USER'S MANUAL FOR PROGRAM HOME RANGE

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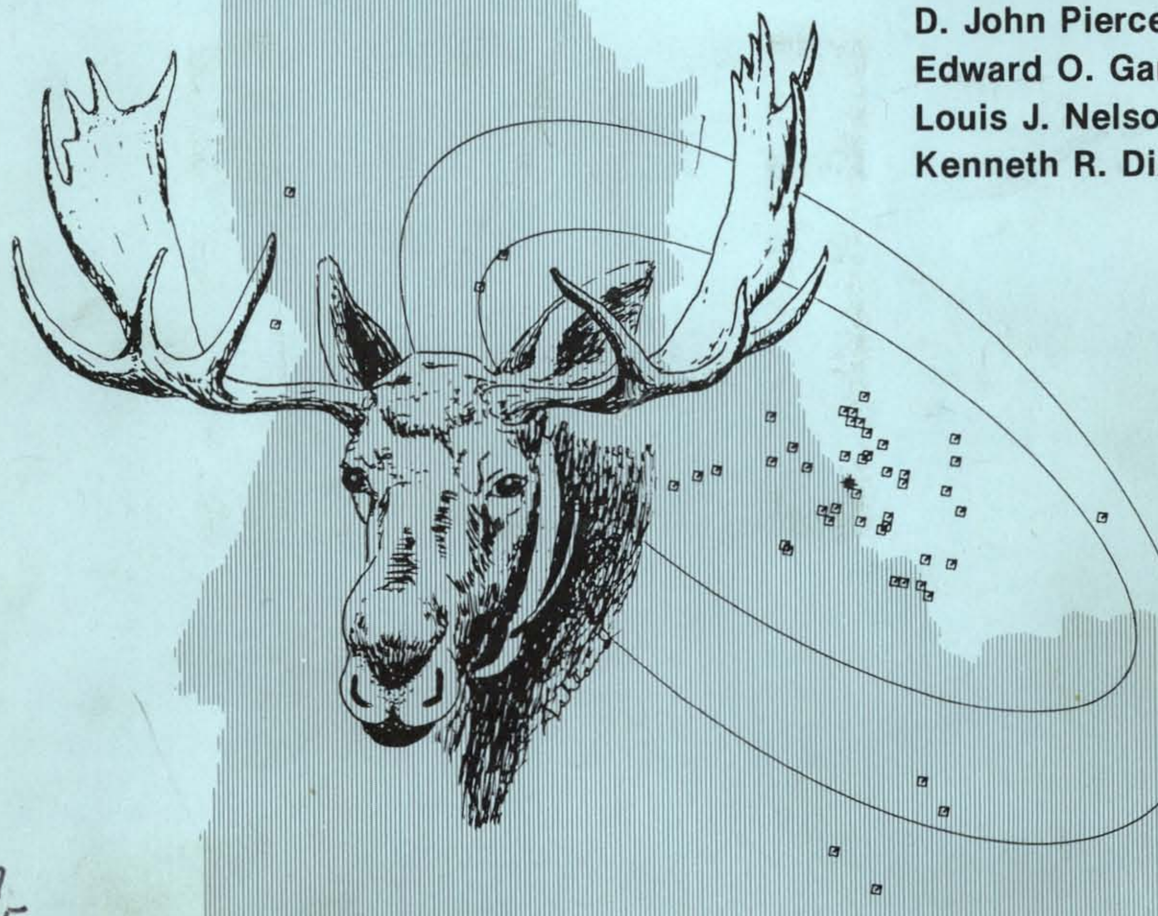

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by

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Initial versions of the main program and several subroutines were developed or modified at the University of Maryland by K. Orhelein. Computer routines to draw contours were originally developed by J.S. Crowell. Development of several statistical procedures benefited from discussions with R.K. Steinhorst and C. Potratz at the University of Idaho. Computer time for this project was provided by the Computer Center, University of Idaho.

INTRODUCTION

Home range has been defined as the area utilized by an individual during its normal activities such as food gathering, mating, and caring for young (Burt 1943). The methods for calculating this area can be classified as statistical or non-statistical (Dixon and Chapman 1980). A variety of methods have been commonly used in the literature including convex polygon (Hayne 1949) and non-circular home range (Jennrich and Turner 1969). Recent papers have identified several problems with these commonly used techniques (Schoener 1981, Anderson 1982). Other techniques employ the concept of calculating a utilization distribution based on frequency of animal locations (Anderson 1982, Ford and Krumme 1979). The HOME RANGE program was developed to provide home range estimates based on an extension of the harmonic mean measure of activity (Dixon and Chapman 1980) and other commonly used methods, and to test the assumptions of these methods.

HOME RANGE differs from the original program of Dixon and Chapman (1980) in several important ways: 1) animal observations are relocated to a mean distance from the nearest grid point, 2) this distance is the mean radius of the grid and thus harmonic calculations depend on the grid size, 3) a utilization distribution is produced from the harmonic mean measure at grid points, 4) utilization contours may be estimated as percentiles of this distribution, 5) biases resulting from changes of scaling factors have been minimized, 6) density of grid points for harmonic mean calculations may be increased, 7) outlier locations are identified, and 8) core areas are identified and plotted. In addition, the program computes the minimum convex polygon, non-circular home range, and a robust non-circular home range (Samuel and Garton in prep) for comparison. Animal locations may be tested for bivariate normality using a two-dimensional Kolmogorov goodness-of-fit test. The robust non-circular home range uses maximum likelihood type estimators to identify possible outliers and calculate home range. This weighted distribution may also be tested for bivariate normality.

Dixon and Chapman (1980) recommended that observations within one unit of distance to a grid point should be biased by adding one. This procedure has several disadvantages. First, the bias is not independent of scale. The addition of one unit may be appropriate for small harmonic values, but inappropriate for animals with large home ranges. Second, if observations are close to a grid point the use of a small bias causes the bias factor to overwhelm the harmonic calculation. A more suitable bias should incorporate the scale of the home range being estimated. HOME RANGE relocates all observations to a mean distance from the nearest grid point. This distance is the radius that encompasses half the area of the grid. Thus, the bias automatically changes with grid size and scale variations.

The determination of a utilization distribution requires estimating the probability of use at any location in the home range. The harmonic values at each grid point may be used to calculate a utilization distribution. All grid points with harmonic values that exceed the maximum for any animal location are considered to be outside the home range. These are excluded from the utilization distribution. The potential utilization (observations/area) is estimated at each grid point by dividing the total number of animal locations by the squared harmonic value at the grid point. Potential utilization is summed over all grid points within the home range and scaled to 1.0 to create a utilization distribution. Percentages of the utilization distribution are determined from the ordered sum of grid points.

The concept of core areas has recieved considerable use in the ecological literature. The idea has generally been used to denote central areas of consistent or intense use (Kaufmann 1962:170). However, a quantitative definition is noticably absent. Core areas in the HOME RANGE program are defined as the maximum area where the observed utilization distribution exceeds a uniform utilization distribution. The uniform distribution is used as the null model since it indicates a lack of preference for areas within the home range. A Kolmogorov test (D+, p=.05) is used to determine if observed use is significantly greater than expected. The test is made on the ordered cumulative distribution of the observed data and the uniform model. Test criteria that correct for sample size (Stephens 1974) are used in the program. An illustration of the statistical test and further description of the methods is presented in Samuel et al. (in prep.).

PROGRAM APPLICATION

Determination of an animal's activity patterns is an iterative process. The nature of the location data, sampling intensity, and scope of the home range analysis deserve careful consideration. The delineation of activity areas separate from the home range boundary necessitate a more detailed consideration of sampling biases and limitations. We have identified two areas where inappropriate data can strongly influence the size and shape of estimated activity areas.

One concern is the data collection proceedure. Only those locations that meet the implied assumptions should be included in the analysis. The first assumption requires that locations be independent from each other. This assumption is frequently violated when data are collected by repeated observations seperated by relatively short time intervals. This problem is especially critical when sampling efforts are not equally distributed through time. For example: an animal was radio-located on two consecutive days. On the first day the researcher spent the entire day with the animal recording locations every hour. At the end of the day 10 relocations were collected. On the second day the researcher only located the animal once in the morning and once in the evening; the rest of the day was spent locating other individuals. If all data were entered 12 relocations would define the animal's home range for those two days. The data from the first day would weight the importance of use on that area heavier than that for the area used on the second day, when in fact an equal amount of time (one day) was spent in each area.

A second related assumption is that the probability of detecting an animal in any part of its home range is proportional to the amount of time the animal spends in that area. This assumption may be frequently violated when data is collected while radio tracking from the ground in relatively inaccessible areas. Data collected from animals with large home ranges are also susceptible to violating this assumption. When biologists are more apt to locate animals that are close to roads or trails the estimate of potential use for these accessible areas will be biased. This should not be a significant problem with data collected from an airplane. Similarly researchers may be tempted to oversample areas where animals are easiest to locate (e.g. nest or denning sites). The usual approach is to locate an animal as many times as possible. While many relocations are obviously desirable, effort must be tempered by techniques that reduce the biases associated with sampling procedures.

Locations which violates these assumptions cause areas of high potential use to be identified, reflecting data collection proceedures and not animal behavior. It is extremely important that the user attempting to describe activity areas identify sources of bias and remove inappropriate data from the analysis. If not results from the HOME RANGE program may be totally misleading.

Extreme locations is the second area where inappropriate data dramatically affects home range estimates. Outliers frequently represent transiticnal locations between seasonal use areas or one time excursions to areas beyond the boundaries of the normal home range. Outliers influence home range estimates using convex polygon, nonweighted probability ellipse, and harmonic mean techniques. The inclusion of outlying points results in a substantial area included in the home range boundary which may be outside areas normally used by the individual. The HOME RANGE program helps to identify these outliers through three different procedures: 1) a binomial test of observation density, 2) a weighted bivariate normal technique, and 3) a list of points with large harmonic values. We suggest that these procedures be used to identify data errors and to assist in the identification of observations that are outside the normal use area.

If the biologist is interested in identifying the area in which an animal repeatedly confines it's daily activities, outlying points should be excluded from the home range analysis. By this definition occassional excursions outside the "normal" area of use is not considered part of the home range (see Burt 1943). If on the other hand the goal is to define total areas of potential use outliers should remain in the analysis. This latter approach was used to describe total seasonal use areas of moose by combining data from multiple years (Pierce 1983). In this case the objective was to identify yearly shifts of activity centers within the total area of potential use.

Contours that are chosen based upon the utilization distribution define areas that encompass a percentage of the total potential use. Outlying points have a dramatic affect on the large percentage contours (e.g. 95%), but usually have smaller influence on the selection of lower percentage contours (e.g. 75%). Outliers tend to have less of an influence with large sample sizes than with small sample sizes, especially for the harmonic mean technique. Outliers also affect the selection of core use areas.

Once the user decides which data to include in the analysis he/she must determine the scale and grid density that will be used when calculating harmonic mean home range estimates. Decreasing the grid density or increasing the number of units/inch on the X,Y axes (i.e. scale) results in locations being concentrated around fewer grid points. The result is a reduced ability to distinguish between areas of different potential use. Separate centers of activity become increasingly difficult to distinguish by this effect. Convsersely, the points may become so widely separated that the observations have no influence on each other (see Anderson 1982: fig. 1). As a general rule, we feel that scale, units per inch, should first be selected to result in a large dispersion of locations without exceeding the limit of the plotter boundaries and at a convient scale for transfer to habitat maps or aerial photos. Next, grid density should be selected to achieve an average of one observation per grid point. This can be accomplished by the following algorithm.

a) calculate the number of effective points (EP) from the total points (TP) and the number of points defining the perimeter of the convex polygon home range.

EP = (TP - PP) + .25 (PP)

b) calculate the average area per grid point (AVG) from the minimum convex polygon (MCP) area and the number of effective points.

AVG = MCP area / EP

c) calculate the grid width (GW) per point by

GW = SQRT(AVG)

d) no. of grid points on the X axis is

(units per inch / GW) * 24

e) no. of grid points on the Y axis is

(units per inch / GW) * 10.5

The results are rounded to the lower integer value and input on the program selection card (page 14). Also see example 4.

PROGRAM OVERVIEW

Five sections of program input and output occur during a run: program control, data input, print output, data output, and plot output. Program control consists of six subsections that provide a title for the run, select program options, provide scale information to the program, report the method used for entering animal locations, choose the plot offset, and determine the values of contours to be plotted. Data input contains format specifications and animal locations, according to the method selected in program control. Printed output summarizes the options selected, lists animal locations for verification, provides data on harmonic values, and shows home range estimates for the methods selected. Data output is designed for use in secondary analysis of home range calculations. Two computer files may be produced. One file contains the grid point coordinates rescaled in inches from the plot origin. The second file contains the harmonic values calculated at each grid point. The final output is a plot of animal locations and selected home range estimates. Each input and output phase is described in the following sections.

PROGRAM OPTIONS

The HOME RANGE program features seven basic options for calculating various aspects of home range use patterns. These features may be selected in total or in subsets as specified on the SELECT card. The options chosen may vary depending upon the quantity and quality of data acquired, user objectives, and interpretational insight. A brief discussion of each option and pertinent literature sources follows to aid in the selection process.

Utilization Contours

These contours are based on the harmonic means calculated at grid points systematically located throughout the animal's home range. Harmonic means are one of several areal distributions described in detail by Neft (1966). The advantages and applications of harmonic means as a measure of activity are discussed by Dixcn and Chapman (1980). The contours may be chosen as a specified harmonic value (Dixon and Chapman 1980) or as a specified percentage of the animal's utilization distribution. The concept of utilization distribution is discussed by Van Winkle (1975) and Anderson (1982).

Weighted Non-circular Home Range

This technique is a variation of the standard non-circular home range approach developed by Jennrich and Turner (1969). A bivariate normal distribution of animal locations is assumed, but loci that are far removed from the geometric center have a reduced influence on the home range ellipse. The home range estimate uses the weighting procedure reported by Randles et al. (1978). Details of the procedure and an example of the influence of outlying points on the size and orientation of the home range estimate is given in Samuel and Garton (in prep.).

Core Areas

The existance of core areas within an animal's home range was formalized by Kaufmann (1962). Ewer (1968) provides additional description of these areas of intense use. HOME RANGE identifies core areas by comparing the utilization distribution from harmonic mean calculations with a uniform use model (Samuel et al. in prep.). The identification of core areas is an effort to describe the "internal anatomy" of home ranges (Adams and Davis 1967, Leuthold 1977).

Outliers

Extreme locations may have a substantial influence on the home range determination. Outlier locations are identified (but not excluded from analysis) by a statistical confidence interval test. The test compares a relative measure of location density between progressively less extreme locations in the data. Significant changes in the relative density are used to identify potential outliers. Exclusion of these points from the input data set is required to remove their influence on the home range estimates.

Non-circular Home Range

This is the traditional bivariate normal approach to home range analysis developed by Jennrich and Turner (1969). Schoener (1981) and Anderson (1982) provide some valuable critiques on the method.

Bivariate Distribution Test

Animal locations may be tested for bivariate normality or uniformity using a Kolmogorov goodness-of-fit test. The two dimensional test is accomplished by transforming the loci into principal component scores (Koeppl et al. 1975, Morrison 1976: Chapter 8, Smith 1983). See Saunders and Laud (1980) for a discussion of the appropriatness of using the Kolmogorov test in a multidimensional context. Critical values for the test are calculated using the more powerful EDF procedures (Stephens 1974) rather than a chi-squared test (Smith 1983). The traditional D statistic and a Kuiper V statistic are calculated to test bivariate distributions. A detailed example of the test and its application is presented in Samuel and Garton (in prep.).

Convex Polygon

The final home range calculation uses the convex polygon estimator (Hayne 1949). The program reports the area and perimeter points for this method. The home range may be plotted by connecting the perimeter points.

PROGRAM CONTROL

Program control is comprised of six input sections that direct program execution and options. Cards must be ordered in the sequence of title card, selection card, scale card, method card, offset card, and contour cards.

Title Card

The title card is an alphanumeric string of 40 characters that will be displayed on print and plot output.

Format	(A5,5X,5A8)
Col 1 - 10	TITLE
Col 11 - 50	Title

Col 1-10. 'TITLE'

Col 11-50. Alphanumeric string to be displayed on plot output.

Selection Card

The selection card indicates those options and calculations that should be performed.

Format	(A6,4X,7I1,2I5)
Col 1 - 10	SELECT
Col 11	'0' Only plot animal locations
	'1' To plot contours
	'2' Suppress harmonic mean calculation
Col 12	'1' to plot weighted non-circular home range

Col 13	'1' To plot core areas
Col 14	'1' To identify outliers
Col 15	'1' To plot non-circular home range
Col 16	'1' To test for bivariate normality
Col 17	"1' To estimate minimum convex polygon
Col 18 - 22	No. of grid points on X axis
Col 23 - 27	No. of grid points on Y axis

Col 1-10. 'SELECT'

Col 11. Animal locations are always plotted. When Col 11 = '1' the contours specified by the contour cards are also plotted. Core areas will not be plotted if contours are not selected. When Col 11 = '2' the animal locations are plotted, but calculation of harmonic means at each grid point is suppressed. Contours and animal locations are plotted in black ink.

Col 12. If Col 12 = '1' then the 95% robust non-circular home range is plotted in red ink. The robust non-circular home range will be calculated when Col 12 = '1' or Col 16 = '1'. Weighted points are identified.

Col 13. The maximum area that meets the definition of a core area will be plotted. No plot will occur if the area is not significantly different from uniform (p = .10). Core areas are added to the list of contours to be plotted. Core areas will not be estimated unless the contour cards specify values less than 1.0 for all selected contours.

Col 14. When Col 14 = '1' animal observations that may be outliers are identified. Outliers are tested using a binomial model of the percentage of error polygons containing observations. Observations are tested in decreasing harmonic mean order. A one-tailed 95% confidence interval test is made to identify significant changes in the precent of error polygons with observations. Outlier points are not removed from harmonic mean calculations. Outliers will be identified only when all contours are percentiles of the utilization distribution (contour values less than 1.0).

Col 15. If Col 15 = '1' then the 95% non-circular home range is plotted in green ink. The non-circular home range wil be calculated when Col 15 = '1' or Col 16 = '1'.

Col 16. A test for bivariate normality is made on both the robust and non-circular home ranges when Col 16 = '1'. For the robust test a 90% truncated distribution is compared to the unweighted observed distribution. A test for bivariate uniform distribution is also calculated.

Col 17. The minimum convex polygon area is estimated when Col 17 = '1'. The area and perimeter points are calculated. The area is not plotted, but may be easily drawn from the perimeter points.

Col 18-22. The number of grid points on the X-axis is set to 48 if this value is zero. A higher or lower grid point density may be specified. Higher grid densities will facilitate location of the harmonic mean center and more accurate plotting of contour levels. It will also result in an increase in CPU time necessary to make the calculations. Changes from the default of 48 must be accompanied by a corresponding ratio change in the Y-axis. If the X-axis is set at 72, Y must be set at 32, a 50% increase in both axes (see Col 23-27 below). The maximum number of grid points on the X-axis is 72.

Col 23-27. Same as Col 18-22, but for the Y-axis. The default is 21 grid points. A change in grid density along the Y-axis must be accompanied by a proportional change in grid density on the X-axis. The maximum number of grid points on the Y-axis is 32.

Scale Card

The scale card supplies information on the units of data measurement, the number of units per plot inch, and the error polygon size.

Format	(A5,5X,2A6,1X,F7.4,1X,F10.5)
Col 1 - 10	SCALE
Col 11 - 22	Units of measurement of X and Y coordinates (ex. meters, kilometers)
Col 24 - 30	No. of units per plot inch
Col 32 - 41	Min. distance between observations

Col 1-10. 'SCALE'

Col 11-22. The dimension for the scale of the units of measurement (eg., feet, meters, or kilometers). Areas reported in the program output are in these units squared (square feet, square meters, or square kilometers).

Col 24-30. Number of measurement units per plot inch. This parameter scales the length of the X and Y axes. The axes are 24 and 10 inches respectively. Data should be input so that the greatest range in the data occurs along the X-axis. Users should make the scale as large as possible, but still include all observations and contours on the plot.

Col 32-41. The minimum distance between observations is required to estimate an average error polygon. Error polygons are treated as simple squares with this distance being equal to one side. The distance value must be greater than 3 units, otherwise calculations for the harmonic means will be biased. Distances are the same units of measure as Col 11-22.

Method Card

The method card indicates the manner in which the animal locations were recorded. One of three different methods must be selected.

Format (A6,4X,A6)

Col 1 - 10 METHOD

Col 11 - 16 Method of data entry

'ENTER'

'EVAL 1'

'EVAL 2'

Col 1-10. 'METHOD'

Col 11-16. The method of data entry describes how the animal locations were recorded. The 'ENTER' method indicates that the X,Y coordinates of the animal have already been calculated. The 'EVAL 1' method assumes that the X,Y coordinates of a station, the angle, and distance of each location are recorded. 'EVAL 2' assumes that two stations and angles are recorded for each animal location. See the Data Input section for a discussion of information required for each method.

Offset Card

The offset card provides an option to either center the animal locations in the plot or to offset the minimum animal location relative to the plot origin.

Format	(A6,4X,F10.2,2X,F10.2,2x,A6)
Col 1 - 10	OFFSET
Col 11 - 20	X offset in same units of data
Col 23 - 32	Y offset in same units of data
Col 35 - 40	'CENTER' for automatic centering

Col 1-10. 'OFFSET'

Col 11-20. The number of units from the origin that the location with the minimum X coordinate will be offset.

Col 23-32. The number of units from the origin that the location with the minimum Y coordinate will be offset.

Col 35-40. If center is specified the animal locations are centered on the plot. X and Y axis offsets are ignored when centering is specified. The centering option requires an interative procedure that increases run cost.

Contour Cards

The first contour card defines the number of utilization contours to be plotted. A subsequent card is required for each contour level plotted. These cards define the value of the contours. When all contour values are less than 1.0 they are treated as percentages of the utilization distribution. For example, a single value of .95 plots the harmonic mean contour that encloses 95% of the utilization volume. Any value greater than or equal to 1.0 causes the contours to be plotted as actual harmonic mean values. Thus, specific harmonic mean contours may be requested, i.e., 20, 40, and 60. A maximum of 100 contours are allowed.

Contour Card 1.

Format (A7,3X,I3)

Col 1 - 10 CONTOUR

Col 11 - 13 No. of contour levels

Col 1-10. 'CONTOUR'

Col 11-13. Number of contour levels to be plotted.

Subsequent contour cards. As many cards as idicated in Col 11-13 of previous card.

Format (F10.4)

Col 1 - 10 Contour level

DATA INPUT

Data cards immediately follow the last contour card. The first input card is a format of the observations that follow. A maximum of 1000 animal locations are allowed. The number of elements contained on each data card is determined by the program control method card.

Format Card

This card specifies the format for reading all subsequent data cards.

Format (A6,12A6)

Col 1 - 6 FORMAT

Col 7 - 78 Format of data to be entered

Col 1-6. 'FORMAT'

Col 7-78. Format for data input (see examples).

Data Cards

One card for each animal location. Up to 1000 locations.

Format (Defined by format card)

Method Options

The three methods of data entry are described in the program control section (Methods Card). Each method requires a different number of data elements that are described below. Data elements should be input in the order specified. ID's are not used in any program computations and are designed for user convience only. An ID element must be entered, but it may be a blank field.

ENTER option. This option assumes that the grid coordinates of the animal locations have already been calculated. Data elements are input as follows:

1) X coordinate
2) Y coordinate
3) observation ID

EVAL1 option. This option assumes that the X,Y coordinates of a station, the angle, and the distance to the animal's location are known. Trigonometric functions are used to find the X,Y grid coordinates of animal locations. Data elements are input as follows:

1) X coordinate
2) Y coordinate
3) angle (in degrees) measured counter-clockwise from the positive X-axis
4) distance
5) observation ID

EVAL2 option. This option assumes that two stations are used in determining animal locations. Each station is assumed to triangulate to the animal location. Data is input in the following order:

1) X coordinate of first station
2) Y coordinate of first station
3) angle (in degrees) measured counter-clockwise

from the positive x-axis

4) X coordinate of second station

5) Y coordinate of second station

6) angle (in degrees) measured counter-clockwise from positive X-axis

7) observation ID

DATA OUTPUT

Print output and plot output are described below in the Examples section. This section covers the computer generated data sets that are available from the program. The first output data file (22) provides a list of the grid locations scaled in inches and the same points translated to the plot origin. A second file (25) reports the calculated harmonic values at each grid location. The grid point harmonic values lower than the maximum observation may be squared and inverted (TOTAL OBSERVATIONS/H**2) to determine the relative utilization volume associated with each grid.

Grid Locations File (22)

The first card reports the plotter inches per grid point.

Format (21X,F9.4,8x,F9.4)

Col 22 - 30 No. of plot inches per X-axis grid point

Col 39 - 47 No. of plot inches per Y-axis grid point

Subsequent cards list the X,Y coordinate values.

Format (2X,I2,2X,I2,3X,F9.4,3X,F9.4)

Col 3 - 4 I index

Col 7 - 8 J index

Col 12 - 20 X(I,J) coordinate value in inches

Col 24 - 32 Y(I,J) coordinate value in inches

Harmonic Mean File (25)

Each output card lists the harmonic means for each grid location.

Format (1X,F10.2,1X,F10.2,1X,F3.0,1X,F3.0,1X,F10.3)

Col 2 - 11	X(I,J) coordinate
Col 13 - 22	Y(I,J) coordinate
Col 24 - 26	I index
Col 28 - 30	J index
Col 32 - 41	Harmonic (I,J) value

The harmonic mean file may be used to generate a 3-dimensional plot of the utilization distribution. Example 5 shows the SAS/GRAPH procedures necessary to produce a utilization plot.

EXAMPLES

Four examples are shown to illustrate the options available in the HOME RANGE program. All the examples are based on the home range estimate of a single animal (moose 33) during the summer. Data for the relocations are listed in example 1, but deleted from all other examples. The data from example 1 should to used to check proper implementation of the home range program. The year and julian date are used as the observation id. The first example illustrates the bivariate normal and minimum convex polygon approach. The second example shows the use of a single contour to encompass a percentage of the relocations. Example 3 chooses contours based on percentages of the activity distribution. Example 4 follows example 3, but shows the home range by choosing the grid density recommended in the program overview section. Example 5 uses the SAS/GRAPH procedure G3D (Council and Helwig 1981) to show the utilization distribution in 3-dimensions.

Example 1

Input

```
TITLE      MOOSE 33 - SUMMER
SELECT     0100111
SCALE      METERS         2000.0  200.0
METHOD     ENTER
OFFSET     10000.        3000.0
CONTOUR    002
0.75
0.95
FORMAT     (F7.0,2X,F6.0,2X,A5)
5082400  624600  81230
5082500  623600  81231
5082400  623600  81232
5085000  628000  79176
5082000  625800  79184
5084200  625600  79189
5079400  624400  79199
5082400  625000  79204
5081600  624600  79211
5073200  620400  79219
5083200  626200  79224
5083000  625200  79227
5082600  626800  79240
5081400  625600  79247
5074800  619000  79255
5081200  626000  79261
5082200  625000  79269
5083900  625300  81175
5084200  625000  81182
5081200  625600  81189
5082700  625700  81203
5083600  626200  81210
5083100  625100  81215
5080700  623100  81222
5083100  625000  81229
5081500  625700  81238
5082600  625800  81244
5081300  625700  81251
5082000  625500  81257
5084000  624800  80183
5082800  624800  80183
5082500  624400  80189
5080800  623400  80202
5087400  623200  80227
5082400  625600  80234
5082900  626600  80263
5077000  622600  79158
```

```
5077600  622200  79159
5076200  622000  79162
5076000  622600  79163
5081200  624600  80125
5080600  624600  80128
5081200  624200  80129
5081800  625200  80160
5081700  625700  80167
5079600  625400  79136
5077800  622800  79142
5077800  623800  79151
5077600  623200  79156
5076000  622600  79164
5087800  621600  80138
5086900  621400  80147
5082300  624400  80156
5082000  625400  80167
5088400  620600  81126
5086800  623200  81133
5080600  622700  81147
5083900  624700  81152
5083900  624700  81155
5084400  625000  81162
```

```
************************************************
*  This section displays the control cards for *
* example 1.  The relocation data for moose 33 *
* follows the format card.  The data are       *
* recorded in UTM grid coordinates.  The X     *
* coordinate is recorded first, followed by the*
* Y coordinate, and location id.  The location *
* id represents the year and julian date of the*
* observation.                Note: the listing*
* of the relocation data has been deleted from *
* all subsequent examples.                     *
************************************************
```

Output

```
ENTER TITLE

TITLE IS MOOSE 33 - SUMMER


ENTER OPTIONS FOR CONTOURS, WEIGHTED NON-CIRCULAR HOME RANGE, CORE AREA ,
   OUTLIER OBSERVATIONS, NON-CIRCULAR HOME RANGE, BIVARIATE NORMAL TEST,
   AND MINIMUM CONVEX POLYGON AREA

ANSWER WAS 0 1 0 0 1 1 1

     WEIGHTED NON-CIRCULAR HOME RANGE WILL BE PLOTTED

     NON-CIRCULAR HOME RANGE WILL BE PLOTTED

     LOCATIONS WILL BE TESTED FOR BIVARIATE NORMALITY

     MINIMUM CONVEX POLYGON WILL BE ESTIMATED

 NUMBER OF GRID POINTS ON X AND Y AXIS ARE      48      21

 ENTER UNITS , PLOT INCH SCALE, AND MIN. DISTANCE BETWEEN OBSERVATIONS

   2000.00 METERS        = 1 INCH ON PLOTTER OR

   1 METERS       =   0.0005 INCHES ON PLOTTER

    MINIMUM MEASURED DISTANCE BETWEEN OBSERVATIONS = 200.00000  METERS

ENTER METHOD (ENTER, EVAL 1, EVAL 2)

METHOD IS ENTER


ENTER OFFSET AND CENTERING OPTION

X OFFSET IS   10000.00  Y OFFSET IS    3000.00
 WITH NO AUTOMATIC CENTERING


ENTER NUMBER OF CONTOURS

THERE ARE   2 CONTOURS WHICH ARE
```

```
0.7500
0.9500

CONTOUR LEVELS ARE TREATED AS PERCENTILES OF THE ANIMAL UTILIZATION
   DISTRIBUTION

*******************************************
*   This portion of the output describes the *
* input control cards that were specified to *
* execute Example 1.                         *
*******************************************


X AND Y COORDINATES AND IDS ARE READ IN WITH THE
 FOLLOWING FORMAT    (F7.0,2X,F6.0,2X,A5)

THE DATA VALUES ARE

 OBSR          X COORD             Y COORD          ID
 ------------------------------------------------------

    1     5082400.00         624600.00     81230
    2     5082500.00         623600.00     81231
    3     5082400.00         623600.00     81232
               .                  .            .
               .                  .            .
   59     5083900.00         624700.00     81155
   60     5084400.00         625000.00     81162

 XMIN=   5063200.00      YMIN=     616000.00
 XMAX=   5078400.00      YMAX=     625000.00

THE MINIMUM H VALUE IS    1208.43  AT 20,10

 ******************************************
 *   The x,y coordinates and id for each    *
 * relocation are listed in the order of input*
 * The minimum and maximum for each axis is   *
 * calculated.  The location and harmonic     *
 * value of the center of activity is shown.  *
 *   Note:  this portion of the output has    *
 * been deleted from all subsequent examples. *
 ******************************************
```

GRID POINT HARMONIC MEAN BY CBS

OBSR	X-CORD	Y-CORD	H-MEAN
1	5082400.00	624600.00	1208.432
2	5082500.00	623600.00	1579.580
3	5082400.00	623600.00	1579.580
	.	.	.
	.	.	.
59	5083900.00	624700.00	1640.992
60	5084400.00	625000.00	1640.992

```
*********************************************
*   The relocation coordinates and calculated *
* harmonic values are listed in the same      *
* sequence as the previous section.           *
*   Note:  this section of output has been    *
* deleted from Example 3.                     *
*********************************************
```

SORTED HARMONIC MEANS

OBSR	X-CORD	Y-CORD	H-MEAN
1	5082400.00	624600.00	1208.432
2	5082400.00	625000.00	1208.432
3	5082200.00	625000.00	1208.432
	.	.	.
	.	.	.
59	5074800.00	619000.00	5913.523
60	5073200.00	620400.00	6314.781

```
*******************************************
*   Relocations are displayed in harmonic  *
* mean ascending order.  Harmonic values   *
* represent average distance between points.*
* Lower harmonic values are close to the   *
* center of activity.  Large harmonic values*
* should be reviewed for extreme locations. *
* Subsequent reference to observations is  *
* based on the order of this sorted list.  *
*******************************************
```

ESTIMATED PERCENTILE CONTOUR LEVELS

1	3992.903	0.750
2	5763.356	0.950

```
*******************************************
*   Two contour levels were input to the    *
* program.  However, since the contour option *
* was not chosen, the contours were not drawn *
*******************************************
```

WEIGHTED NON-CIRCULAR HOME RANGE AREA

75% = 21441248.64
95% = 46443137.85
SQRT DET S = 2463884.95
XMEAN = 5081650.70
YMEAN = 624575.78
SXX/SYY = 3.194
SXY = 1785826.44

LIST OF WEIGHTED POINTS

X-CORD	Y-CORD	WEIGHT
5077000.00	622600.00	0.97082
5076000.00	622600.00	0.81663
5076000.00	622600.00	0.81663
5077600.00	622200.00	0.98982
5076200.00	622000.00	0.80681
5087400.00	623200.00	0.50502
5086800.00	623200.00	0.54736
5085000.00	628000.00	0.75217
5086900.00	621400.00	0.38700
5087800.00	621600.00	0.36853
5088400.00	620600.00	0.30512
5074800.00	619000.00	0.45963
5073200.00	620400.00	0.51279

WEIGHTED NON-CIRCULAR HOME RANGE HAS BEEN PLOTTED

BIVARIATE NORMALITY TEST FOR GOODNESS OF FIT
TEST USES K/S DMAX PROCEDURE (ALPHA=.1)

DMAX = 0.173 CRITICAL VALUE = 0.118

TEST USES KUIPER STATISTIC (ALPHA=.1)

V = 0.302 CRITICAL VALUE = 0.197

```
FOR    47 OBSERVATIONS

HOME RANGE SIGNIFICANTLY DIFFERENT THAN BIVARIATE NORMAL

   CRITICAL DMAX VALUES FOR ALPHA = .05, .025, .01 ARE
             0.128  0.137  0.148

   CRITICAL V VALUES FOR ALPHA = .05, .025, .01 ARE
             0.212  0.226  0.241


*************************************************
*   The 75% and 95% robust bivariate home range *
* areas are estimated.  The 95% area is 46 sq   *
* km.  The SQRT DET S may be used to produce    *
* other percent estimates (see Jennrich and     *
* Turner 1969).                                 *
* The observations are tested for bivariate     *
* normality.  Weighted points are removed and a *
* truncated distribution is tested.  Critical   *
* test statistics are set for alpha=0.1.  The   *
* observations were found to be significantly   *
* different from robust bivariate normal.       *
* additional critical values are provided for   *
* other alpha levels.  It is recommended that   *
* alpha = .10 be used for samples smaller than  *
* 30 locations and alpha = .05 be used for      *
* samples greater than 30.                      *
*************************************************


   JENNRICH/TURNER NON-CIRCULAR HOME RANGE AREA

       75% =  43049356.86
       95% =  93247704.39
       SQRT DET S =   4946944.29
       XMEAN =    5081736.00
       YMEAN =     624348.75
       SXX/SYY =         3.304
       SXY =   1807639.83


   NON-CIRCULAR HOME RANGE HAS BEEN PLOTTED

          BIVARIATE NORMALITY TEST FOR GOODNESS OF FIT
          TEST USES K/S DMAX PROCEDURE (ALPHA=.1)

   DMAX = 0.175        CRITICAL VALUE = 0.104

          TEST USES KUIPER STATISTIC (ALPHA=.1)
```

V = 0.328   CRITICAL VALUE = 0.175

FOR   60 OBSERVATIONS

HOME RANGE SIGNIFICANTLY DIFFERENT THAN BIVARIATE NORMAL

CRITICAL DMAX VALUES FOR ALPHA = .05, .025, .01 ARE
0.114 0.122 0.132

CRITICAL V VALUES FOR ALPHA = .05, .025, .01 ARE
0.188 0.201 0.214

```
**************************************************
*   The 75% and 95% home range areas for the    *
* bivariate normal method are estimated.  The   *
* 95% home range area is 93 sq km.  The         *
* observations are tested for bivariate         *
* normality.  Both Dmax and V tests exceed the *
* critical test values.  Other critical values *
* are also provided.                            *
**************************************************
```

BIVARIATE UNIFORM TEST FOR GOODNESS OF FIT
TEST USES K/S DMAX PROCEDURE (ALPHA=.1)

DMAX = 0.225   CRITICAL VALUE = 0.155

TEST USES KUIPER STATISTIC (ALPHA=.1)

V = 0.419   CRITICAL VALUE = 0.204

FOR   60 OBSERVATIONS

HOME RANGE SIGNIFICANTLY DIFFERENT THAN UNIFORM DISTRIBUTION

CRITICAL DMAX VALUES FOR ALPHA = .05, .025, .01 ARE
0.172 0.188 0.207

CRITICAL V VALUES FOR ALPHA = .05, 0.25, .01 ARE
0.220 0.235 0.252

```
**************************************************
*   A test for bivariate uniform distribution   *
* is performed on the data.  A bivariate uniform*
* distribution is rejected for both test        *
* statistics.                                   *
**************************************************
```

CONVEX POLYGON HOME RANGE

THERE ARE 8 POINTS DEFINING THE PERIMETER OF THIS HOME RANGE.

NO.	INDEX	X	Y
1	55	5085000.00	628000.00
2	53	5087400.00	623200.00
3	58	5088400.00	620600.00
4	59	5074800.00	619000.00
5	60	5073200.00	620400.00
6	49	5076000.00	622600.00
7	43	5079600.00	625400.00
8	55	5085000.00	628000.00

NOTE: 1. POINTS ARE LISTED CLOCKWISE.
2. THIS POLYGON ENCLOSES ALL 60 POINTS, I.E., NO OUTLIERS WERE EXCLUDED.
3. FIRST AND LAST POINTS ARE THE SAME TO CLOSE THE POLYGON.

THE AREA OF THIS CONVEX POLYGON HOME RANGE IS:

ENCLOSED AREA = 73320035.93 SQUARE UNITS

TOTAL AREA WITHIN CONTOUR = 73320035.93 SQUARE UNITS

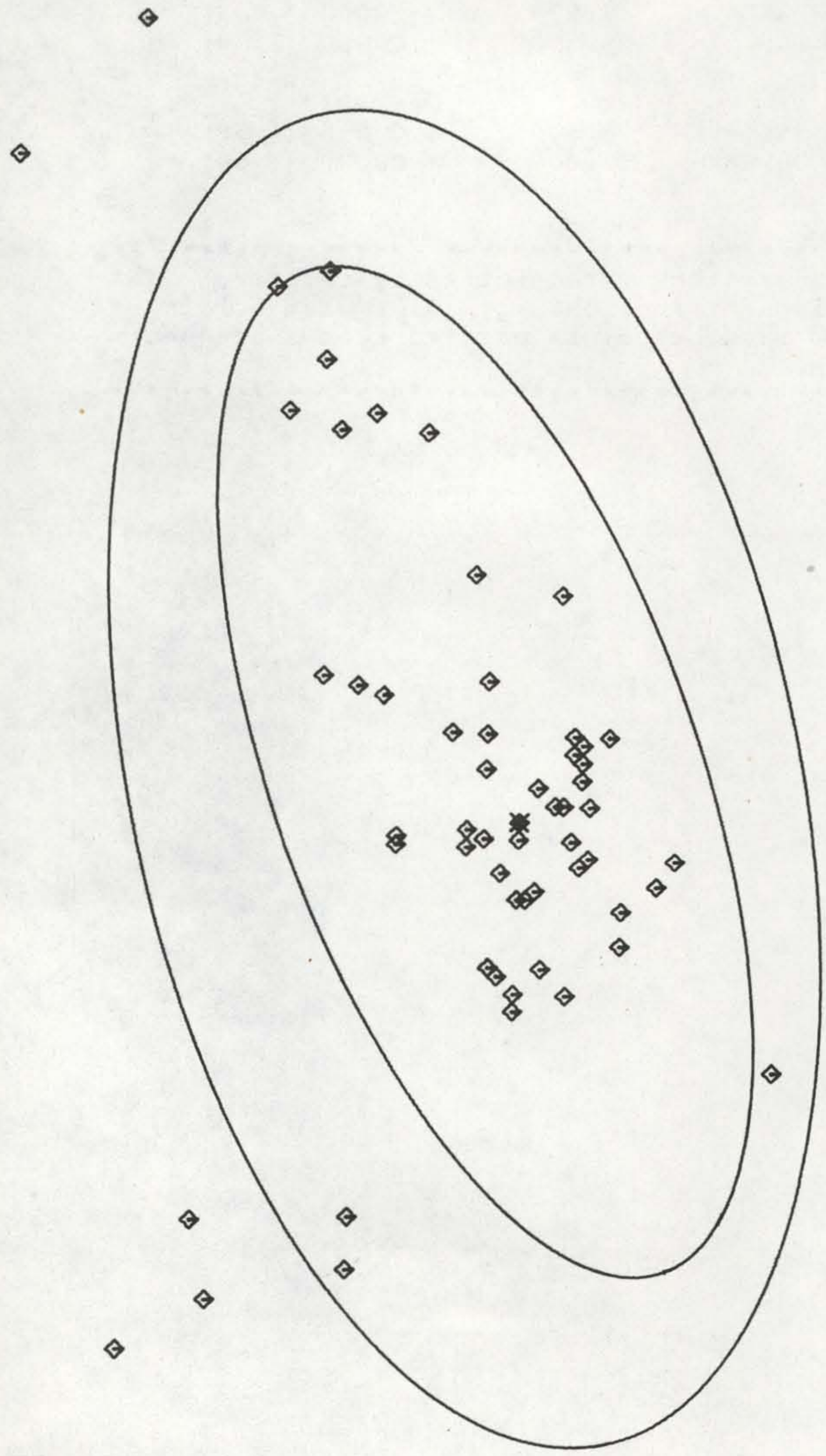
```
***************************************************
*   The minimum convex polygon (MCP) home range   *
* is calculated from the observations.  The       *
* observation number and coordinates for each     *
* point on the MCP perimeter are identified.      *
* The home range is 73 sq km.                     *
***************************************************
```

THE GRID COORDINATES ARE

```
X COORD (   1) =       9.600     Y COORD (   1) =       4.300
X COORD (   2) =       9.600     Y COORD (   2) =       4.500
X COORD (   3) =       9.500     Y COORD (   3) =       4.500
X COORD (   4) =       9.300     Y COORD (   4) =       4.600
          .              .                 .              .
          .              .                 .              .
X COORD (  59) =       5.800     Y COORD (  59) =       1.500
X COORD (  60) =       5.000     Y COORD (  60) =       2.200
```

```
**************************************************
*   The observations are plotted by relative     *
* scale (inches) from the x,y (0,0) plot origin. *
*   Note:  this output is omitted from subsequent*
* examples.                                      *
**************************************************
```

Plot



Example 2

Input

```
TITLE     MOOSE 33 - SUMMER
SELECT    1000000
SCALE     METERS          2000.0  200.0
METHOD    ENTER
OFFSET    10000.        3000.0
CONTOUR   001
5750.
FORMAT    (F7.0,2X,F6.0,2X,A5)
```

```
*************************************************
*   Input control cards for Example 2.  The     *
* observation data (listed in Example 1) has been*
* deleted.                                      *
*************************************************
```

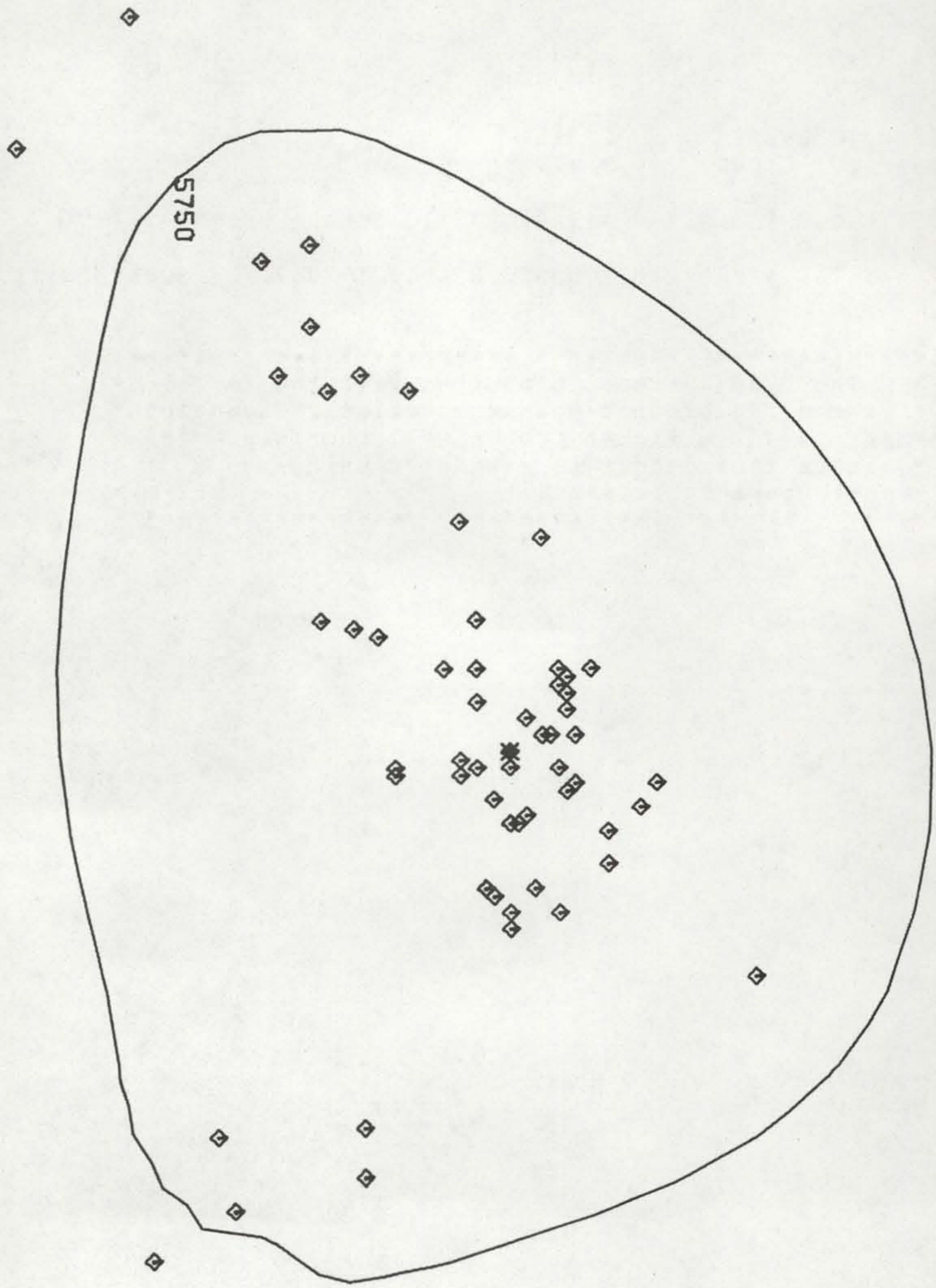
Output

```
ENTER TITLE

TITLE IS MOOSE 33 - SUMMER


ENTER OPTIONS FOR CONTOURS, WEIGHTED NON-CIRCULAR HOME RANGE, CORE AREA ,
   OUTLIER OBSERVATIONS, NON-CIRCULAR HOME RANGE, BIVARIATE NORMAL TEST,
   AND MINIMUM CONVEX POLYGON AREA

ANSWER WAS 1 0 0 0 0 0 0


     CONTOURS WILL BE PLOTTED

 NUMBER OF GRID POINTS ON X AND Y AXIS ARE        48        21

 ENTER UNITS , PLOT INCH SCALE, AND MIN. DISTANCE BETWEEN OBSERVATIONS

   2000.00 METERS          = 1 INCH ON PLOTTER OR

    1 METERS         =    0.0005 INCHES ON PLOTTER


    MINIMUM MEASURED DISTANCE BETWEEN OBSERVATIONS = 200.00000  METERS

ENTER METHOD (ENTER, EVAL 1, EVAL 2)

METHOD IS ENTER


ENTER OFFSET AND CENTERING OPTION

X OFFSET IS   10000.00  Y OFFSET IS    3000.00
 WITH NO AUTOMATIC CENTERING


ENTER NUMBER OF CONTOURS

THERE ARE   1 CONTOURS WHICH ARE

   5750.0000
```

```
*************************************************
*   The input control cards for Example 2 are    *
* listed.  One contour at 5750 will be plotted.  *
*************************************************
```

```
        CONTOUR LEVEL =      1      H MEAN =    5750.000

    THE FOLLOWING LINES WOULD BE DRAWN
    ----------------------------------

    LINES=    122
    MOVE TO  6.000       2.479
    DRAW TO  5.990       2.490
       .        .           .
       .        .           .
    DRAW TO  6.185       2.315
    DRAW TO  6.000       2.479

        ENCLOSED AREA = 117197087.16  SQUARE UNITS

        TOTAL AREA WITHIN CONTOUR = 117197087.16  SQUARE UNITS

    ***********************************************
    *   The 5750 contour is plotted with the      *
    * preceeding plotter pen instructions. Locations*
    * are given in inches from the plct origin.  Area*
    * within the coutour is estimated using the    *
    * cartographers formula.                        *
    ***********************************************
```

Plot



Example 3

Input

```
TITLE     MOOSE 33 - SUMMER
SELECT    1011000
SCALE     METERS         2000.0  200.0
METHOD    ENTER
OFFSET    10000.        3000.0
CONTOUR   002
0.75
0.95
FORMAT    (F7.0,2X,F6.0,2X,A5)
```

```
*************************************************
*   The input control cards for Example 3 are   *
* listed.  Two contours encompassing 75% and 95% *
* of the activity use will be drawn.  The       *
* observation data is listed in Example 1.      *
*************************************************
```

Output

```
ENTER TITLE

TITLE IS MOOSE 33 - SUMMER


ENTER OPTIONS FOR CONTOURS, WEIGHTED NON-CIRCULAR HOME RANGE, CORE AREA ,
   OUTLIER OBSERVATIONS, NON-CIRCULAR HOME RANGE, BIVARIATE NORMAL TEST,
   AND MINIMUM CONVEX POLYGON AREA

ANSWER WAS 1 0 1 1 0 0 0

     CONTOURS WILL BE PLOTTED

     CORE AREAS WILL BE PLOTTED

     OUTLIERS WILL BE IDENTIFIED

 NUMBER OF GRID POINTS ON X AND Y AXIS ARE      48      21

 ENTER UNITS , PLOT INCH SCALE, AND MIN. DISTANCE BETWEEN OBSERVATIONS

   2000.00 METERS          = 1 INCH ON PLOTTER OR

    1 METERS       =   0.0005 INCHES ON PLOTTER

    MINIMUM MEASURED DISTANCE BETWEEN OBSERVATIONS = 200.00000  METERS

ENTER METHOD (ENTER, EVAL 1, EVAL 2)

METHOD IS ENTER


ENTER OFFSET AND CENTERING OPTION

X OFFSET IS   10000.00  Y OFFSET IS    3000.00
 WITH NO AUTOMATIC CENTERING


ENTER NUMBER OF CONTOURS

THERE ARE   2 CONTOURS WHICH ARE

      0.7500
      0.9500
```

CONTOUR LEVELS ARE TREATED AS PERCENTILES OF THE ANIMAL UTILIZATION DISTRIBUTION

```
************************************************
*   The input control cards read by the program *
* are displayed with the options chosen.        *
************************************************
```

SORTED HARMONIC MEANS

OBSR	X-CORD	Y-CORD	H-MEAN
1	5082400.00	624600.00	1208.432
2	5082400.00	625000.00	1208.432
	.	.	.
	.	.	.
59	5074800.00	619000.00	5913.523
60	5073200.00	620400.00	6314.781

POINT 5086900.00 621400.00 WAS CLASSIFIED AS AN OUTLIER

POINT 5087800.00 621600.00 WAS CLASSIFIED AS AN OUTLIER

POINT 5088400.00 620600.00 WAS CLASSIFIED AS AN OUTLIER

POINT 5074800.00 619000.00 WAS CLASSIFIED AS AN OUTLIER

POINT 5073200.00 620400.00 WAS CLASSIFIED AS AN OUTLIER

```
************************************************
*   The harmonic values for each observation are *
* listed.  A bivariate test comparing the density*
* of observations is used to identify potential  *
* outliers.  This list may be used to review     *
* points that may be extreme locations or data   *
* errors.  These points should not be arbitrarily*
* removed.                                       *
************************************************
```

```
ESTIMATED PERCENTILE CONTOUR LEVELS
     1  3992.903      0.750
     2  5763.356      0.950

       3318.868      ESTIMATED CORE AREA WITH  24.6 PERCENT OF AREA
                       AND  61.3 PERCENT OF UTILIZATION VOLUME
```

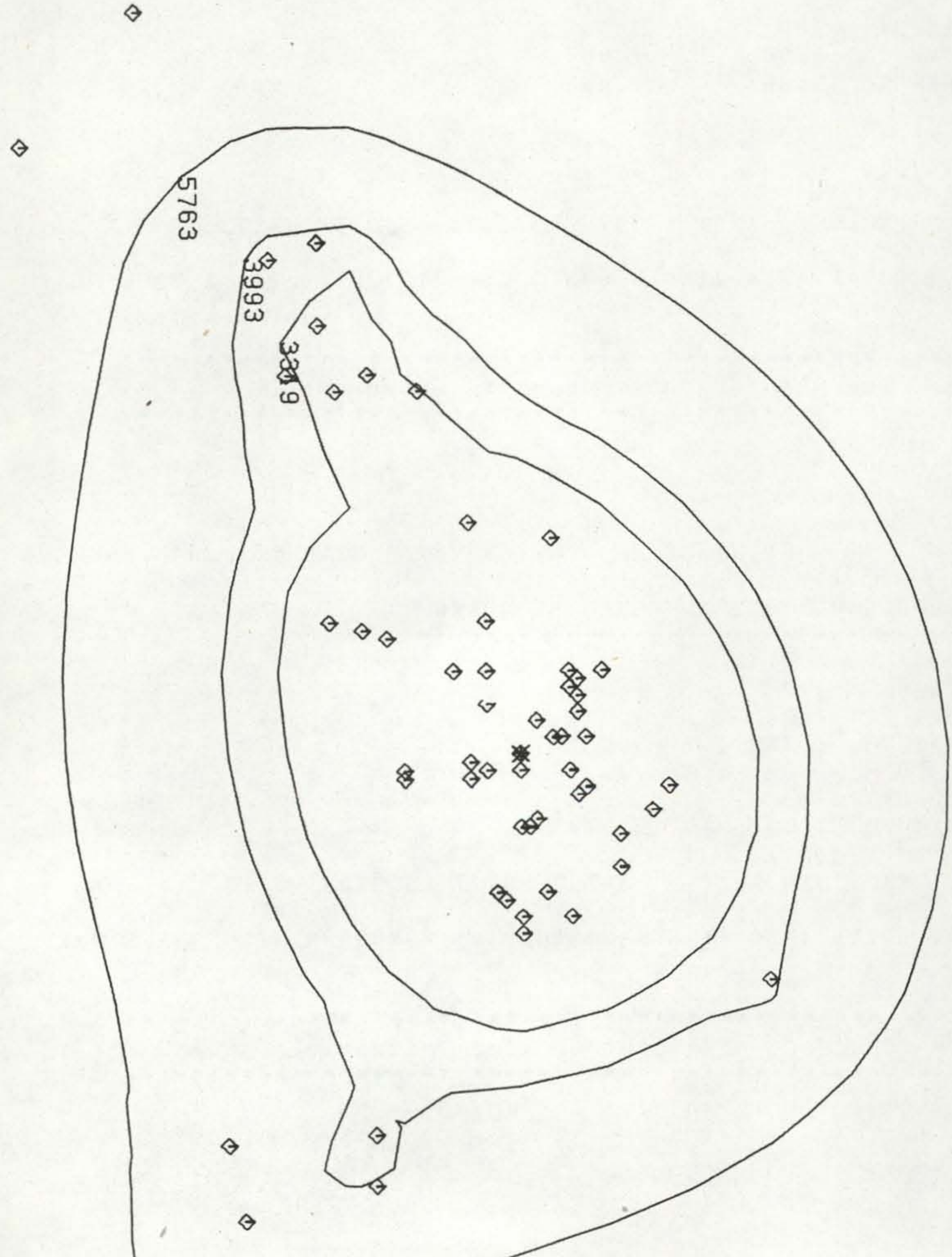
```
**************************************************
*   The 75% and 95% activity contours will be    *
* plotted at the indicated harmonic values.  A   *
* significant core area was found and will be    *
* plotted.  The estimated percent of area and    *
* use volume are estimated for the core area.    *
**************************************************
```

```
          CONTOUR LEVEL =      1      H MEAN =    3992.903

THE FOLLOWING LINES WOULD BE DRAWN
-----------------------------------

 LINES=     98
 MOVE TO  6.500        2.861
 DRAW TO  6.419        2.919
    .        .            .
    .        .            .
 DRAW TO  6.500        2.861

     ENCLOSED AREA =  54593444.82  SQUARE UNITS

     TOTAL AREA WITHIN CONTOUR =  54593444.82  SQUARE UNITS
```

```
**************************************************
*   The pen instructions are listed to show the  *
* contour chosen and the enclosed area.  This    *
* list illustrates the 75% contour.              *
**************************************************
```

```
          CONTOUR LEVEL =        2     H MEAN =    5763.356

THE FOLLOWING LINES WOULD BE DRAWN
-------------------------------------

 LINES=    124
 MOVE TO  6.000         2.467
 DRAW TO  5.983         2.483
    .        .            .
    .        .            .
 DRAW TO  6.000         2.467

     ENCLOSED AREA = 117705572.13  SQUARE UNITS

     TOTAL AREA WITHIN CONTOUR = 117705572.13  SQUARE UNITS

  ***********************************************
  *   The 95% percent contour is shown.         *
  ***********************************************


          CONTOUR LEVEL =        3     H MEAN =    3318.868

THE FOLLOWING LINES WOULD BE DRAWN
-------------------------------------

 LINES=     70
 MOVE TO  7.000         3.074
 DRAW TO  6.752         3.252
    .        .            .
    .        .            .
 DRAW TO  7.000         3.074

     ENCLOSED AREA =  34200988.77  SQUARE UNITS

     TOTAL AREA WITHIN CONTOUR =  34200988.77  SQUARE UNITS

  ***********************************************
  *  The core area contour area estimate is shown. *
  ***********************************************
```

Plot



Example 4

Input

```
TITLE      MOOSE 33 - SUMMER
SELECT     1011000   41    18
SCALE      METERS          2000.0  200.0
METHOD     ENTER
OFFSET     10000.        3000.0
CONTOUR    002
0.75
0.90
FORMAT     (F7.0,2X,F6.0,2X,A5)
```

```
************************************************
*    The control cards are shown.  The input data *
* cards have been deleted.  See example 1.        *
*    Note: a change in grid density was made in   *
* this run.                                       *
*  The number of X and Y grid points are          *
* calculated below (refer to algorithm - page 7).*
*       EP = 54 = (60 - 8) + .25 (8)    - page 29 *
*    AVG = 1,357,778 = 73,320,036 / 54  - page 29 *
*           GW = 1165 = SQRT(1,357,778)           *
*  No. of grid points on the X axis is            *
*          41 = (2000 / 1165) * 24                *
*  No. of grid points on the Y axis is            *
*          18 = (2000 / 1165) * 10.5              *
************************************************
```

Output

```
ENTER TITLE

TITLE IS MOOSE 33 - SUMMER


ENTER OPTIONS FOR CONTOURS, WEIGHTED NON-CIRCULAR HOME RANGE, CORE AREA ,
   OUTLIER OBSERVATIONS, NON-CIRCULAR HOME RANGE, BIVARIATE NORMAL TEST,
   AND MINIMUM CONVEX POLYGON AREA

ANSWER WAS 1 0 1 1 0 0 0


     CONTOURS WILL BE PLOTTED

     CORE AREAS WILL BE PLOTTED

     OUTLIERS WILL BE IDENTIFIED

 NUMBER OF GRID POINTS ON X AND Y AXIS ARE       41       18

 ENTER UNITS , PLOT INCH SCALE, AND MIN. DISTANCE BETWEEN OBSERVATIONS

   2000.00 METERS         = 1 INCH ON PLOTTER OR

    1 METERS        =    0.0005 INCHES ON PLOTTER

    MINIMUM MEASURED DISTANCE BETWEEN OBSERVATIONS = 200.00000  METERS

ENTER METHOD (ENTER, EVAL 1, EVAL 2)

METHOD IS ENTER


ENTER OFFSET AND CENTERING OPTION

X OFFSET IS    10000.00  Y OFFSET IS     3000.00
 WITH NO AUTOMATIC CENTERING


ENTER NUMBER OF CONTOURS

THERE ARE   2 CONTOURS WHICH ARE

      0.7500
      0.9000
```

CONTOUR LEVELS ARE TREATED AS PERCENTILES OF THE ANIMAL UTILIZATION DISTRIBUTION

```
**************************************************
*   This section recaps the options selected.    *
* See previous examples.                         *
**************************************************
```

GRID POINT HARMONIC MEAN BY CBS

OBSR	X-CORD	Y-CORD	H-MEAN
1	5082400.00	624600.00	1559.568
2	5082500.00	623600.00	2323.177
3	5082400.00	623600.00	2323.177
	.	.	.
	.	.	.
59	5083900.00	624700.00	2171.275
60	5084400.00	625000.00	1827.098

```
************************************************
*   The harmonic mean values for each location *
* are listed.  Note:  these values are slightly*
* different from those in example 3 due to the *
* change in grid density.                      *
************************************************
```

```
        SORTED HARMONIC MEANS

    OBSR      X-CORD        Y-CORD       H-MEAN
    ----      ------        ------       ------

      1   5082000.00    625800.00    1224.862
      2   5082400.00    625000.00    1224.862
      3   5081400.00    625600.00    1224.862
               .             .            .
               .             .            .
     59   5074800.00    619000.00    5932.335
     60   5073200.00    620400.00    6057.500

    POINT 5086900.00   621400.00 WAS CLASSIFIED AS AN OUTLIER

    POINT 5087800.00   621600.00 WAS CLASSIFIED AS AN OUTLIER

               .              .              .

               .              .              .

    POINT 5073200.00   620400.00 WAS CLASSIFIED AS AN OUTLIER

  **********************************************
  *   The sorted harmonic values for each location *
  * are listed and outliers are identified.  See  *
  * example 3 for more discussion.                *
  **********************************************



    ESTIMATED PERCENTILE CONTOUR LEVELS
         1  3914.618       0.750
         2  5651.121       0.950

         3256.425      ESTIMATED CORE AREA WITH  24.7 PERCENT OF AREA
                        AND  60.2 PERCENT OF UTILIZATION VOLUME


  ***********************************************
  *   The contours for 75% and 95% of the activity  *
  * distribution are estimated.  A core area contour*
  * is also estimated.  Note: these contours are    *
  * slightly different than example 3 due to changes*
  * in grid density.                                *
  ***********************************************
```

```
        CONTOUR LEVEL =      1     H MEAN =    3914.618

  THE FOLLOWING LINES WOULD BE DRAWN
  ------------------------------------

   LINES=    78
   MOVE TO  6.439       2.926
      .        .           .
      .        .           .
   MOVE TO  6.438       2.927

       ENCLOSED AREA =     51674224.85  SQUARE UNITS

       TOTAL AREA WITHIN CONTOUR =  51690368.65  SQUARE UNITS
```

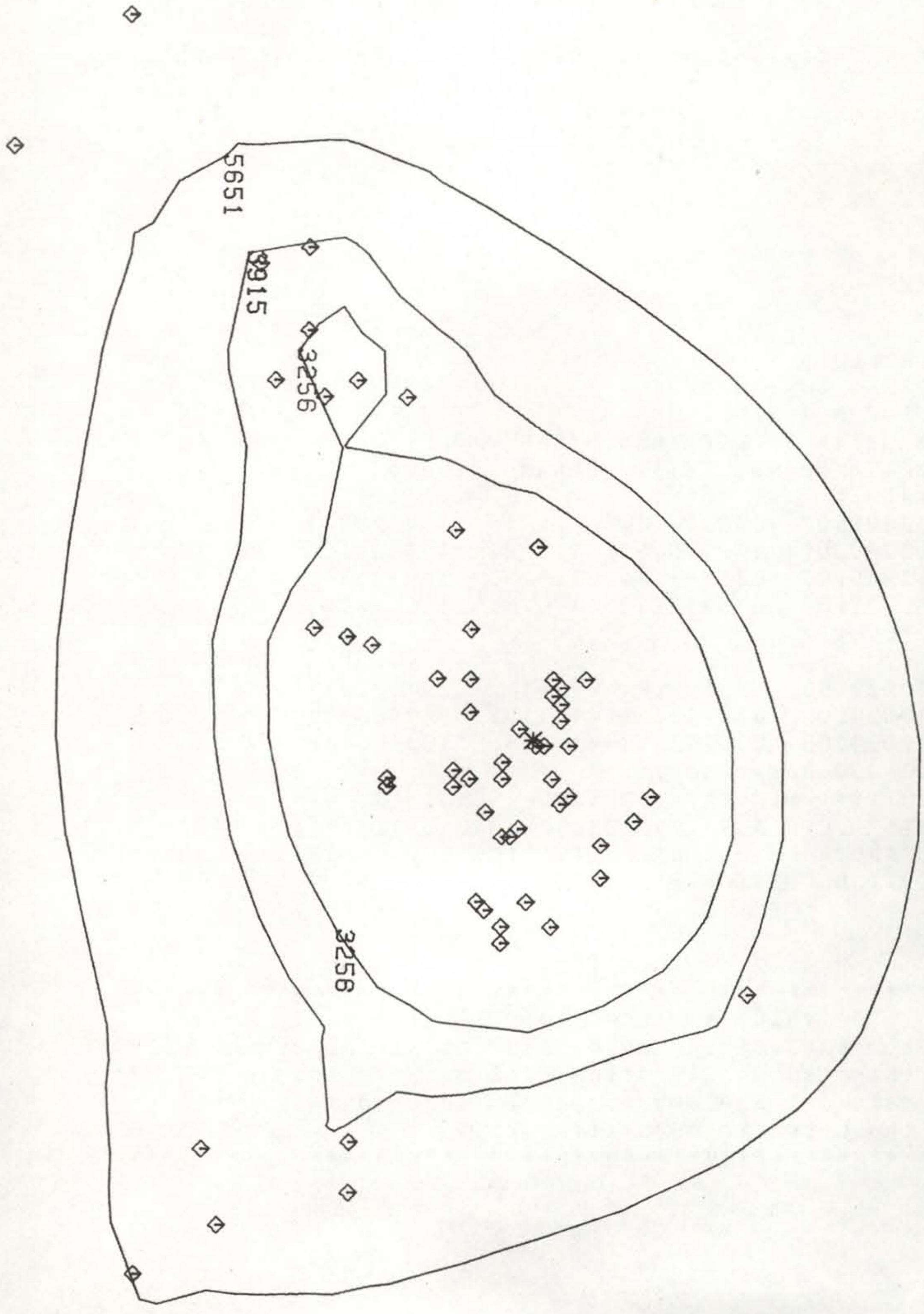
```
****************************************************
*   The contour for the 75% activity area is       *
* shown with area estimation.                      *
****************************************************
```

```
        CONTOUR LEVEL =      2     H MEAN =    5651.121

  THE FOLLOWING LINES WOULD BE DRAWN
  ------------------------------------

   LINES=   104
   MOVE TO  5.854       2.777
   DRAW TO  5.778       2.851
      .        .           .
      .        .           .
   DRAW TO  5.854       2.777

       ENCLOSED AREA = 113107732.77  SQUARE UNITS

       TOTAL AREA WITHIN CONTOUR = 113107732.77  SQUARE UNITS
```

```
****************************************************
*   The 95% activity contour and area are shown.  *
****************************************************
```

```
        CONTOUR LEVEL =      3     H MEAN =   3256.425

THE FOLLOWING LINES WOULD BE DRAWN
-----------------------------------

 LINES=    62
 MOVE TO  7.024       3.240
 DRAW TO  6.868       3.356
    .        .           .
    .        .           .
 MOVE TO 10.537       3.512

     ENCLOSED AREA =   31115875.24  SQUARE UNITS
 DRAW TO 10.537       3.512
    .        .           .
    .        .           .
 DRAW TO 10.537       3.512

     ENCLOSED AREA =          915.53  SQUARE UNITS

     TOTAL AREA WITHIN CONTOUR =  31116882.32  SQUARE UNITS

 *************************************************
 *   The core area contour is shcwn.             *
 *************************************************
```

Plot



Example 5

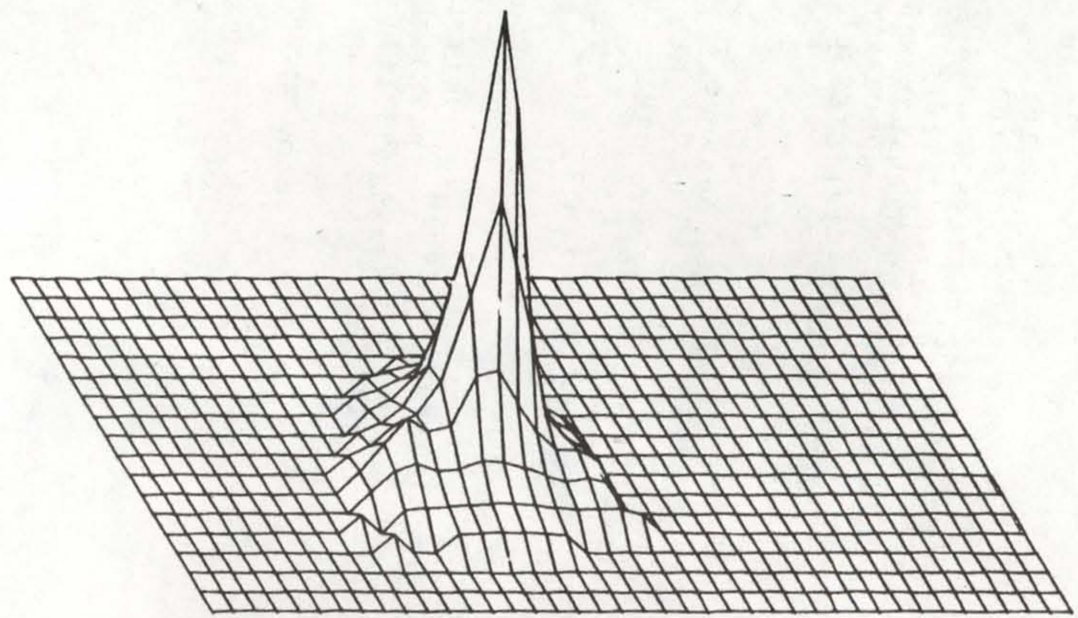
This example illustrates the use of data from the harmonic mean file (25) to produce a 3-dimensional picture of the utilization distribution. The SAS/GRAPH procedure G3D (Council and Helwig) is used to produce the plot on a Tektronics 4662.

Input

```
DATA PLOT;
 RETAIN CUT 6058.0;
 INPUT X Y NX NY HMEAN;
 IF HMEAN GT CUT THEN HMEAN = 0.0;
   ELSE HMEAN = ((1 / HMEAN) ** 2);
 CARDS;
5063200.00  616000.00  1.   1.   19802.879
5063200.00  617170.69  1.   2.   19333.383
5063200.00  618341.44  1.   3.   18933.066
5063200.00  619512.19  1.   4.   18607.141
    .           .       .    .        .
    .           .       .    .        .
5110029.00  633560.94 41.  16.   29490.410
5110029.00  634731.69 41.  17.   29880.391
5110029.00  635902.44 41.  18.   30310.992
PROC G3D DATA=PLOT;
 PLOT Y*X = HMEAN / ROTATE=15 NOAXES;
 TITLE .C=BLACK .F=TITALIC .H=2 UTILIZATION DISTRIBUTION;
 FOOTNOTE .C=BLACK .F=TITALIC .H=2 MOOSE 33 - SUMMER;
 GOPTIONS DEVICE=TEK4662;


*************************************************
*   The value assigned to CUT is slightly above  *
* the largest harmonic value of all observations.*
* This causes all grids with greater harmonic    *
* values to be set to zero.  Input data is from  *
* the harmonic mean file (25).                   *
*************************************************
```

Plot

UTILIZATION DISTRIBUTION



MOOSE 33 - SUMMER

JCL EXAMPLES

The first example illustrates a FORTRAN compilation of the HOME RANGE program. A load module is created and stored for subsequent execution. Some JCL and system library conventions may be unique to the U of I computer system.

```
//JHOMRAN JOB   (USERID,123-45-6789),NAME
//STEP1   EXEC  FORTGCL
//FORT.SYSIN  DD  *
    Home range program code
/*
//LKED.SYSLIB   DD
//          DD  DSN=SYS1.PLOTLIB,DISP=SHR
//SYSLMOD  DD  DSN=WLSAMUEL.HOMRAN(HOMER),SPACE=(TRK,(20,5,2),RLSE),
//          DCB=SYS1.LINKLIB,DISP=(NEW,CATLG),UNIT=DISK

//
```

The second example illustrates the JCL requirements for program execution. This example assumes that a load module has been previously created (see previous example).

```
//JSAMPLE  JOB  (USERID,123-45-6789),NAME
//STEP1  EXEC  PGM=HOMER
//STEPLIB  DD  DSN=WLSAMUEL.HOMRAN,DISP=SHR
//FT13F001  DD  DSN=PTAPE,UNIT=TAPE,DISP=(,KEEP),
//         DCB=(RECFM=U,BLKSIZE=512,DEN=2),LABEL=(,NL)
//FT06F001  DD  SYSOUT=A
//FT07F001  DD  SYSOUT=B
//FT22F001  DD  DUMMY
//FT25F001  DD  DUMMY
//FT05F001  DD  *
    Program control cards
    Data input cards

//
```

PROGRAM DETAILS

Program Size

The program consists of a main routine and 16 subroutines excluding standard FORTRAN intrinsic functions and required plot routines. The program contains approximately 2300 cards, including numerous comment cards to aid in following program flow. Execution requires approximately 300K for the code without overlay structure on an IBM system OS/VS1.

Dimension Limitations

Program array dimensions allow a maximum of 1000 animal locations to be processed, up to 100 contour levels may be specified, and the number of grid points cannot exceed 72 on the X-axis and 32 on the Y-axis. The majority of program arrays and arithemetic operations are in IBM single precision with approximately 7 decimal digits of accuracy.

Run Costs

Run costs vary by the number of animal locations and the options selected. A typical cost with most options in effect and 40 locations is approximately $5.00 on the University of Idaho IBM 4341 OS/VS1 system and requires 30 seconds of CPU time.

The costs of individual runs may be controlled by judicious selection of program options on the SELECT card.

A substantial amount of program time may be required to compute the harmonic means at each grid point. This calculation should be suppressed when only convex polygon or bivariate home range estimates are required. The centering option, while convenient, requires additional computer time. This cost may be avioded by determining appropriate X,Y values for the OFFSET card. Finally, it may be possbile to reduce I/O costs by not writting to files 22 and 25 (see JCL example 2) or not plotting the output tape.

Availability

The program is written in IBM FORTRAN IV level G so that it should function on most brands of digital computers with minor or no modifications. Plotter capabilities are required. The program is designed to produce CALCOMP plotter instructions on an output file (13). Conversion of plot instructions will be required for different plot devices. A software routine (ELIPS) available for CALCOMP plotters was used to produce bivariate probability ellipses. A substitute routine developed at Oregon State University is listed in the next section to accommodate users without equivalent software.

Ellipse Routine

The following generalized ellipse routine was developed by Eric Rexstad and Scott Lutz at OSU.

```
C
C     REPLACEMENT OF CALCOMP 'ELIPS' ROUTINE.  GENERALLY BORROWED
C      FROM 'MICROCOMPUTER GRAPHICS' BY MYERS 1982.
C
      ROTAT = ANGLE * 3.1415926 / 180.
      SINROT = SIN( ROTAT )
      COSROT = COS( ROTAT )
C
C       USE POLAR COORDINATES TO GENERATE 200 POINTS ON PERIMETER
C        OF ELLIPSE
C
      DO 400 THETA = 0., 6.2831853, 0.0314159
        X = RMAJ * COS( THETA )
        Y = RMIN * SIN( THETA )
        XPT = X * COSROT - Y * SINROT + ( XMEAN - XMIN ) * XSCALE
        YPT = X * SINROT + Y * COSROT + ( YMEAN - YMIN ) * XSCALE
C
C    IF THIS IS FIRST POINT GENERATED, LIFT PEN TO PERIMETER OF
C      ELLIPSE
C
        IF ( THETA .EQ. 0. ) THEN
          CALL PLOT( XPT, YPT, 0, 0 )
        ELSE
          CALL PLOT( XPT, YPT, 1, 0 )
        END IF
  400 CONTINUE
```

LITERATURE CITED

Adams, L. and S.D. Davis. 1967. The internal anatomy of home range. J. Mammal. 48: 529-536.

Anderson, D.J. 1982. The home range: a new nonparametric estimation technique. Ecology 63:103-112.

Burt, W.H. 1943. Territorality and home range concepts as applied to mammals. Journal of Mammalogy 24:346-352.

Council, K.A. and J.T. Helwig (eds.). 1981. SAS/GRAPH user's guide. SAS Institute Inc.

Dixon, K.R. and J.A. Chapman. 1980. Harmonic mean measure of animal activity areas. Ecology 61:1040-1044.

Ewer, R.F. 1968. Ethology of mammals. Legos Press, London, England.

Ford, R.G. and D.W. Krumme. 1979. The analysis of space use patterns. Journal of Theoretical Biology 76:125-155.

Hayne, D.W. 1949. Calculation of size of home range. Journal of Mammalogy 39:190-206.

Jennrich, R.I. and F.B. Turner. 1969. Measurement of non-circular home range. Journal of Theoretical Biology 22:227-237.

Kaufmann, J.H. 1962. Ecology and social behavior of the coati, Nasua nirica on Barro Colorado Island, Panama. Univ. of Calif. Publ. Zool. 60:95-222.

Koeppl, J.W., N.A. Slade, R.S. Hoffmann. 1975. A bivariate home range model with possible application to ethological data analysis. J. Mammal. 56:81-90.

Leuthold, W. 1977. African ungulates: a comparative review of their ethology and behavioral ecology. Springer-Verlag, New York.

Morrison, D.F. 1976. Multivariate statistical methods. Mcgraw-Hill, New York.

Neft, D.S. 1966. Statistical analysis for areal distributions. Monograph Series Number 2. Regional Science Research Institute, Philadelphia, Pennsylvania, USA.

Pierce, D.J. 1983. Food habits, movements, habitat selection and population parameters of moose in northcentral Idaho and relationship to forest management. Univ. of Idaho. Unpublished masters thesis.

Randles, R.H., J.D. Brofitt, J.S. Romberg, and R.V. Hogg. 1978. Generalized linear and quadratic discriminate functions using robust estimates. J. Am. Statist. Assoc. 73:564-568.

Samuel, M.D. and E.O. Garton. (In prep). Home range: a robust bivariate normal estimate and tests of underlying assumptions.

Samuel, M.D., D.J. Pierce and E.O. Garton. (In prep). Identifying areas of concentrated use within the home range.

Saunders, R. and P. Laud. 1980. The multidimensional Kolmogorov goodness-of-fit test. Biometrika 67:237.

Schoener, T.W. 1981. An empirically based estimate of home range. Theoretical Population Biology 20:281-325.

Smith, W.P. 1983. A bivariate normal test for elliptical home-range models: biological implications and recommendations. J. Wildl. Manage. 47:613-619.

Stephens, M.A. (1974). EDF statistics for goodness of fit and some comparisons. J. Amer. Stat. Assoc. 69:730-737.

Van Winkle, W. 1975. Comparison of several probabilistic home-range models. J. Wildl. Manage. 39:118-123.

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