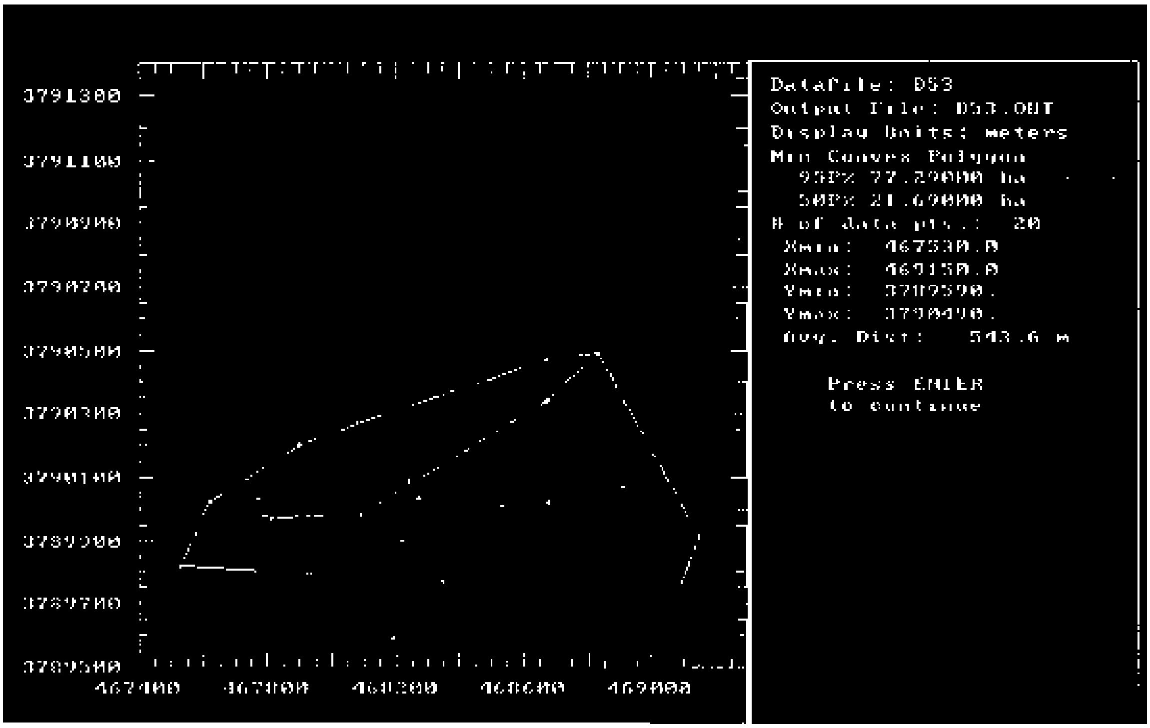
Deer #4, 50% and 95% MCP Hot/Dry seasonal home range on CRLRR, 1998.



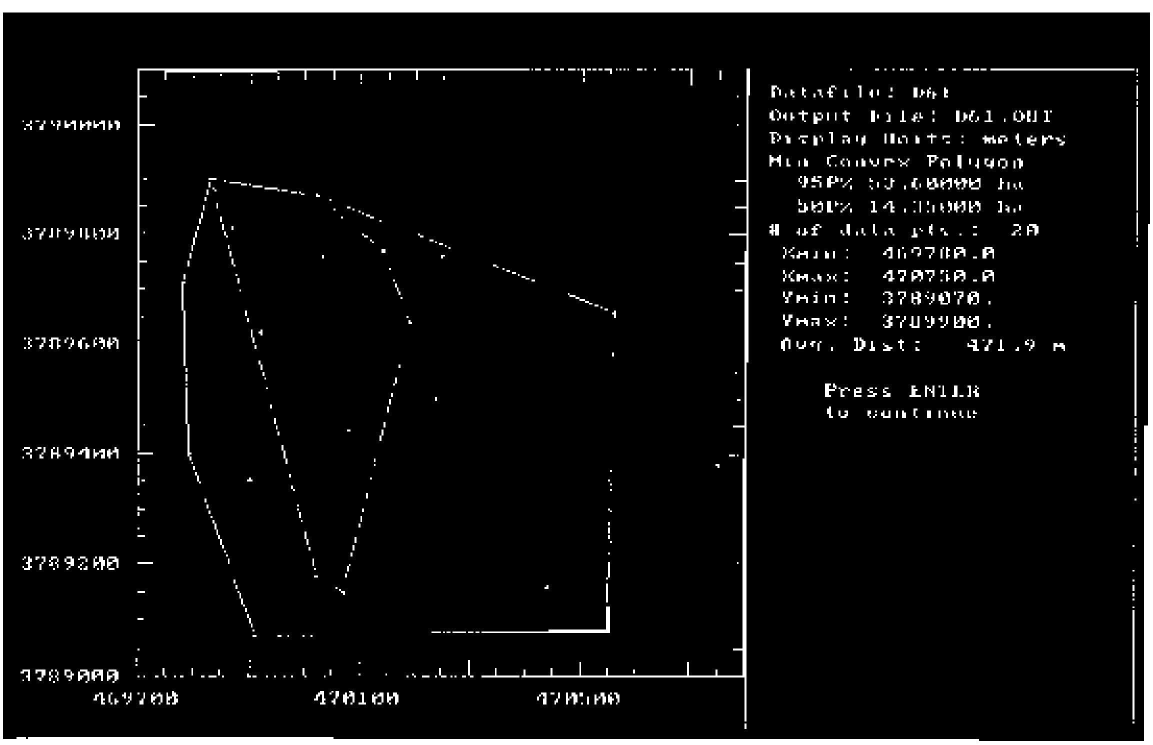
Deer #4, 50% and 95% MCP Hot/Wet seasonal home range on CRLRR, 1998.



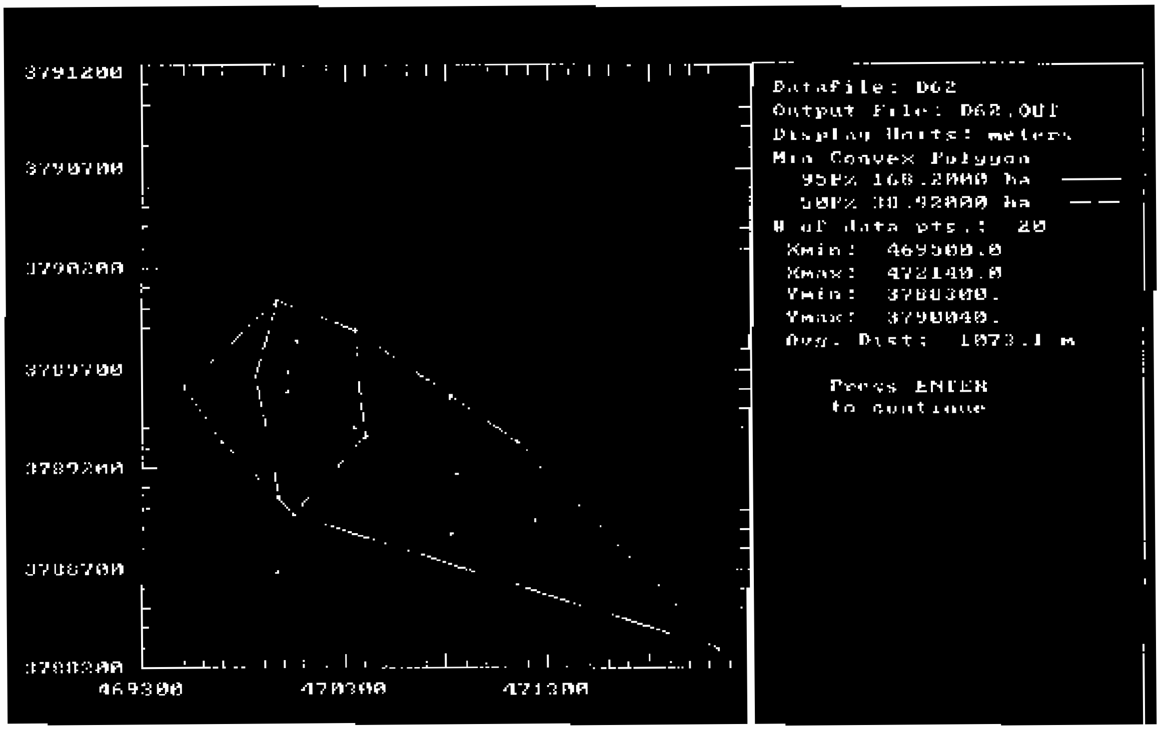
Deer #4. 50% and 95% MCP Cool seasonal home range on CRLRR, 1997-98.



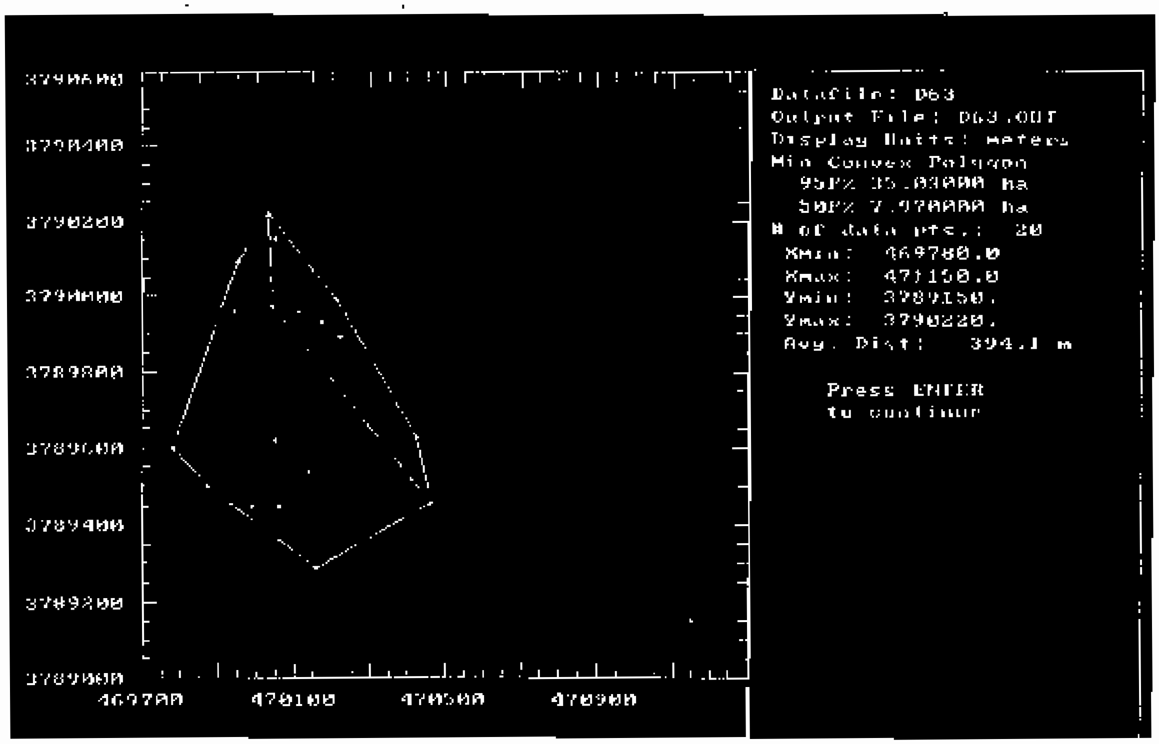
Deer #5, 50% and 95% MCP Hot/Dry seasonal home range on CRLRR, 1998.



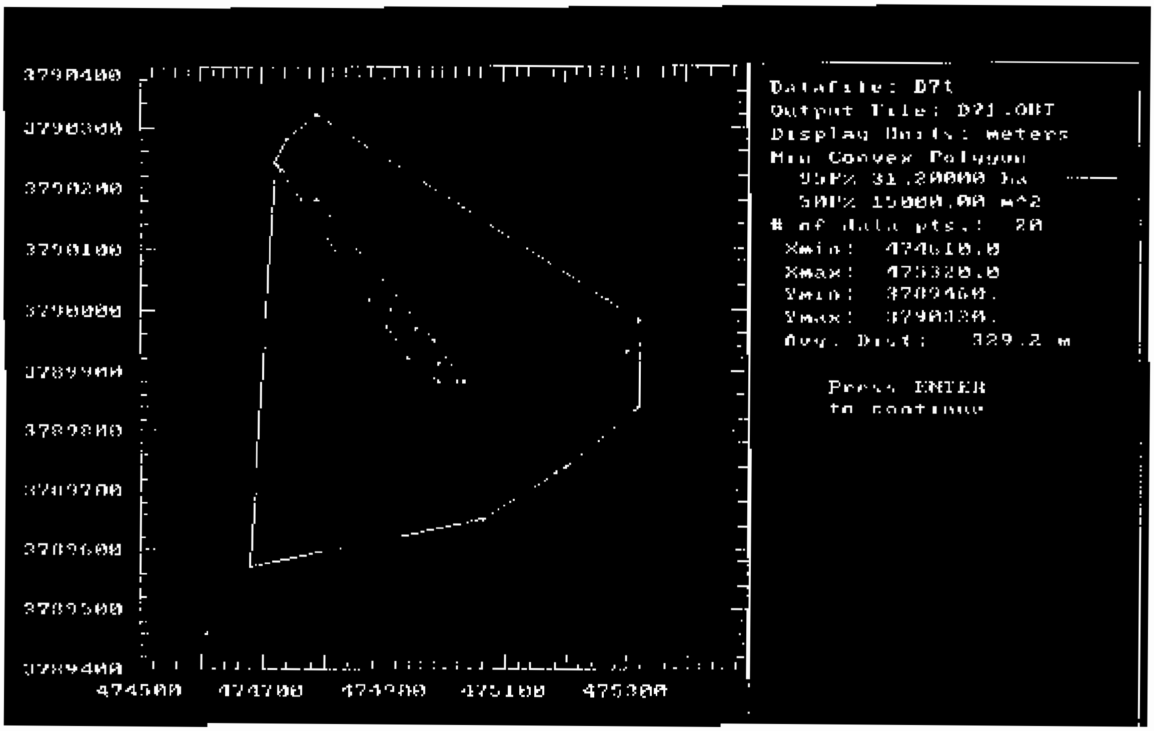
Deer #5, 50% and 95% MCP Hot/Wet seasonal home range on CRLRR, 1998.



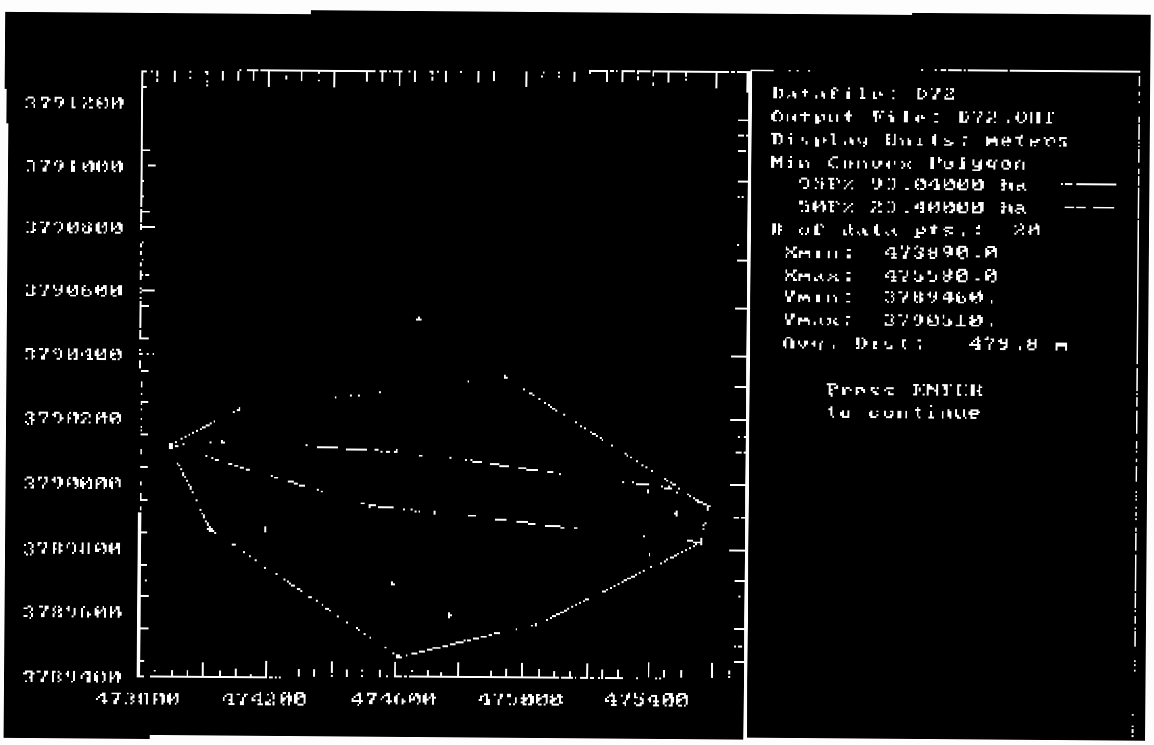
Deer #5, 50% and 95% MCP Cool seasonal home range on CRLRR, 1997-98.



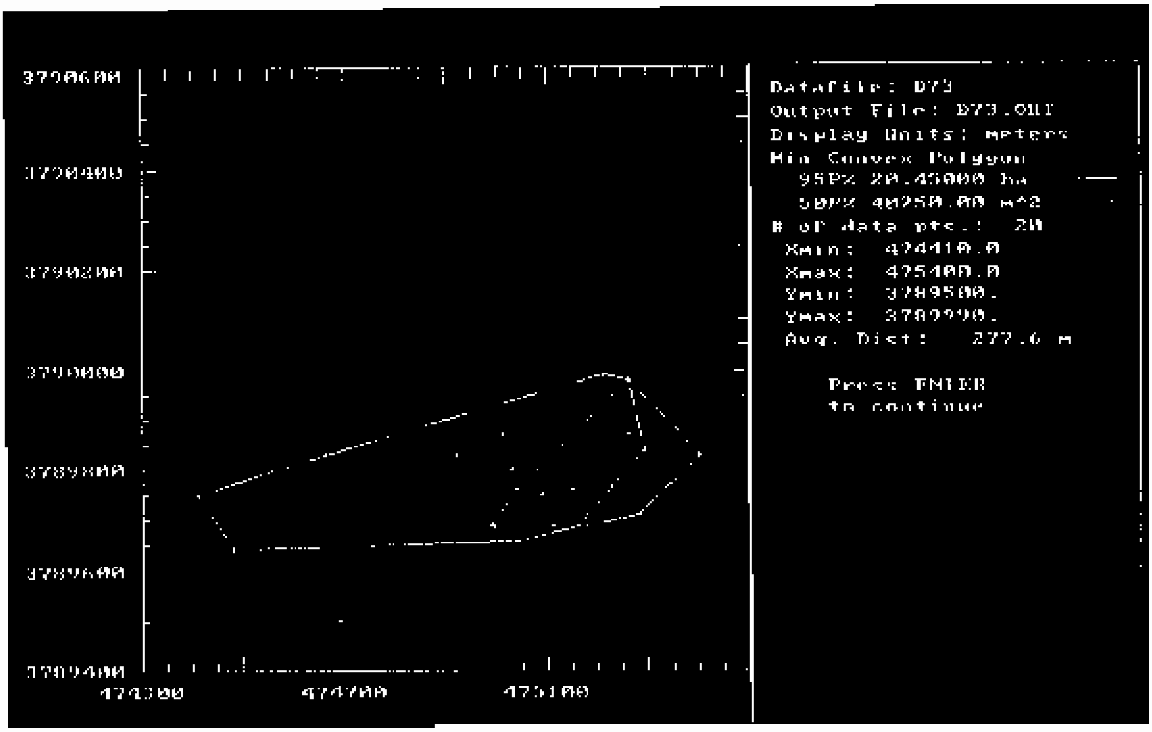
Deer #6, 50% and 95% MCP Hot/Dry seasonal home range on CRLRR, 1998.



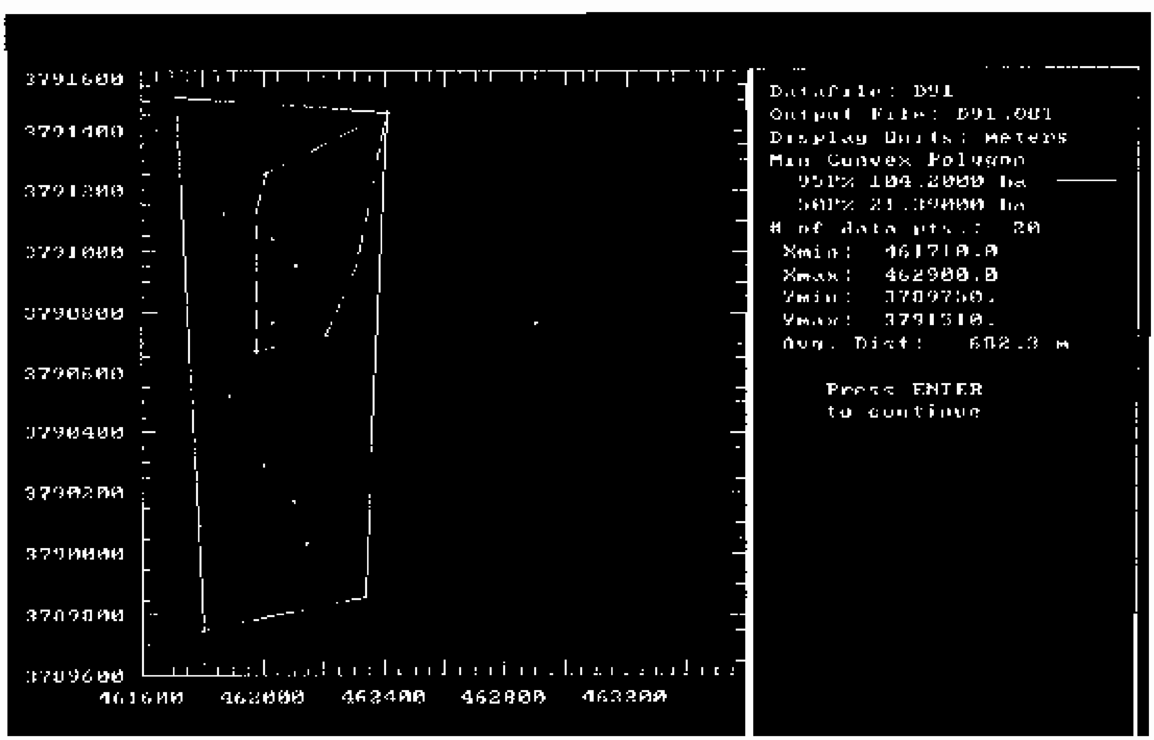
Deer #6, 50% and 95% MCP Hot/Wet seasonal home range on CRLRR, 1998.



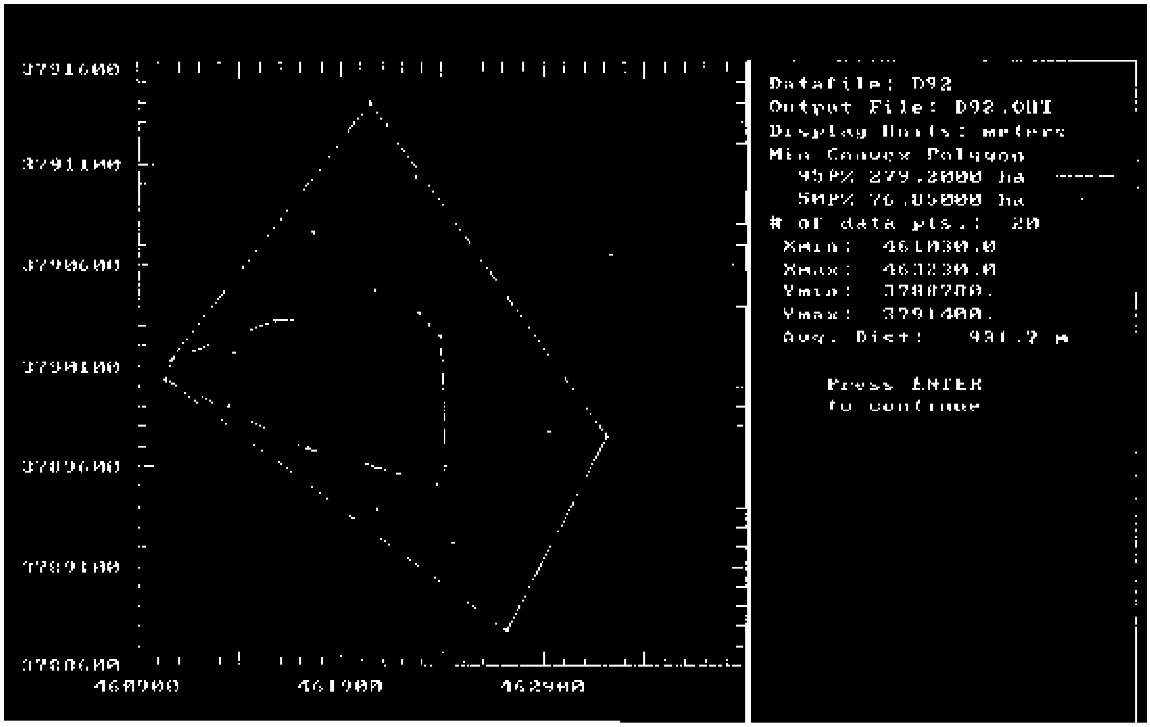
Deer #6, 50% and 95% MCP Cool seasonal home range on CRLRR, 1997-98.



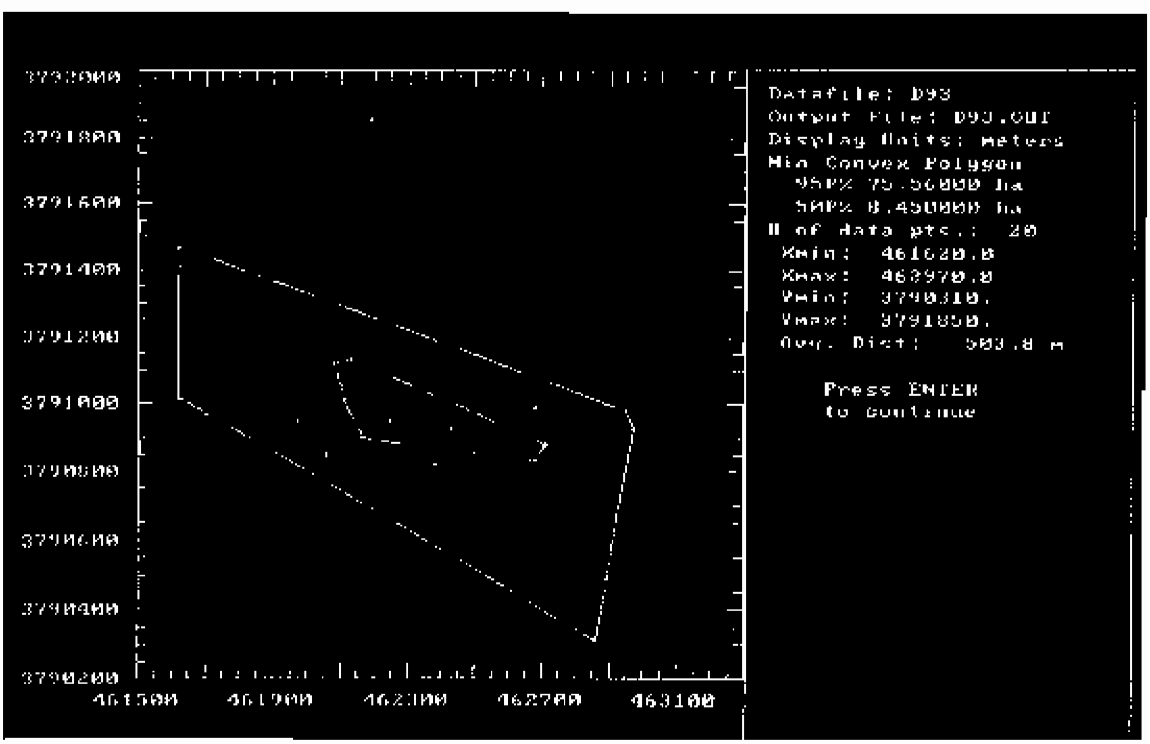
Deer #7, 50% and 95% MCP Hot/Dry seasonal home range on CRLRR, 1998.



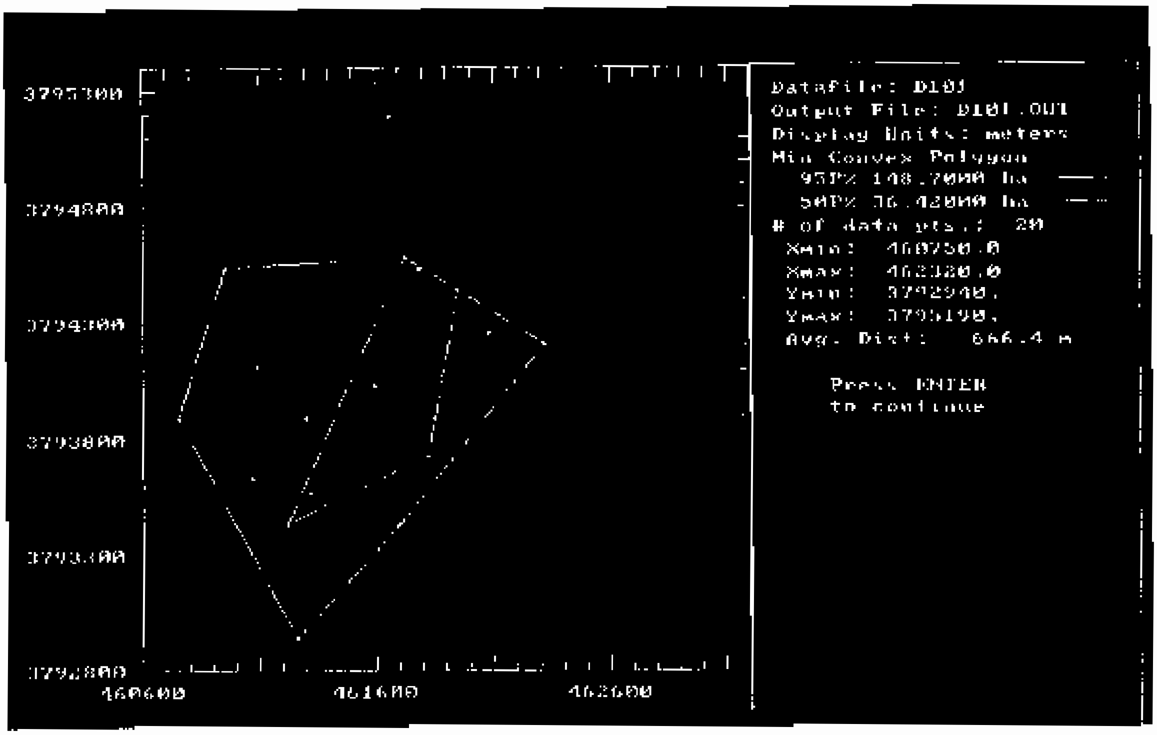
Deer #7, 50% and 95% MCP Hot/Wet seasonal home range on CRLRR, 1998.



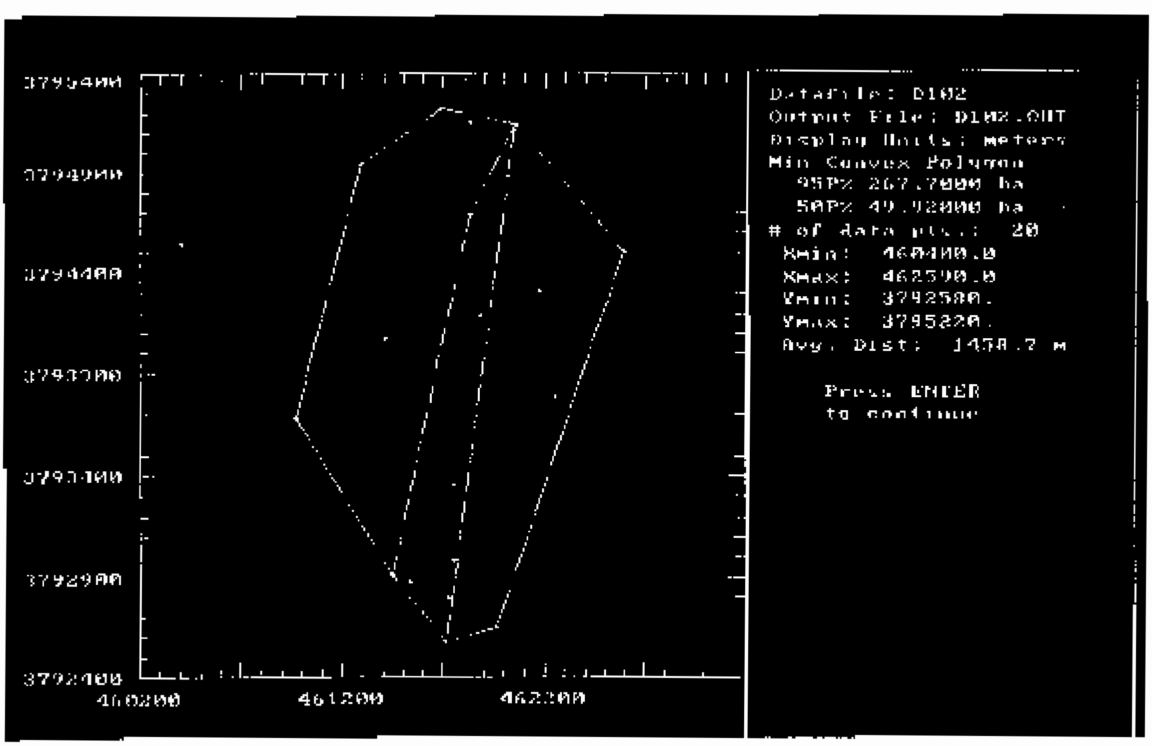
Deer #7, 50% and 95% MCP Cool seasonal home range on CRLRR, 1997-98.



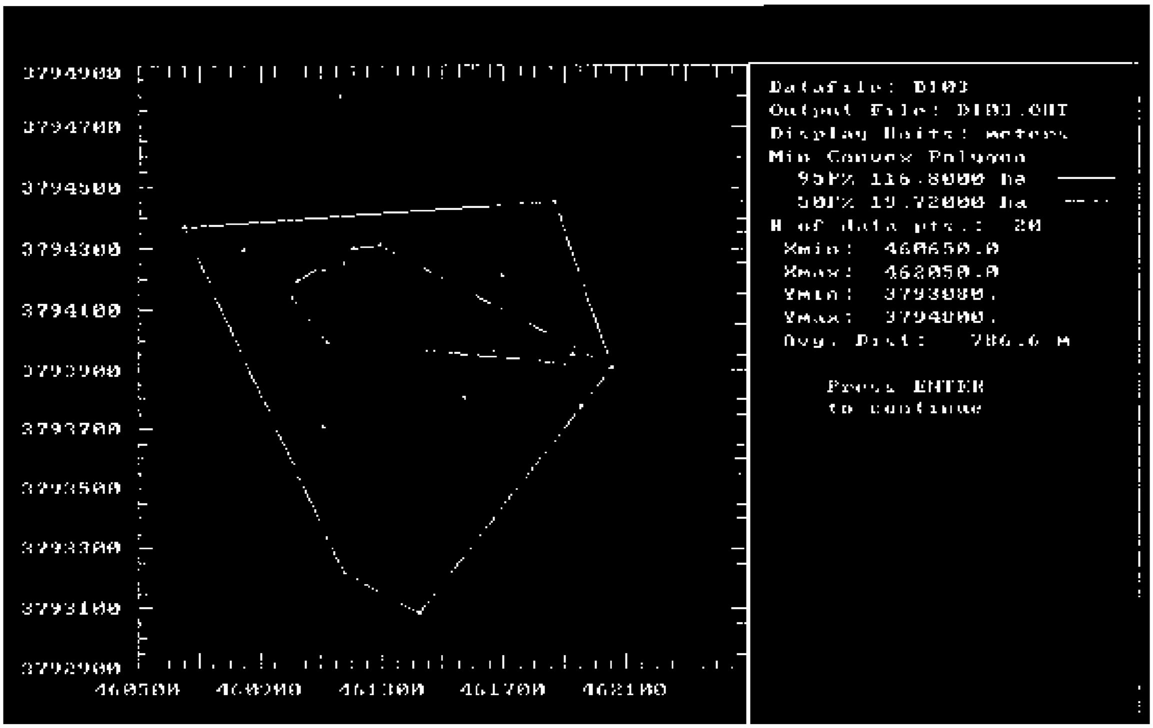
Deer #8, 50% and 95% MCP Hot/Dry seasonal home range on CRLRR, 1998.



Deer #8, 50% and 95% MCP Hot/Wet seasonal home range on CRLRR, 1998.



Deer #8, 50% and 95% MCP Cool seasonal home range on CRLRR, 1997-98.



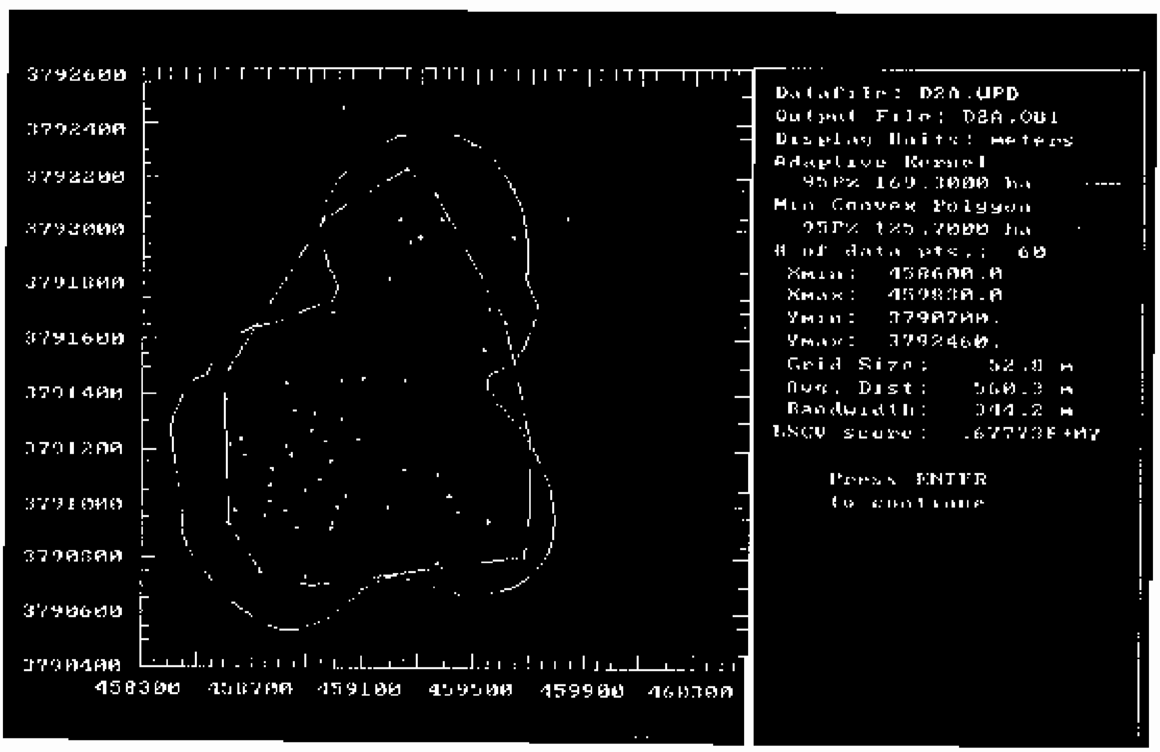
APPENDIX C

HOME RANGE ESTIMATORS COMPARISON: 95% ADAPTIVE KERNEL AND MINIMUM CONVEX POLYGON ANNUAL HOME RANGE OVERLAYS

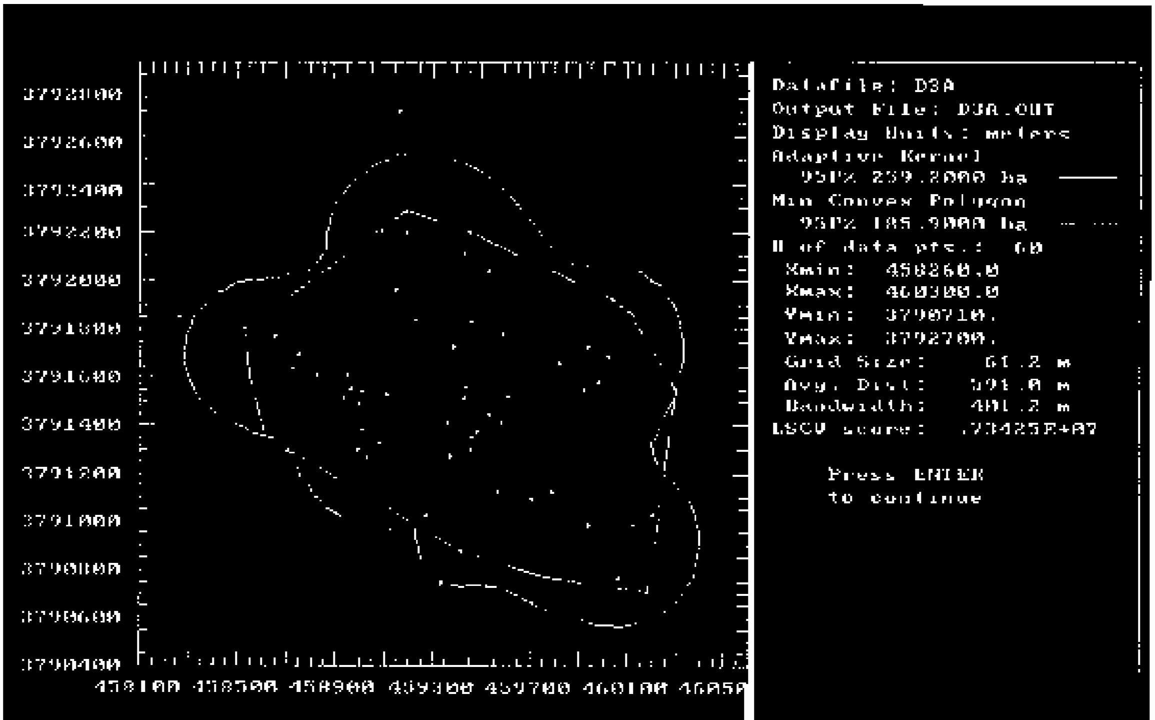
Minimum Convex Polygon Area............................... – – – – – – – – –

Adaptive Kernel Area.. ————————

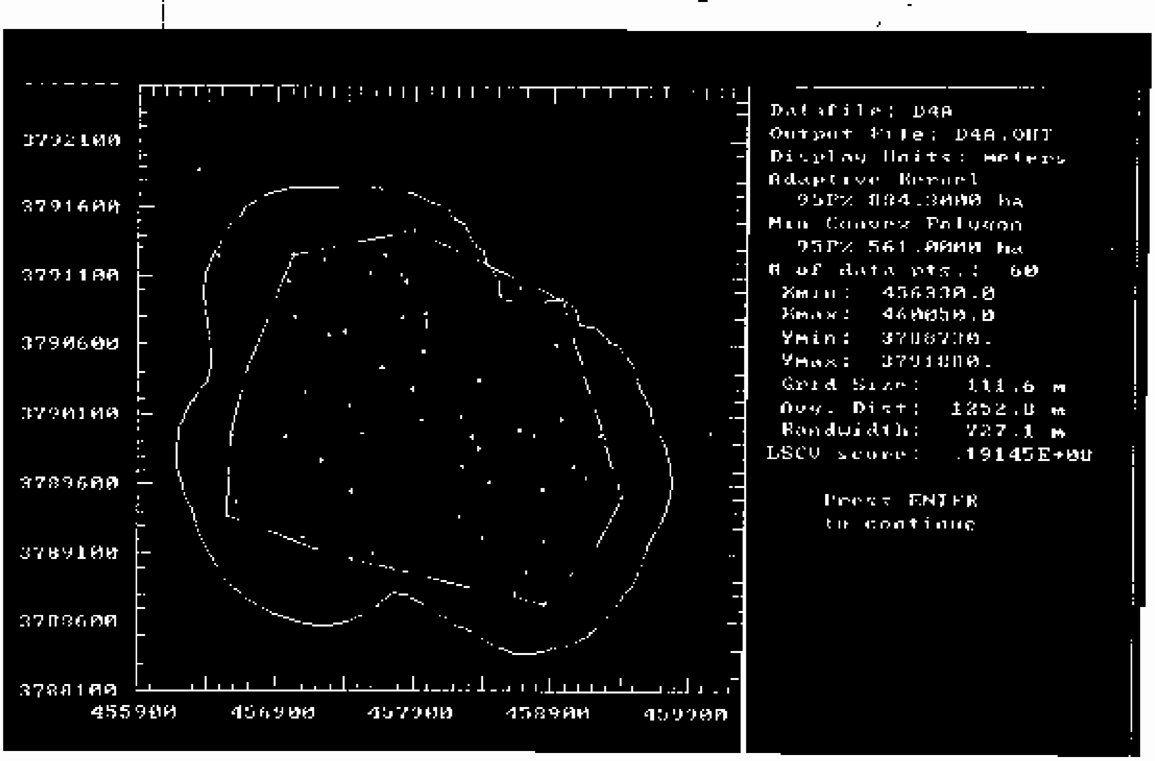
Deer #1, 95% AK and MCP annual home range on CRLRR, 1997-98.



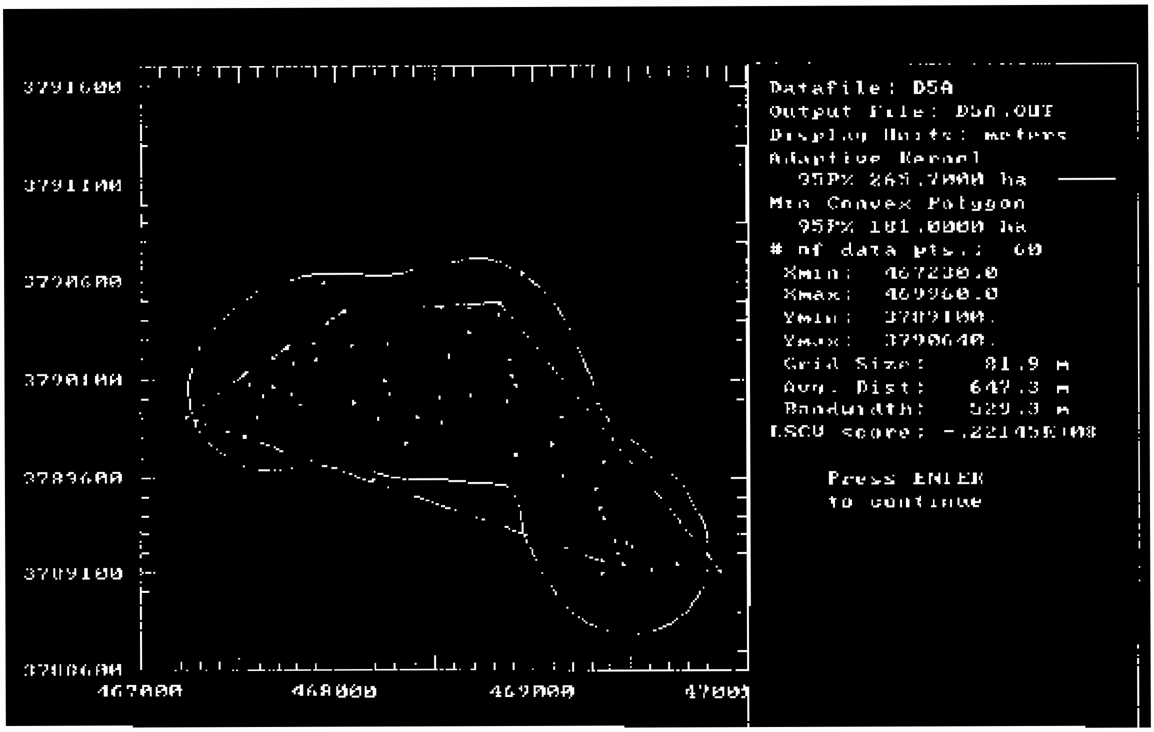
Deer #2, 95% AK and MCP annual home range on CRLRR, 1997-98.



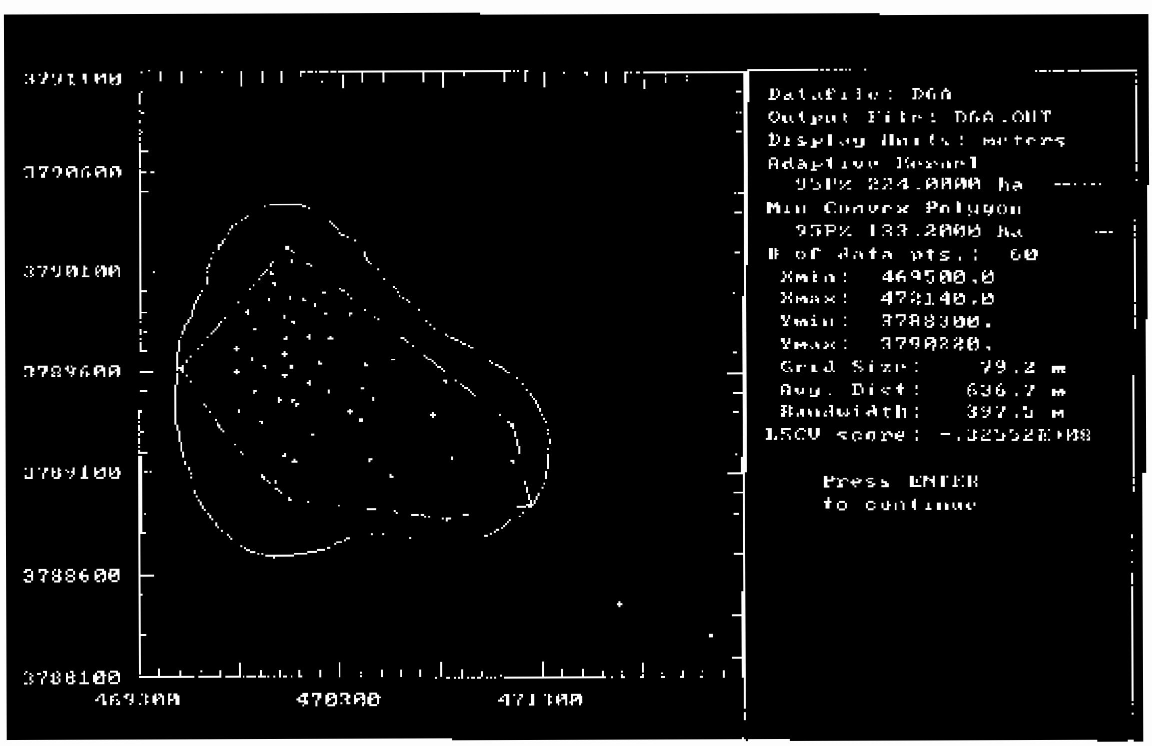
Deer #3, 95% AK and MCP annual home range on CRLRR, 1997-98.



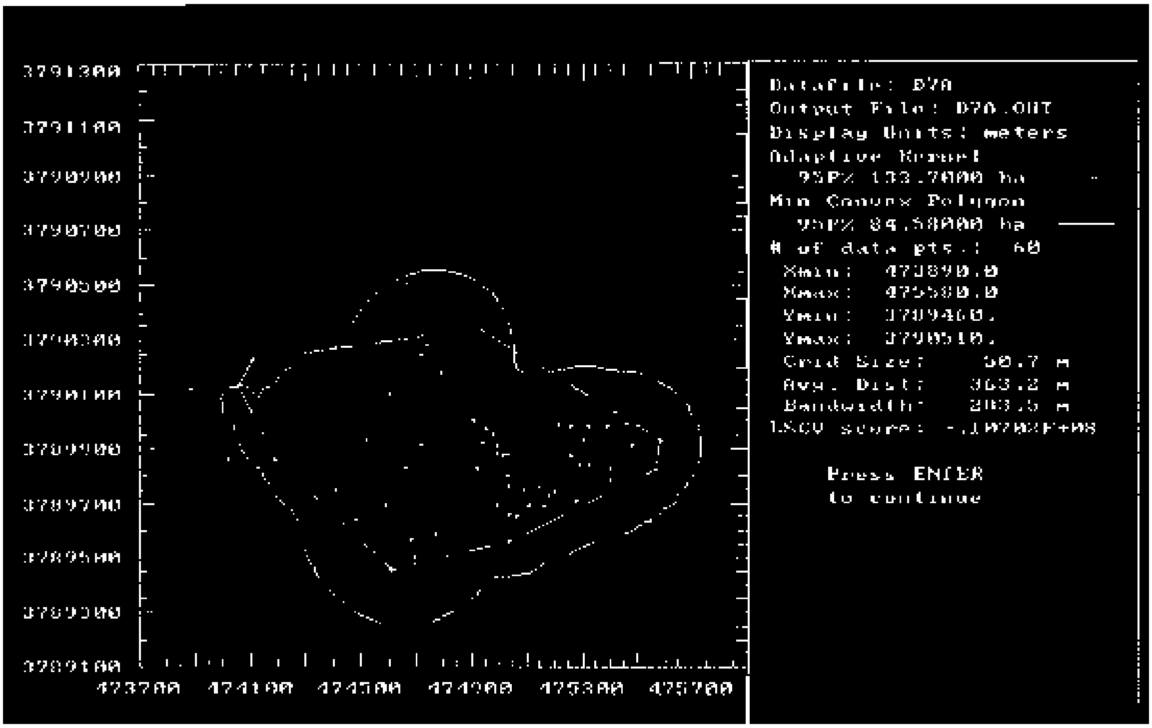
Deer #4, 95% AK and MCP annual home range on CRLRR, 1997-98.



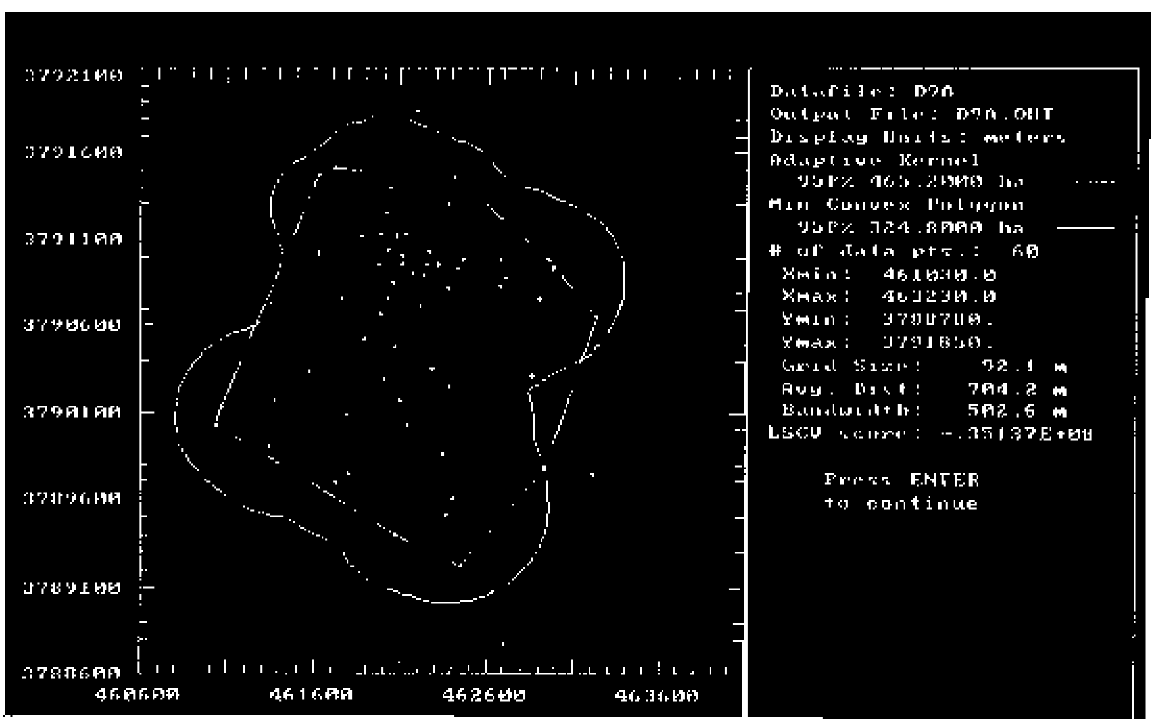
Deer #5, 95% AK and MCP annual home range on CRLRR, 1997-98.



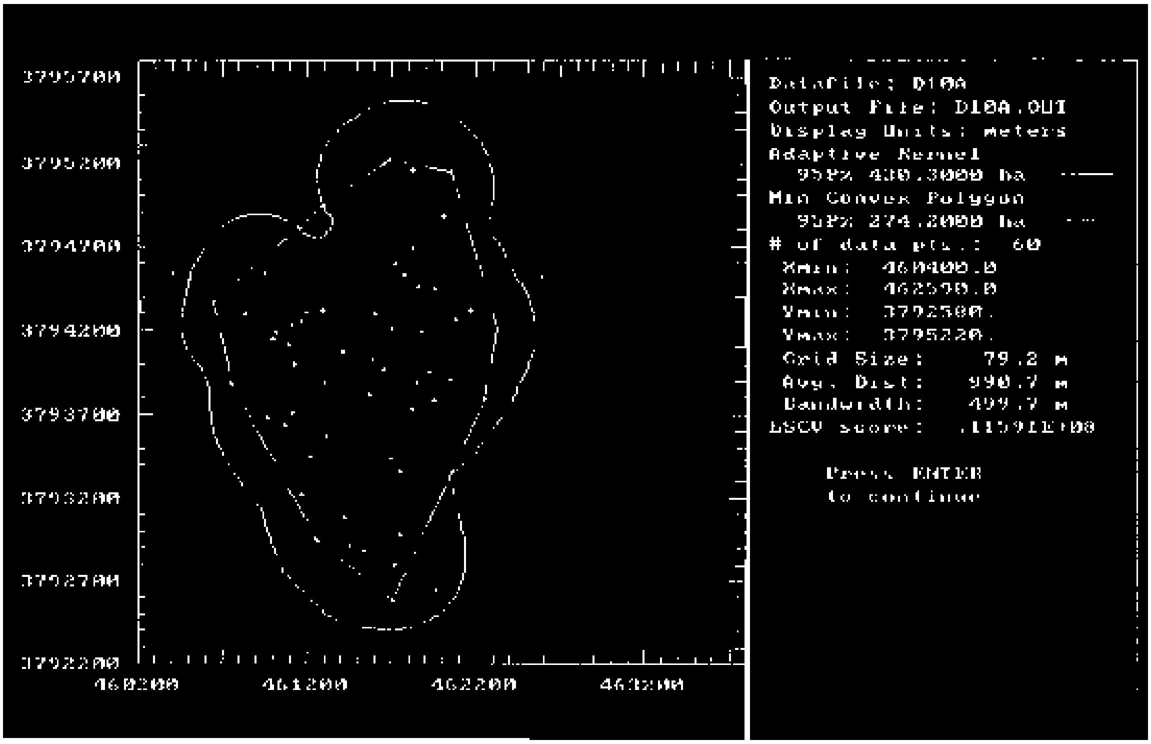
Deer #6, 95% AK and MCP annual home range on CRLRR, 1997-98.



Deer #7, 95% AK and MCP annual home range on CRLRR, 1997-98.



Deer #8, 95% AK and MCP annual home range on CRLRR, 1997-98.



LITERATURE CITED

Austin, D.D., and P.J. Urness. 1986. Effects of cattle grazing on mule deer diet and area selection. J. Range Manage. 39:18-21.

Bekoff, M., and L.D. Mech. 1984. Simulation analysis of space use: home range estimates, variability, and sample size. Behav. Res. Methods, Instruments, and Comput. 16:32-37.

Bernardo, D.J., B.W. Boudreau, and T.C. Bidwell. 1994. Economic tradeoffs between livestock grazing and wildlife habitat: a ranch-level analysis. Wildl. Soc. Bull. 22:393-402.

Berry, R.J. 1992. Initial mule deer herd study at the New Mexico State University Corona Research Ranch. M.S. Thesis, New Mexico State Univ., Las Cruces. 68pp.

Burt, W.H. 1943. Territoriality and home range concepts as applied to mammals. J. Mammal. 24:346-352.

Carpenter, L.H., and O.C. Wallmo. 1981. Habitat evaluation and management. Pages 399-422 *in* O.C. Wallmo, ed. Mule and black-tailed deer of North America. Univ. Nebraska Press, Lincoln.

Clary, W.P., M.B. Baker, P.F. O'Connell, T.N. Johnsen Jr., and R.E. Campbell. 1974. Effects of pinyon-juniper removal on natural resource products and uses in Arizona. USDA Forest Service Research Paper. RM-128. 28pp.

Del Frate, G.G. 1990. Home range, movements and characteristics of a coyote population in the northern Chihuahuan Desert. M.S. Thesis, New Mexico State Univ., Las Cruces. 85pp.

Dick-Peddie, W.A. 1993. New Mexico vegetation; past present and future. Univ. New Mexico Press, Albuquerque. 244pp.

Garrott, R.A., G.C. White, R.M. Bartmann, L.H. Carpenter, and A.W. Alldredge. 1987. Movements of female deer in northwest Colorado. J. Wildl. Manage. 51:634-643.

Harris, S., W.J. Cresswell, P.G. Forde, W.J. Trewhella, T. Woollard, and S. Wray. 1990. Home-range analysis using radio-tracking data – a review of problems and techniques particularly as applied to the study of mammals. Mammal Rev. 20:97-123.

Hart, C.R. 1992. Broom snakeweed [Gutierrezia sarothrae (Pursh) Britt. & Rusby] and associated herbage response to seasonal burning in New Mexico. Ph.D. Diss., New Mexico State University, Las Cruces. 128pp.

Howard, V.W., Jr., L.D. Cosper, and G.M. Southward. 1994. Seasonal deer and elk use of treated versus untreated pinyon-juniper habitat in western New Mexico. New Mexico Agric. Exp. Sta. Res. Rep. No. 691. 10pp.

Jackson, R.M., M. White, and F.F. Knowlton. 1972. Activity patterns of young white-tailed deer fawns in south Texas. Ecology 53:262-270.

Jennrich, R.I., and F.B. Turner. 1969. Measurement of non-circular home range. J. Theor. Biol. 22:227-237.

Joseph, J.O. 1995. Seasonal food habits of mule deer at the Corona Range and Livestock Research Ranch, central New Mexico. M.S. Thesis, New Mexico State Univ., Las Cruces. 56pp.

Kie, J.G., J.A. Baldwin, and C.J. Evans. 1994. CALHOME: home range analysis program. Electronic User's Manual. U.S. For. Serv., Fresno and Albany, Calif. 19pp.

Kie, J.G., J.A. Baldwin, and C.J. Evans. 1996. CALHOME: a program for estimating animal home ranges. Wildl. Soc. Bull. 24:342-344.

Kufeld, R.C., D.C. Bowden, and D.L. Schrupp. 1988. Influence of hunting on movements of female deer. J. Range Manage. 38:167-171.

Kunkel, K.E. 1984. Temperature and precipitation summaries for selected New Mexico locations. New Mexico Dept. Agric. 190pp.

Lair, H. 1987. Estimating the location of the focal center in red squirrel home ranges. Ecology 68:1092-1101.

Lawson, E.J., and A.R. Rodgers. 1997. Differences in home-range size computed in commonly used software programs. Wildl. Soc. Bull. 25:721-729.

Leopold, B.D., P.R. Krausman, and J.J. Hervert. 1984. Comment: the pellet-group census technique as an indicator of relative habitat use. Wildl. Soc. Bull. 12:325-326.

Loft, E.R., and J.G. Kie. 1988. Comparison of pellet-group and radio triangulation methods for assessing deer habitat use. J. Wildl. Manage. 52:524-527.

_____, J.W. Menke, and J.G. Kie. 1991. Habitat shifts by mule deer: the influence of cattle grazing. J. Wildl. Manage. 55:16-26.

Mackie, R.J. 1970. Range ecology and relations of mule deer, elk and cattle in the Missouri River Breaks, Montana. Wildl. Monogr. 20. 79pp.

Mohr, C.O. 1947. Table of equivalent populations of North American mammals. Am. Midland Nat. 37:223-249.

Moore, W.J. 1994. Preliminary evaluation of the Corona Range and Livestock Research Ranch mule deer herd. M.S. Thesis, New Mexico State Univ., Las Cruces. 65pp.

Morrill, W.I. 1988. Overview of wildlife ranching in the U.S.A. Pages 30-36 *in* R. Valdez. ed., and J. Knight tech. ed. Proc. Of the First International Wildlife Ranching Symposium. USDA Cooperative Extension Service, New Mexico State Univ., Las Cruces.

Ozoga, J.J., L.J. Verme, and C.S. Bienz. 1982. Parturition behavior and territoriality in white-tailed deer: impact on neonatal mortality. J. Wildl. Manage. 46:1-11.

Pederson, J.C., and K.T. Harper. 1984. Does summer range quality influence sex ratios among mule deer fawns in Utah? J. Range Manage. 37:64-66.

Pieper, R.D. 1983. Pinyon-juniper and juniper woodlands. in: Bartlett, E.T. and D.R. Betters (Tech. Coord.). Timber-forage interrelationships in western montane forests. West. Reg. Res. Bull. W-156. 37pp.

Riley, S.J., and A.R. Dodd. 1984. Summer movements, home range, habitat use, and behavior of mule deer fawns. J. Wildl. Manage. 48:1302-1310.

SAS Institute Inc. 1989. SAS/STAT® Users guide, version 6, fourth edition, volume 2, Cory, NC: SAS Institute Inc., 943pp.

Short, H.L., D.R. Deitz, and E.E. Remmenga. 1966. Selected nutrients in mule deer browse plants. Ecology 47:222-229.

_____, H.L., W. Evans, and E.L. Boeker. 1977. The use of natural and modified pinyon-juniper woodlands by deer and elk. J. Wildl. Manage. 41:543-559.

Smallidge, S.T. 1997. The Corona Range and Livestock Research Ranch mule deer study. M.S. Thesis, New Mexico State Univ., Las Cruces. 65pp.

Steerey, W. 1979. Distribution, range use, and population characteristics of mule deer associated with the Schafer Creek winter range, Bridger Mountains, Montana. M.S. Thesis, Montana State Univ., Bozeman. 119pp.

Wallmo, O.C. 1973. Important game animals and related recreation in arid shrublands of the United States. Proc. Workshop U.S. /Austral. Rangelands Panel 3:98-107.

_____, O.C., L.H. Carpenter, W.L. Regelin, R.B. Gill, and D.L. Baker. 1977. Evaluation of deer habitat on a nutritional basis. J. Range Manage. 30:122-127.

White, G.C., and R.A. Garrott. 1990. Analysis of wildlife radio-tracking data. Academic Press, San Diego, CA. 383pp.

Worton, B.J. 1987. A review of models of home range for animal movement. Ecol. modeling 38:277-298.

_____. 1989. Kernel methods for estimating the utilization distribution in home-range studies. Ecology 70:164-168.

_____. 1995. Using Monte Carlo simulation to evaluate kernel-based homerange estimators. J. Wildl. Manage. 59:794-800.