Alaska Department of Fish and Game
Division of Wildlife Conservation

Federal Aid in Wildlife Restoration
Research Progress Report

1 July 1992 - 30 June 1994

Lower Susitna Valley Moose Population Identity and Movement Study

Ronald D. Modafferi

Grant W-24-2
Study 1.38
December 1994

Alaska Department of Fish and Game
Division of Wildlife Conservation
December 1994

Lower Susitna Valley Moose Population Identity and Movement Study

Ronald D. Modafferi

Federal Aid in Wildlife Restoration
Research Progress Report
1 July 1992–30 June 1994

Grant W-24-2
Study 1.38

This is a progress report on continuing research. Information may be refined at a later date.
If using information from this report, please credit author(s) and the Alaska Department of Fish and Game.

STATE OF ALASKA
Tony Knowles, Governor

DEPARTMENT OF FISH AND GAME
Carl L. Rosier, Commissioner

DIVISION OF WILDLIFE CONSERVATION
Wayne L. Regelin, Acting Director

Additional copies of this report and other Division of Wildlife Conservation publications are available from:

Publications Specialist
ADF&G, Wildlife Conservation
P.O. Box 25526
Juneau, AK 99802
(907) 465-4190

RESEARCH PROGRESS REPORT

State: Alaska

Project No.: W-24-1
W-24-2

Project Title: Big Game Investigations

Job No.: 1.38

Study Title: Lower Susitna Valley Moose Population Identity and Movement Study

Period Covered: 1 July 1992-30 June 1994

SUMMARY

Alaska Department of Fish and Game (ADF&G) staff aerial surveyed, marked, and radiotracked moose in the lower Susitna River valley in Southcentral Alaska from October 1985 to February 1991. Survey and radiotracking data gathered (April 1980 to May 1986) during previous moose studies in lowland riparian areas of the lower Susitna River valley were incorporated into the database. Site specific information on herd density, sex/age composition, and distribution of moose were compiled from moose censuses and surveys in the study area. Data on moose killed by collisions with trains in Alaska were collected, analyzed in relation to snowpack depth, and published. Archived data on in utero fetus counts of moose in Southcentral Alaska were gathered, analyzed, and published. Data collected on survival of radiocollared moose were analyzed and written for publication. We analyzed data on birthing chronology, twinning rates and calf/cow ratios of radiocollared female moose. This report mainly contains data, findings, and discussions related to analysis of point-location data collected in monitoring radiocollared moose.

To select equipment, methods and procedures for analyzing point-location data collected in radiotelemetry studies, a radiotelemetry data analysis group was formed among Alaska Department of Fish and Game staff. The working group included biologists, biometricians and a data analyst/programmer. The group identified computer hardware and software for conducting analyses of radiotelemetry point-location data. The group acknowledged that point-location data collected in lower Susitna Valley moose studies would be used to refine this process.

Equipment and software identified for use in analyzing point-location data were: a 486-based computer with windows environment; CALHOME, a home range analysis software; Lotus 1-2-3, a spreadsheet program; ArcView, a geographic information system software; and FoxPro, a relational database management system. The adaptive kernel method in CALHOME was selected for home range analyses.

ADF&G staff outlined procedures for isolating and manipulating subsets of moose point-location data from the database file through home range analyses. Adaptive kernel home range analyses identified relationships between home range size, number of utilization distributions and bandwidth. Home range size varied from 9 mi^2 to 205 km^2. Plots of home ranges showed 1 (unimodal) to 8 (multimodal) discrete utilization distribution polygons. Bandwidth had large effects on home range size and polygon number. In many cases, bandwidth selected by minimizing the least squares cross validation value appeared to provide a better estimate of home range than the optimum bandwidth selected by the program. These analyses clarified the need to identify an objective method for selecting bandwidth in adaptive kernel home range analysis. ADF&G staff discussed recommendations for future activities.

CONTENTS

BACKGROUND

Before statehood in 1959, the Susitna River Valley was ranked as the most productive moose (*Alces alces*) habitat in the territory (Chatelain 1951). Today, the innate potential of this area as habitat for moose is unsurpassed throughout the state.

The lower Susitna Valley is the focal point of more development than any other nonurban region in the state. Proposed and progressing projects involving grain and crop agriculture, dairy and grazing livestock, commercial forestry and logging, personal-use cutting of firewood, mineral and coal mining, land disposals, wildlife ranges and refuges, human recreation, human settlement, urban expansion, development of the highway and railway systems, and increased railroad traffic in the region may greatly detract from the area's potential to support moose.

Although development and associated activities may reduce the moose population in the Susitna Valley, resource users have demanded increased allocations to satisfy consumptive and nonconsumptive uses. This conflict created a tremendous need by local, state, and federal land and resource management agencies for timely and accurate knowledge about moose populations in Subunits 13E, 14A, 14B, 16A, and 16B. These informational needs will intensify in response to (1) increased pressures to develop additional lands, (2) increased numbers of users and types of resource use, and (3) more complex systems for allocating resources to potential users.

The Division of Wildlife Conservation lacks necessary information about moose populations in the lower Susitna Valley to accurately assess the effects from these increasing resource demands. The division is unable to dispute or condone specific demands, or provide recommendations to regulate and minimize negative effects on moose populations or habitat. The division must be knowledgeable about moose population behavior to mitigate negative effects to moose populations or their habitat.

The division is the source of much information on moose populations for decisions on land use and resource allocation in the lower Susitna Valley. To be more effective in this capacity, the division should consolidate available data and expand that database with studies on movements and identity of moose populations.

Data from these studies will improve the division's ability to recognize, evaluate, and/or mitigate activities affecting moose populations and their habitat.

Habitat and environmental conditions vary greatly in the lower Susitna Valley. Large environmental differences may lead to area specific differences in moose population behavior. Therefore, a series of interrelated moose movements and population identity studies should be conducted at different locations in the lower Susitna Valley. Studies should be initiated where there are immediate conflicts in resource use. After evaluating conflicts in resource use in the lower Susitna Valley, we knew our studies should begin in the western foothills of the Talkeetna Mountains in Subunits 14A and 14B. Some of the densest postrut aggregations of moose in the region and, perhaps, the state are on Bald Mountain Ridge and Willow Mountain in the western foothills of Talkeetna Mountains. Subunits 14A and 14B provide recreation and resources to over half of Alaska's human population. This area is the focus of many development activities and conflicts in resource use. These Subunits have unique problems involving moose and transportation systems. Environmental information required for the recent Susitna River hydroelectric project emphasized the inadequacy of basic knowledge about moose populations in the area. Data from environmental assessment studies for the hydroelectric project pointed out inaccurate assumptions about moose populations in the lower Susitna Valley.

Historical information available on moose populations in the Susitna Valley is limited to (1) harvest statistics (ADF&G files), (2) inconsistently conducted sex-age composition surveys (ADF&G files); (3) inconsistently collected data for train- and vehicle-killed moose (ADF&G files), (4) a population movement study based on resightings of "visually collared" moose (ADF&G files), (5) studies on railroad mortality and productivity of the railbelt subpopulation (Rausch 1958, 1959), (6) a radiotelemetry population identity study in the Dutch and Peters Hills (Didrickson and Taylor 1978), (7) an incomplete study of moose-snowfall relationships in the Susitna Valley (ADF&G files), (8) a study of extensive moose mortality in a severe winter (1970-71), for which there is no final report, and (9) a pilot study to develop a rapid-assessment technique to identify and characterize moose winter range (Albert and Shea 1986).

Recent studies designed to assess effects of a proposed hydroelectric project on moose have provided much data on moose populations in areas adjacent to the Susitna River downstream from Devil Canyon (Arneson 1981; Modafferi 1982, 1983, 1984, 1988*b*). These studies suggest that moose sex-age composition counts conducted in alpine habitat postrut concentration areas of Subunits 14A and 14B were biased, including samples from unhunted moose populations and excluding samples from segments of hunted moose populations. Moose killed by hunters and trains in winter in Subunit 14B were fall residents of Subunit 16A. Fall resident moose of Subunit 16A migrated to winter areas in Subunit 14A. Moose vulnerable in fall hunts in Subunit 16A were included in Subunit 14A and 14B population composition and trend surveys. Moose that calved in Subunit 16A were fall residents of Subunit 14B. These data indicate that assumptions about movements and identities of moose populations in Subunits 14A and 14B (i.e., western foothills of the Talkeetna Mountains) may be incorrect or too simplistic.

Previous progress reports on lower Susitna Valley moose population identity and movement studies have been published (Modafferi 1987, 1988*a*, 1990, 1992).

OBJECTIVES

Primary

- To more precisely delineate moose annual movement patterns and location, timing, and duration of use of seasonal habitats

- To use movement patterns to identify and delineate major moose populations in the lower Susitna Valley

- To assess effects of seasonal timing on results of annual fall sex-age composition and population trend moose surveys

- To relate findings to moose population management in lower Susitna Valley

Peripheral

- To identify areas and habitats that are important for maintaining the integrity of moose populations in the lower Susitna Valley

- To locate moose winter areas and calving areas in the lower Susitna Valley

- To identify moose populations that sustain hunting mortality and "accidental" mortality in highway and railroad rights-of-way

- To determine moose natality rates and timing of calving

- To determine survival rates and timing calf and adult mortality

STUDY AREA

The study was conducted in a 25,000 km^2 area in the lower Susitna Valley in Southcentral Alaska (Fig. 1). The area is bordered on the north and west by the Alaska Mountain Range, on the east by the Talkeetna Mountains, and on the south by Cook Inlet. It encompasses all watersheds of the Susitna River downstream from Devil Canyon and includes all or portions of Subunits 14A, 14B, 16A, 16B, and 13E (Fig. 2).

Monthly mean temperatures range from 16 C in July to -13 C in January; maximum and minimum temperatures of 25 and -35 C are not uncommon. Total annual precipitation varies from about 40 cm in the southern portion to over 86 cm in the northern and western portions. Maximum winter snow depth varies from less than 20 cm in the southern portion to over 200 cm in the northern and western portions. Climatic conditions generally become more inclement away from the maritime influence of Cook Inlet. Elevations within the area range from sea level to rugged mountain peaks well above 1500 m.

Vegetation in the area is diverse and varied, depending on elevation. Vegetation types include wet coastal tundra and marsh, open low-growing spruce forest, closed spruce hardwood forest, treeless bog, shrubby thicket and alpine tundra (Viereck and Little 1972). Dominant habitat and canopy types in the area are characterized as: (1) floodplain - dominated by willow (*Salix* spp.) and poplars (*Populus* spp.), (2) lowland - dominated by a mixture of wet bogs and closed or open, mixed paper birch (*Betula papyrifera*)/white spruce (*Picea glauca*)/aspen (*Populus tremuloides*) forests, (3) mid elevation - dominated by mixed or pure stands of aspen/paper birch/white spruce, (4) higher elevation - dominated by alder (*Alnus* spp.), willow, and birch shrub thickets or grasslands (*Calamagrostis* spp.), and (5) alpine tundra - dominated by sedge (*Carex* spp.), ericaceous shrubs, prostrate willows, and dwarf herbs. Vegetation, climate and geography of the area were described in detail by Viereck and Little (1972) and Modafferi (1991). Moose surveys in postrut areas were conducted above timberline in alpine tundra habitats, roughly between elevations from 600 to 1,200 m. Moose surveys in winter areas were conducted in lowland floodplain habitats between elevations of 30 to 300 m.

Moose populations in this region increased during 1980-84 and 1985-87 and decreased in 1984-85 and 1987-91 (Griese 1993*a*, 1993*b*). Moose populations in the area were probably at or very near carrying capacity before winter 1984-85. Moose were hunted during subunit-specific open seasons. In most subunits, male moose were hunted every year during a September season. In some areas, limited numbers of permits were issued for the harvest of antlerless and/or cow moose during the September season and/or a December through February season. Accidental collisions of moose with trains and highway vehicles were noteworthy sources of mortality in the region, particularly in deep-snow winters (Rausch 1958, Modafferi 1991). Moose predators in the area included wolves (*Canis lupus*) and brown (*Ursus arctos*) and black bears (*U. americanus*).

Information on predator densities in the area was largely circumstantial, but densities were relatively low in relation to many other areas in Alaska. Wolf density estimates ranged from about 1-2 wolves/100 km^2 in Subunits 14A, 14B and southern 16A to about 2-7 wolves/1000 km^2 in Subunits 13E, 16B and northern 16A (Ballard 1992*a*, Masteller 1994). In general, wolf populations probably increased during 1980-91. Brown bear density estimates ranged from 7-25 bears/1000 km^2 in Subunits 14A and 14B to about 12-35 bears/1000 km^2 in Subunits 13E, 16A, and 16B (Miller 1987, Grauvogel 1990, Griese 1993*a*). Brown bear populations were probably increasing during the study. Black bear density estimates ranged from about 35-104 bears/1000 km^2 in Subunits 14A and 14B (Grauvogel 1990) to about 90-193 bears/1000 km^2 in Subunits 13E, 16A, and 16B (Miller 1987, Griese 1993*b*). Black bear hunting over bait and increasing brown bear populations may have caused a decrease in black bear populations during the study.

METHODS

Moose Distribution Surveys

ADF&G staff conducted moose sex-age composition surveys during late autumn through winter to gather information on moose distribution and utilization of postrut areas. Surveys were conducted from October though April, 1986-91 in 7 discrete areas above timberline in the western foothills of the Talkeetna Mountains in Subunits 14A and 14B. Surveys were initiated in autumn after snowcover was adequate to observe moose. ADF&G staff surveyed about every 1-2 weeks, unless weather and snow conditions impeded aerial surveying and counting of moose. Surveys were terminated in spring when snow cover was inadequate to observe moose. Search effort during surveys was to count all moose. Search intensity varied with moose density but was usually about 1 minute/km^2. Surveys were conducted in PA-12 Super Cub aircraft. Moose were classified in categories of calf, nonantlered adult, antlered yearlings (moose with antlers measuring <76 cm; Gasaway 1975, Gasaway et al. 1987), and antlered adults (moose with antlers $\geq$76 cm). In previous investigations in the study area, similar survey procedures were used to conduct moose sex-age composition surveys in lowland riparian winter areas during October through April (Modafferi 1988*b*). Surveys in winter areas were conducted in the Susitna River floodplain between Devil Canyon and Cook Inlet in Subunits 16A, 16B and 13E in 1981-85 and in the Alexander Creek, Moose Creek, Deshka River and Yentna River floodplains in Subunits 16A and 16B in 1984-85. Data from these surveys were analyzed to compile information on moose distribution in winter and moose utilization of lowland winter areas.

Capture, Radiocollaring, and Monitoring Moose

Moose were captured for radiocollaring by darting either from a helicopter or approached on foot or snowmachine. Moose were immobilized with etorphine hydrochloride (M99, Lemmon Co., Sellersville, Pa.) with or without xylaxine hydrochloride (Rompun, Haver-Lockhart, Shawnee, Kans.) or carfentanil citrate (Wildnil, Wildl. Lab., Fort Collins, Colo.). M99 and Wildnil were antagonized with diprenorphine (M50-50, Lemmon Company, Sellersville, Pa.), naloxone hydrochloride (Dupont Pharmaceuticals, Garden City, N.J.) or naltrexone hydrochloride (Dupont Pharmaceuticals, Garden City, N.J.). Immobilized moose were ear tagged and fitted with a visual-numbered canvas collar (Franzmann et al. 1974) and radiotransmitter with or without a mortality option (Telonics, Mesa, Ariz.). Moose were captured during December and January in postrut areas in Subunits 14A and 14B and during January through April in lowland winter areas in Subunits 16B. Capture procedures took place in the western foothills of the Talkeetna Mountains between the south fork of Montana Creek and the Little Susitna River in 1985-89, in the Alexander Creek floodplain in 1987, and in the floodplains of the Yentna and the Skwentna Rivers between Lake Creek and Old Skwentna in 1988-89 (Fig. 3).

Capture procedures in postrut areas began after 18 November 1985, when aerial surveys indicated peak numbers of moose were present in those areas (Modafferi 1987). Capture procedures in winter areas commenced after 1 January after numbers of moose in postrut areas decreased and numbers of moose observed in winter areas increased. Radiocollars were allocated within winter areas and within and between postrut areas in relation to distribution of moose.

Age of captured moose was estimated mainly by incisor tooth wear. However, in the lower Susitna River study, a first incisor tooth was removed from captured moose for cementum aging (Sergeant and Pimlott 1959). Captured moose were >18 months of age and few moose were <30 months. All were considered adults.

Radiocollared moose were radiotracked 1-5 times each month for visual observation using a telemetry-equipped Cessna-152, -180, -185 or a Piper PA-18 Super Cub fixed-wing aircraft and standard aerial radiotracking procedures (Ballard et al. 1991). Not all radiocollared moose were located on each survey, but radiofixes on >60 moose during a single 1-day survey were common. I searched intensively at each site to confirm precise locations and to verify the animal was alive. Moose were monitored from capture to death or date of censor. I attributed death of moose at capture locations or within 4 days after collaring to capture stress.

During 1980-85, 75 moose were captured, radiocollared and monitored as part of a moose movement study in the lower Susitna River valley (Arneson 1981; Modafferi 1982, 1983, 1984, 1988*b*). My study area encompassed radiofix point locations of these moose. Moose point location and descriptive data collected in the former study were incorporated into my database. Radiocollared moose that survived to January 1986 were monitored in my study.

Survival

Radiocollared moose were judged dead by direct observation, by transmitter pulse rate if the transmitter contained the mortality/movement option, or radiofix location if radiofix locations on consecutive surveys were identical. When a moose was judged to be dead, an intensive aerial search was conducted to locate the radiocollar, parts of a moose carcass, and/or a disturbed site suggesting the animal was dead. Locations were revisited and aerially searched until sufficient evidence confirmed or refuted that the moose was dead. Locations were visited on foot to verify death.

Date and cause of death of radiocollared moose that died from legal hunter-harvest, illegal harvest, defense of life or property, and collisions with vehicles or trains were provided by hunters, ADF&G, the Alaska Department of Public Safety, and the Alaska Railroad Corporation.

Deaths of moose judged to be dead during radiotracking aerial surveys were categorized into 1 of 4 groups based on circumstances and/or evidence at the site of death: (1) illegal harvest, (2) accident, (3) winter kill, or (4) other. Illegal harvest was assigned mainly to moose radiotracked to a residential housing development during the hunting season. The accident group included deaths resulting from injuries and drowning. Intact moose carcasses on the snow with no evidence suggesting predation or accident were considered winter-killed. The remaining group, other, included deaths caused by predation and wounding injuries. Several moose deaths assigned to the other group were bulls that died in late September during or shortly after the beginning of hunting season. Death of bulls in this calendar period likely resulted from wounds inflected by hunters (Gasaway 1983, Fryxell et al. 1988) and/or from wounds incurred during rut-related fights with other bull moose (Koore 1959). The category other also included cows that died in the period mid May through July. Death of cows in this calendar period likely resulted from complications with birthing (Markgren 1969) and/or confrontations with bears (Ballard 1992 *b*).

Precise date of death was known for train kills, hunter harvest, illegal harvest, and kills in defense of life or property. For deaths in which the date was unknown, the mid-point date between the last two surveys was used. This interval was $\leq$15 days in 30% of the deaths, $\leq$35 days in 65% of the deaths, but $\geq$45 days in 6 deaths.

Censoring

Moose were censored from the database if: (1) the transmitter was lost or failed, (2) an animal emigrated from the study area, or (3) when the study was terminated. Lost or failed transmitters were censored on the midpoint between the dates of the last 2 radiofixes. Hunter harvested moose were censored on the reported date of kill.

Censoring of hunter harvested moose could affect estimates of survival if moose mortality in the winter after hunting season was compensatory with hunter harvest of moose. I used regression analysis to examine for evidence of a compensatory relationship between hunter harvest in autumn and mortality the following winter. Hunter bull harvest was regressed on bull deaths assigned to all sources, winter kill, and other. Analyses encompassed calendar years 1980-90.

Snow Conditions

Snowpack depth measurements were used to appraise snow conditions. These measurements were from Alaska Climatological Data Reports, U.S. Department of Commerce, NOAA, National Environmental Satellite, Data and Information Service, National Climate Data Center, Asheville, North Carolina for October through April during 1980-91. Snow conditions were characterized using maximum snowpack depth and the duration of deep snowpack from October through April. Measurements at Wasilla, Willow, Talkeetna, and Skwentna weather stations were used to reflect general snow conditions in the study area. In a few instances, snow measurement data were unavailable for a particular month at a weather station. In these cases, data from the next nearest weather station were used to proportionalize maximum snow depth for the month in question.

Management and Analysis of Moose Point-Location Data

Radiofix locations (audio-visual or audio) were plotted on 1:63,360-scale USGS topographic maps during radiotracking surveys. Radiofix point locations were later transferred to translucent overlays of maps for computer digitizing. Digitized point-location data files were joined to descriptive data files, forming unified data files. Unified data files from Lower Susitna River, Talkeetna Mountains, Alexander Creek and Yentna/Skwentna rivers studies were combined, forming a master file containing all data collected in studies of radiocollared moose in lower Susitna River valley.

Data records of all monitored female radiocollared moose were used to study chronology of calf birthing, chronology of breeding, twinning rates and calf/cow ratios in lower Susitna River valley moose populations. Data fields containing information on survey date and number of calves associated with radiomarked females were segregated from the database, perused and "cleansed" of errors.

Data records from all radiocollared moose were used to study survival of moose in lower Susitna River valley moose populations. Data fields containing information on capture date, dates of point location, and date the moose was determined to be dead or censored were segregated from the database, perused and "cleansed" of errors.

Data records from all radiocollared moose were used to study movements, seasonal range, and home range in lower Susitna River valley moose populations. Data fields containing information on number, date, x and y coordinates, number of point locations were segregated from the database, perused and "cleansed" of errors.

To relate point locations, movements and home range of radiocollared moose to management and biology of moose, prominent events in management and life history of moose were identified and delimited with calendar dates and Julian days (Table 1). Management and life history events identified were calving, summer range, rut, postrut range, winter range, moose surveys, fall hunts, and winter hunts. Point-location data were analyzed in relation to these events and calendar date periods.

Movements, Seasonal Range, and Home Range Analyses

Environmental requirements of moose change during the calendar year. For example, moose use different habitat in winter than during calving or postrut. If the habitat is patchy, moose must move seasonally to access different habitats. Spatial relationship of seasonal habitat patches determines the size and conformation of moose home ranges. Short distances between patches of seasonal habitat lead to small home ranges and, possibly, unimodal utilization distributions. Large distances between habitat patches lead to large home ranges, and possibly, multimodal utilization distributions. To accurately describe moose home range, one must include an assessment of the distance between utilization distributions (seasonal ranges or habitats) along with area measurements. In many species, multimodal utilization distributions include 2 nonoverlapping polygons, representing a summer and a winter range. However, data in this study indicated that moose home range may have included more than 2 nonoverlapping utilization distributions and that longest annual movement may not be to a winter range. In this study, ADF&G staff will investigate methods of evaluating spatial relationship between seasonal ranges. Eventually, descriptions of moose home range will include a measure of spatial relationship between seasonal ranges.

Radiotelemetry Point-Location Data Analysis Group

Select participants in a working group to organize and develop methods and procedures for analyzing point-location data collected in wildlife radiotelemetry studies. Biologists, biometricians and programmer/analysts will be represented in the group. The group will review, select, and recommend methodologies and computer hardware and software to analyze point-location data the ADF&G collects in radiotelemetry studies of movements and home ranges of wildlife. Point-location data collected in lower Susitna River valley moose movement studies will be used in developing this process.

RESULTS AND DISCUSSION

Surveys of Moose in Postrut and Winter Areas

Moose count data collected on aerial surveys in postrut areas (Modafferi 1990) and winter areas (Modafferi 1988) were used to explain the relationship between snowpack depth, moose movements, and the train moose-kill in Subunits 13E, 14A and 14B in lower Susitna River Valley (Modafferi 1992). We did not analyze moose sex/age composition data.

Capture, Radiocollaring, and Monitoring Moose

Talkeetna Mountains:

Forty-four moose were captured and radiocollared in 7 discrete postrut areas in Subunits 14A and 14B (Fig. 3, area A-G) from 23 December 1985 to 4 February 1986. On December 1987 and 1988, 8 moose were captured and radiocollared in these areas. In January 1987, 7 moose were captured and radiocollared in lowland forest habitat (Fig. 4, Area H) located between Little Willow Creek and the Kashwitna River in Subunit 14B. In February 1989, 5 moose were captured and radiocollared at timber sale sites between Willow Creek and Iron Creek (Fig. 4, Area H). In February and March 1988, 6 moose were captured and radiocollared at personal-use firewood cutting sites near Coal Creek (Fig. 4, Area I). In April 1990, 7 moose were captured and radiocollared at 6 sites along the Parks Highway between the Little Susitna River in Subunit 14A and Sheep Creek in Subunit 14B (Fig. 1).

Alexander Creek:

In March 1987, 20 moose were captured and radiocollared in Alexander Creek floodplain (Fig. 4, Area J).

Yentna and Skwentna Rivers:

In February 1988 and 1989, 30 moose were captured and radiocollared in floodplains of the Skwentna and Yentna rivers between Old Skwentna and McDougall (Fig. 4, Area K).

Lower Susitna River:

At the time I began this study, radiotransmitters on 32 moose captured and radiocollared during previous studies in the lower Susitna River floodplain were operational and transmitting audible radio signals. These moose were monitored in my study. Radiotransmitters on some of these individuals exhibited either weak, infrequent, or no signals. I presumed these transmitters were weakening and expiring from battery failure.

Analysis of Radiotelemetry Point-location Data

Calendar Year and Seasonal Periods:

The calendar year, 7 May to 6 May the following year, was used to study annual home range of moose. A Julian calendar of 1 to 365 days was used to describe the 7 May to 6 May calendar year. To study seasonal home ranges, the Julian calendar year was subdivided into periods related to life history and management of moose (Table 1 and Appendix A).

Radiotelemetry Data Analysis Working Group:

The telemetry data analysis working group was selected. The group included biologists D. A. Anderson and C. C. Schwartz; biometricians E. F. Becker and J. VerHoef; analyst/programmer B. Strauch; and the principal investigator R. D. Modafferi. The group convened in Anchorage September 1993 to discuss and outline a study plan.

Computer System and Software:

The working group selected a computer system, printer, and basic software appropriate to conduct movement and home range analyses on radiotelemetry point-location data. The computer system selected was a 486-66 with 8 Kb of RAM and a Windows operating system. The printer selected was an 8 page per minute laser printer. The 4 softwares selected were Lotus 1-2-3, a spreadsheet program (Lotus Development Corporation 1993); FoxPro, a relational database management system (Microsoft FoxPro, 1993); ArcView, a geographic information system (ArcView 1992) and CALHOME, a home range analysis program (Kie et al. 1994*a*, 1994*b*). FoxPro was used to select, segregate, and manipulate data used in analyses. ArcView facilitated interactive manipulation of data fields within the point-location database, overlaying views of point locations with geographic feature databases and printing hardcopies of data. CALHOME ran home range analyses on X, Y coordinates of point-location data. This program is menu driven, enabling the user to select between 4 home range methods: adaptive kernel (Worton 1989), harmonic mean (Dixon and Chapman 1980), bivariate normal (Jennrich and Turner 1969), and minimum convex polygon (Mohr 1947). CALHOME provides hard copy and screen-display graphic representations of location points and home range polygons. This program also creates an output file, listing distances between successive point locations entered in home range analyses.

Administrative and Analytical Procedures:

Administrative procedures were initiated to purchase a 486-66 computer with a Windows operating system, laser jet printer, and 3 software to conduct analyses of the point-location database file. A copy of CALHOME (beta version) was requested and received (c/o John G. Kie, U.S. Forest Service, Pacific Southwest Research Station, 2081 East Sierra Avenue, Fresno, CA 93710). Computer hardware and the software ArcView and FoxPro were delivered to the Palmer office 28 February 1994. The investigator was briefed on the Windows-based computer system, printer, and ArcView and FoxPro software. The investigator acquainted himself with the computer system, manipulating data with FoxPro and conducting interactive analyses with ArcView on subsets of the point-location data.

The telemetry data analysis working group convened in Anchorage on 11 August 1994 for an overview and discussion on using the updated version of the CALHOME home range analysis program (version 1). The group concluded that the adaptive kernel method (AK) of home range analysis was the most appropriate home range method for analysis of moose point-location data. The AK method, which produces an unbiased density estimate, is least influenced by effects of grid size and placement, and it provides realistic interpretations of unimodal and multimodal utilization distributions. Goodness of fit was evaluated with a least squares cross validation score (LSCV) (Fig. 4 and Fig. 5). In adaptive kernel analyses, the CALHOME program allows the user to select bandwidth, grid cell size and utilization distribution point percentage contours (i.e., % of points included in estimated home range). Trial analyses of data verified compatibility of software and hardware, familiarized staff with AK home range analysis, and simplified data manipulations and procedures for AK analyses. Preliminary home range analyses indicated grid size and bandwidth were important components affecting shape and fit of the utilization distribution contours and estimates of home range. Grid density affects how well a plotted contour approximates the surface of interest. Denser grids provided smoother contours. The group decided to use the densest grid, 50×50, in all adaptive kernel home range analyses. The investigator used the 98% utilization distribution contours in all AK analyses. Experience in monitoring moose and preliminary data analyses indicated very few point locations were clearly extraneous to other point locations.

Point-location data from a sample of moose were used to study relationship between bandwidth size and the moose point-location data. These analyses were used to determine if a single bandwidth could be used in all AK moose home range analyses. To examine this, different size bandwidths were used in analyzing point-location data of each moose (Appendix B). Bandwidths yielding the lowest LSCV, a measure of goodness of fit, were selected as the "ideal" bandwidth for use in home range analyses (Appendix C). We conducted final adaptive kernel analyses using the "ideal bandwidth." We produced hard copy plots of final analysis home range polygons for the subset of moose (Appendix D).

Relationship between bandwidth, home range size, and number of utilization distributions:

Bandwidth selected by the trial and error process in Appendix B ranged from 400 m to 2600 m (Fig. 6). The bandwidths most frequently selected were between 1200 m and 1400 m. Bandwidth from 700 m to 1700 m provided minimum LSCVs in about 80% of the moose. The number of utilization distributions or polygons (i.e., polygon = >2 point locations encircled) identified in a moose home range varied from 1 to 8 (Fig. 7). Area of utilization distributions ranged from 9.2 mi^2 to 204.5 mi^2 (Fig. 8); 75% ranged from 20 mi^2 to 70 mi^2. There was an inverse relationship between number of utilization distribution polygons (centroids) and bandwidth (Fig. 9). There was a positive relationship between home range size and bandwidth (Fig. 10) and between home range size and centroids (Fig. 11).

Year Effects on Point-Location Data:

Radiotelemetry Point-location Data Analysis Working Group was concerned about year effects on estimates of home range. If year effects were not present, home range analyses conducted on point-location data collapsed over years. To explore for year effects in point-location data, point-location data from a sample of moose that exhibited multimodal utilization distributions (polygons) were examined for evidence of year-to-year philopatry in winter to a single utilization distribution polygon.

I presumed that polygons were likely to include year effects. However, I was aware that winter-season × year effects could be present in a unimodal utilization distribution. To force appearance of multiple polygons, home range analyses were performed with shorter bandwidths than those that provided the LSCVs. However, when examining the short bandwidths, I avoided selecting those that fragmented utilization distribution into numerous 1- and 2-point polygons.

The process of selecting a bandwidth to force appearance of multimodal utilization distributions was a very subjective procedure. When I was pleased with the representation of multiple polygons in an AK home range analysis plots of the home range analyses were produced (Appendix E) and the examination for year effects continued as follows: 1) each polygon was labeled with a number; polygons encompassing <3 points were considered as transient ranges or outlying points (outliers) and were not identified as a seasonal range; 2) outliers were classified into groups based on spatial relationship with respect to adjacent polygons and were labeled with a number; 3) data on x,y coordinates, Julian day, and Julian year of point locations (radiofix observations) were copied to a FoxPro database file; 4) database files were translated in LOTUS to .wk1 files; 5) .wk1 files were sorted by the x or y coordinate ("X-COORD,Y-COORD") to identify each location point on a CALHOME home range hard copy output; 6) each location point was assigned the number of the polygon or outlier group; 7) location point polygon numbers were entered into a field ("CENTROID") in the lotus file; 8) lotus files were sorted by Julian year ("CYEAR") 7 May through 6 May the following year (Appendix F); 9) Graphs of the point-location data, Julian day ("CJDAY") × polygon number, were created for each moose; and 10) graphs were examined visually for evidence of overlap in utilization distributions during a common calendar period (i.e., were several utilization distribution polygons represented during the same Julian day?). If the overlap of polygons was a year effect, data from selected years were deleted from graphs to determine if that eliminated the overlap.

There was a very shallow snowpack in lower Susitna River valley in Julian year 1985-86 (Fig. 4). Therefore, in exploring for year effects, I especially examined the hypothesis that moose used different areas (polygons) in the winter of 1985-86 than in winter in other years. The data examined supported this assertion. Many moose, particularly those radiocollared in Unit 14B, used different areas (polygons) in winter 1985-86 than in other years. The data indicated that in 1985-86 many moose stayed in postrut areas or moved only short distances from postrut areas to winter areas. Data gathered on moose surveys in postrut areas supported this movement pattern(Modafferi 1991). The data also indicate that moose did not use the same winter area in years other than 1985-86. These analyses also indicated that some moose used different areas during calving. However, this observation may be misleading because the length of time cow moose utilize calving sites probably depends on neonate survival. Cow moose that lose a calf shortly after calving may move immediately to a summer area, but cows with calves may remain in the calving area longer.

Spatial Relationship Between Season Ranges:

Data analyzed from a cow moose that moved a great distance between utilization distributions indicated the longest movements were between Julian day 340 and Julian day 60 the following year (Fig. 13). Timing of long distance movements correlates with movements from a winter range (late winter) to a calving range (spring). Other long distance movements occurred between Julian day 130 and Julian day 180. Timing of these movements correlates with movements from a rut range to a postrut range. Of particular significance is that the moose did not move great distances between postrut range and winter range.

Publications

Completed:

A manuscript titled "In Utero Pregnancy Rates, Litter Size and Productivity For Social Classes of Cow Moose in South-Central Alaska" was prepared and submitted for publication in the journal *Alces*. The manuscript was accepted and published in *Alces* 28:223-234.

In Draft Form:

A draft of the manuscript *Survival of radiocollared adult moose in lower Susitna River valley, Southcentral Alaska* is in Appendix H.

In Preparation:

- *Birthing chronology, breeding chronology, twinning rate and calf/cow ratios in radiocollared cow moose in lower Susitna River valley in Southcentral Alaska: Characteristics and Relationship with Weather*

- *Movements, Seasonal Range, and Home Range of Radiocollared Moose in Lower Susitna Valley in Southcentral Alaska*

Future Activities

Home range analyses conducted indicate that it is not possible to select a single bandwidth, based on minimum LSCV, for use in analysis of moose point-location data. These analyses indicated bandwidth must be examined in a trial and error process to select bandwidth based on a minimum LSCV value. J. Kie (pers. commun.) indicated that in analyzing deer home range data, the bandwidth selected was as the one which produced the lower LSCV value between the following 2 CALHOME analyses: 1) the program estimated optimum bandwidth and 2) 0.8 times, the program estimated optimum bandwidth value.

Confer with members of telemetry data analysis working group to: 1) establish a standardized method of selecting bandwidth for CALHOME AK home range analyses, 2) outline procedures that adjust for year effects in home range analyses, 3) determine methods outline procedures that adjust for year effects in home range analyses, 3) determine methods of describing spatial relationship between seasonal home ranges in a home range, and 4) determine a method of incorporating information on spatial relationships of seasonal home ranges in home range analyses. Use these methodologies to analyze point-location data collected in lower Susitna Valley moose studies for information on population identity and moose movements.

ACKNOWLEDGMENTS

I especially thank staff of the Alaska Department of Fish and Game (ADF&G) for helping with this study. D. C. McAllister assisted in many aspects of the study. I acknowledge many ADF&G colleagues for assistance in moose capture and radiotracking procedures. P. A. Arneson provided data on moose captured, radiocollared, and monitored during 1980 in Subunits 16A and 13E. J. B. Faro contributed information on moose captured, radiocollared, and monitored in Subunit 16B during 1987-88. My supervisors, K. B. Schneider, D. A. Anderson, and C. C. Schwartz, provided guidance, peer review assistance, and administrative support. I thank J. C. Didrickson, C. A. Grauvogel, H. J. Griese, and M. W. Masteller for their support. I thank light aircraft pilots C. A. Allen, Charlie Allen Flight Service; M. Houte, L. Rogers, C. R. and V. L. Lofstedt, Kenai Air Alaska; W. A. Woods, Woods Air Service; and W. D. Wiederkehr, Wiederkehr Air Inc. for skill, dedication, and enthusiasm on aerial radiotracking surveys. E. B. Becker and Jay VerHoef provided statistical advice and clarified analytical concepts. B. Strauch managed and processed the point-location data file and performed many GIS analyses. S. R. Peterson and other staff at ADF&G, Juneau, provided advice and comments on reports and manuscripts.

LITERATURE CITED

ArcView. 1992. Arc View User's Guide. 2nd ed. Environmental Systems Research Institute, Inc., Redlands, Calif.

Albert, S. W., and L. C. Shea. 1986. Moose winter habitat in the lower Susitna Valley, Alaska: Pilot project on habitat suitability assessment. Alaska Dept. Fish and Game. Tech.Rep. No. 86-6. Juneau. 105pp.

Arneson, P. 1981. Big game studies. Vol. II. Moose. Ann. Prog. Rep. Susitna Hydroelectric Proj. Alaska Dep. Fish and Game. Juneau. 64pp.

Ballard, W. B. 1992*a*. Modelled impacts of wolf and bear predation on moose calf survival. *Alces* 28:79-88.

Ballard, W. B. 1992*b*. Bear predation on moose : a review of recent North American studies and their management implications. *Alces*. Suppl. 1:162-176.

_____, J. S. Whitman, and D. J. Reed. 1991. Population dynamics of moose in south-central Alaska. *Wildl. Monogr.* 114. 49pp.

Chatelain, E. F. 1951. Winter range problems of moose in the Susitna Valley. Proc. Alaska Sci.; Conf. 2:343-347.

Didrickson, J. C., and K. P. Taylor. 1978. Lower Susitna Valley moose population identity study. Alaska Dept. of Fish and Game. Fed. Wildl. Rest. Proj. Final Rept., W-17-8 and 9. Job 1.16R. Juneau. 20pp.

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

Franzmann., A. W., P. D. Arneson, R. E. LeResche, and J. L. Davis. 1974. Developing and testing new techniques for moose management. Alaska Dep. Fish and Game. Fed. aid Wildl. Restor. final Rep., Proj. W-17-2, W-17-3, w-17-4, W-17-5, and W-17-6. 54pp.

Fryxell, J. M. , W. G. Mercer, and R. B. Gellately. 1988. Population dynamics of Newfoundland moose using cohort analysis. *J. Wildl. Manage.* 52:14-21.

Gasaway, W. C. 1975. Moose antlers: How fast do they grow? Alaska Dept. of Fish and Game, Brochure. Juneau. 6pp.

_____, R. O. Stephenson, J. L. Davis, and O. E. Burris. 1983. Interrelationships of wolves, prey and man in Interior Alaska. *Wildl. Monogr.* 84. 50pp.

_____, W. C. D. J. Preston, D. J. Reed, and D. J. Roby. 1987. Comparative antler morphology and size of North American moose. Swedish Wildl. Res. (Suppl.) 1:311-325.

Grauvogel, C. A. 1990. Unit 14 brown bear survey-inventory progress report. Pages 84-94 *in* S. O. Morgan, ed. Annual report of survey-inventory activities. Part V. brown/grizzly bears. Vol. XX. Alaska Dep. Fish and Game. Fed. Aid in Wildl. Rest. Prog. Rep. Proj. w-23-2. Study 4.0. Juneau.

Griese, H. J. 1993*a*. Unit 14A moose survey-inventory progress report. Pages 113-125 in S. A. Abbott, ed. Management Report of Survey-Inventory Activities. Moose. Alaska Dep. Fish and Fame Fed. Aid in Wildl. Rest. Prog. Rep. Proj. W-23-3 and W-23-4. Study 1.0. Juneau. 422pp.

______. 1993*b*. Unit 14B moose survey-inventory progress report. Pages 126-135 in S. A. Abbott, ed. Management Report of Survey-Inventory Activities. Moose. Alaska Dep. Fish and Game Fed. Aid in Wildl. Rest. Prog. Rep. Proj. W-23-3 and W-23-4. Study 1.0. Juneau. 422pp.

Jennrich, R. I., and f. B. Turner. 1969. Measurement of noncircular home range. J. *Theoretical Biology* 22:227-237.

Kie, J. G., J. A. Baldwin, and C. J. Evans. 1994*a*. CALHOME- Data preparation utilities. *Electronic User's Manual*. 8pp.

_____, J. A. Baldwin, and C. J. Evans. 1994*b*. CALHOME Home range analysis program *Electronic User's Manual*. 19pp.

Knorre, E. P. 1959. Ekologiya locya. Trudy Pechora-llych. gos. Zapov. 7:5-167. *in* Lent, P. C. 1971. A review of rutting behavior in moose. *Nat. Can.* (Que.) 101:307-323.

Lotus Development Corporation. 1993. *Lotus User's Guide*. Lotus 1-2-3 for DOS, Release 2.4. 55 Cambridge Parkway, Cambridge, Mass. 435pp.

Markgren, G. 1969. Reproduction of moose in Sweden. Viltrevy 6:127-299.

Masteller. M. 1994. Unit 16 wolf survey-inventory progress report. 1-16 *in* S. A. Abbott, ed. Management Report of Survey-Inventory Activities. Brown Bear. Alaska Dep. fish and game. Fed. Aid in Wildl. Rest. Prog. Rep. Proj. W-23-4 and W-23-5. Study 4.0. Juneau. In prep.

Microsoft FoxPro. 1993. Getting Started Microsoft FoxPro for MS-DOS. Microsoft Corp., Redmond, WA.

Miller, S. D. 1987. Susitna Hydroelectric Project final Rep. Big Game studies . Vol 6. black bear and brown bear. Alaska Dep. Fish and Game. Anchorage. 276pp.

Modafferi, R. D. 1982. Big game studies. Vol II. Moose-Downstream. Final Phase I Rep. Susitna Hydroelectric Proj. Alaska Dep. Fish Game. Juneau. 114pp.

__________. 1983. Big game studies. Vol. II. Moose-Downstream. Prog. Rep. Phase II. Susitna Hydroelectric Proj. Alaska Dep. Fish and Game. Juneau. 114pp.

__________. 1984. Big game studies. Vol. II. Moose-Downstream. Prog. Rep. Phase II. Susitna Hydroelectric Proj. Alaska Dep. Fish and Game. 116pp.

__________. 1987. Lower Susitna Valley moose population identity and movement study. Alaska Dep. Fish and Game. Fed. Aid Wildl. Rest. Prog. Rep. Proj. W-22-5. Job 1.38R. Juneau. 17pp.

__________. 1988*a*. Lower Susitna Valley moose population identity and movement study. Alaska Dep. Fish and Game. Fed. Aid Wildl. Rest. Prog. Rep. Proj. W-22-5 and W-22-6. Job IB 1.38. Juneau. 60pp.

__________. 1988*b*. Big game studies. Vol. I. Moose-Downstream. Final Rep. Susitna Hydroelectric Proj. Alaska Dep. Fish and Game. 211pp.

__________. 1990. Lower Susitna Valley moose population identity and movement study. Alaska Dep. Fish and Game. Fed. Aid Wildl. Rest. Prog. Rep. Proj. W-23-2. Job IB 1.38. Juneau. 46pp.

__________. 1991. Train moose-kill in Alaska: Characteristics and relationship with snowpack depth and moose distribution in lower Susitna Valley. *Alces* 27:193-207.

__________. 1992. Lower Susitna Valley moose population identity and movement study. Alaska Dep. Fish and Game. Fed. Aid Wildl. Rest. Prog. Rep. Proj. W-23-2. Job IB 1.38. Juneau. 39pp.

Mohr, C. O. 1947. Table of equivalent population of North American mammals. *Amer. Midland Nat.* 37:223-249.

Pimlott, D. H. 1959. Reproduction and productivity of Newfoundland moose. *J. Wildl. Manage.* 23:381-401.

Rausch, R. A. 1958. The problem of railroad-moose conflicts in the Susitna Valley. Alaska Dep. of Fish and Game. Fed. Aid Wildl. Rest. Final Rep. Proj. W-3-R. Job 1-4. Juneau. 116pp.

__________. 1959. Some aspects of population dynamics of the railbelt moose populations, Alaska. M.S. Thesis. Univ. Alaska, Fairbanks. 81pp.

Sergeant, D. E., and D. H. Pimlott. 1959. Age determination in moose from sectioned incisor teeth. *J. Wildl. Manage.* 23:315-321.

Viereck, L. A., and E. L. Little, Jr. 1972. Alaska trees and shrubs. U.S. Dept. Agric. Forest Serv. Handbook No. 410. 265pp.

Worton, B. J. 1989. Kernel methods for estimating the utilization distribution in home-range studies. *Ecology.* 70:164-168.

PREPARED BY:

Ronald D. Modafferi
Wildlife Biologist

SUBMITTED BY:

Charles C. Schwartz
Research Coordinator

APPROVED BY:

Wayne L. Regelin, Acting Director
Division of Wildlife Conservation

Steven R. Peterson,
Division of Wildlife Conservation

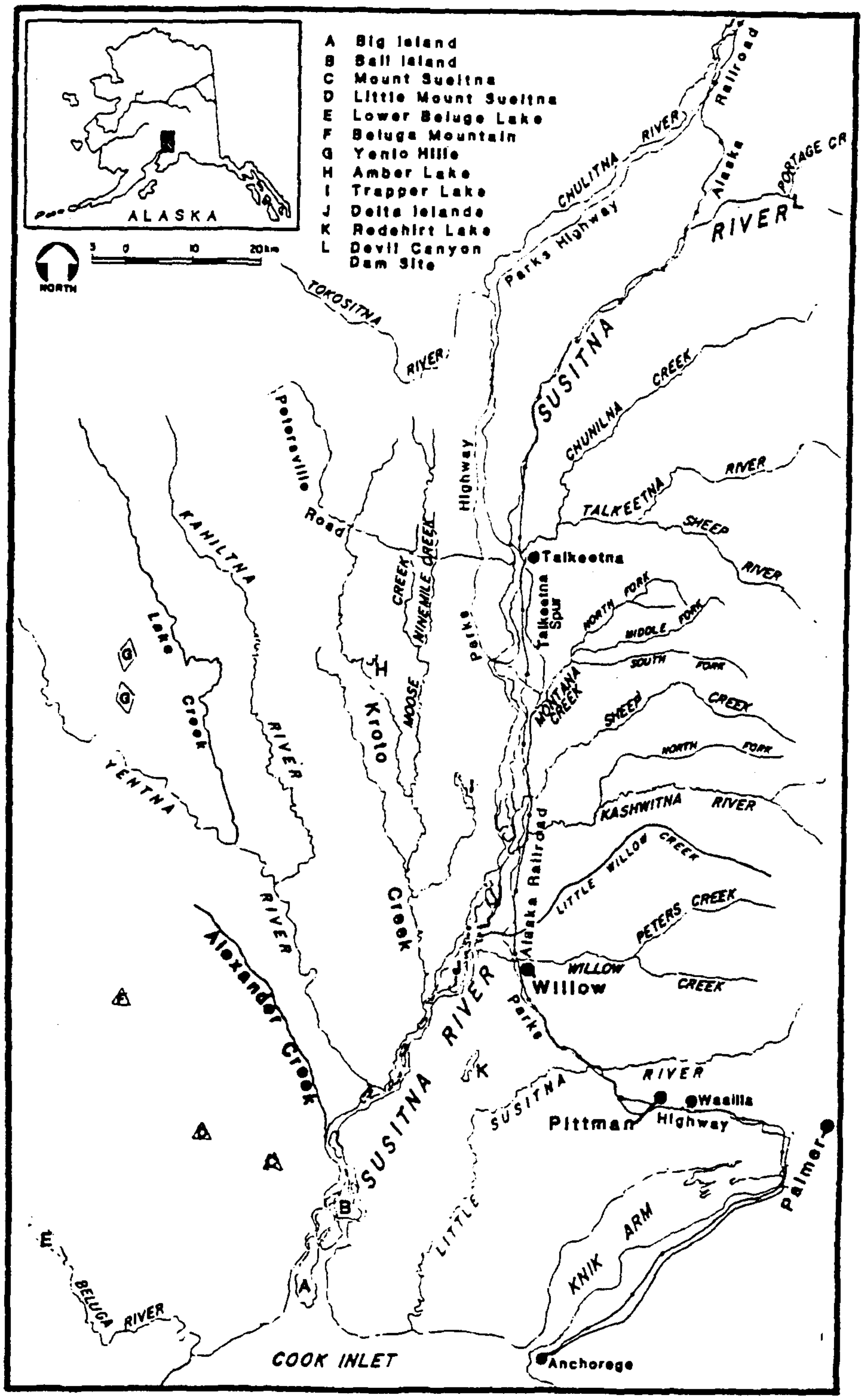


Figure 1. Map showing location of the study area in Alaska with names listed for rivers, lakes and other prominent landscape features.

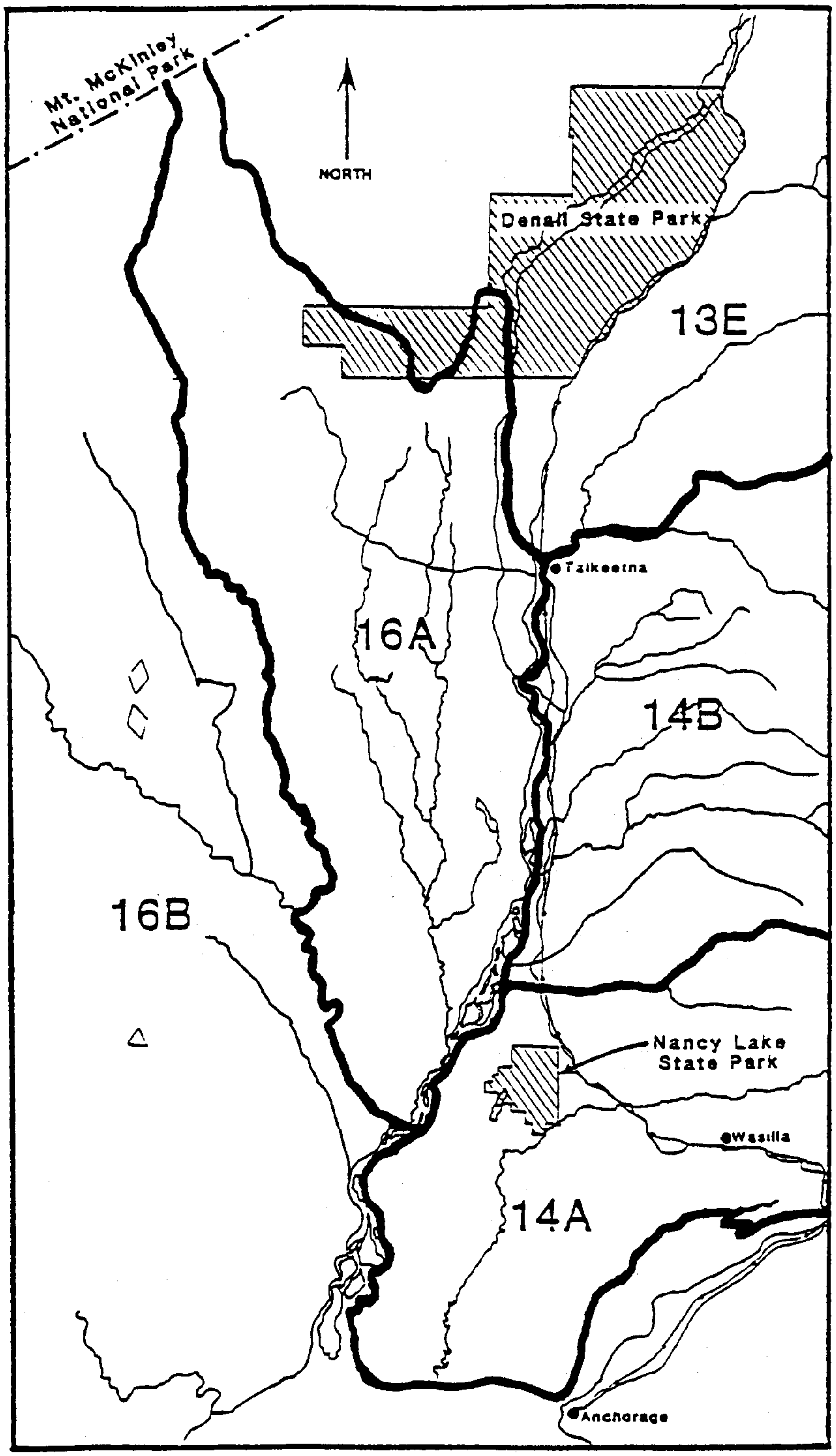


Fig. 2. Location of Game Management Subunits (13E, 14A, 14B, 16A and 16B) and state and national parks in the study area.

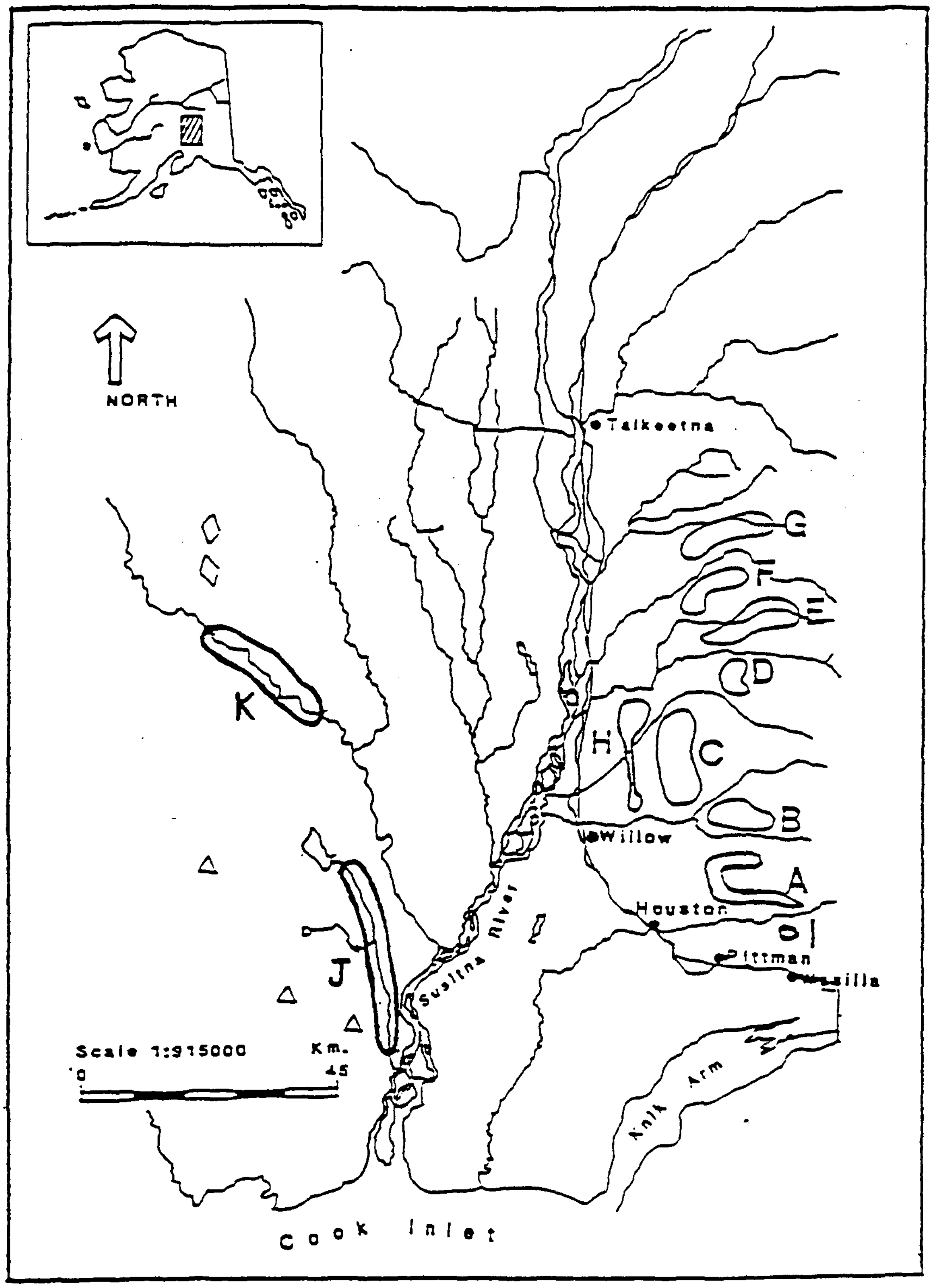


Fig.3. Locations of Talkeetna Mountains alpine habitat moose postrut areas (A-G), Kashwitna Corridor Forest (H), Coal Creek timber cut area (I), Alexander Creek (J) and the Lake Creek/Skwentna area (K) where moose were captured and radio-marked. A = Bald Mountain, B = Moss Mountain, C = Willow Mountain, D = Witna Mountain, E = Brownie Mountain, F = wolverine Mountain, and G = Sunshine Mountain.

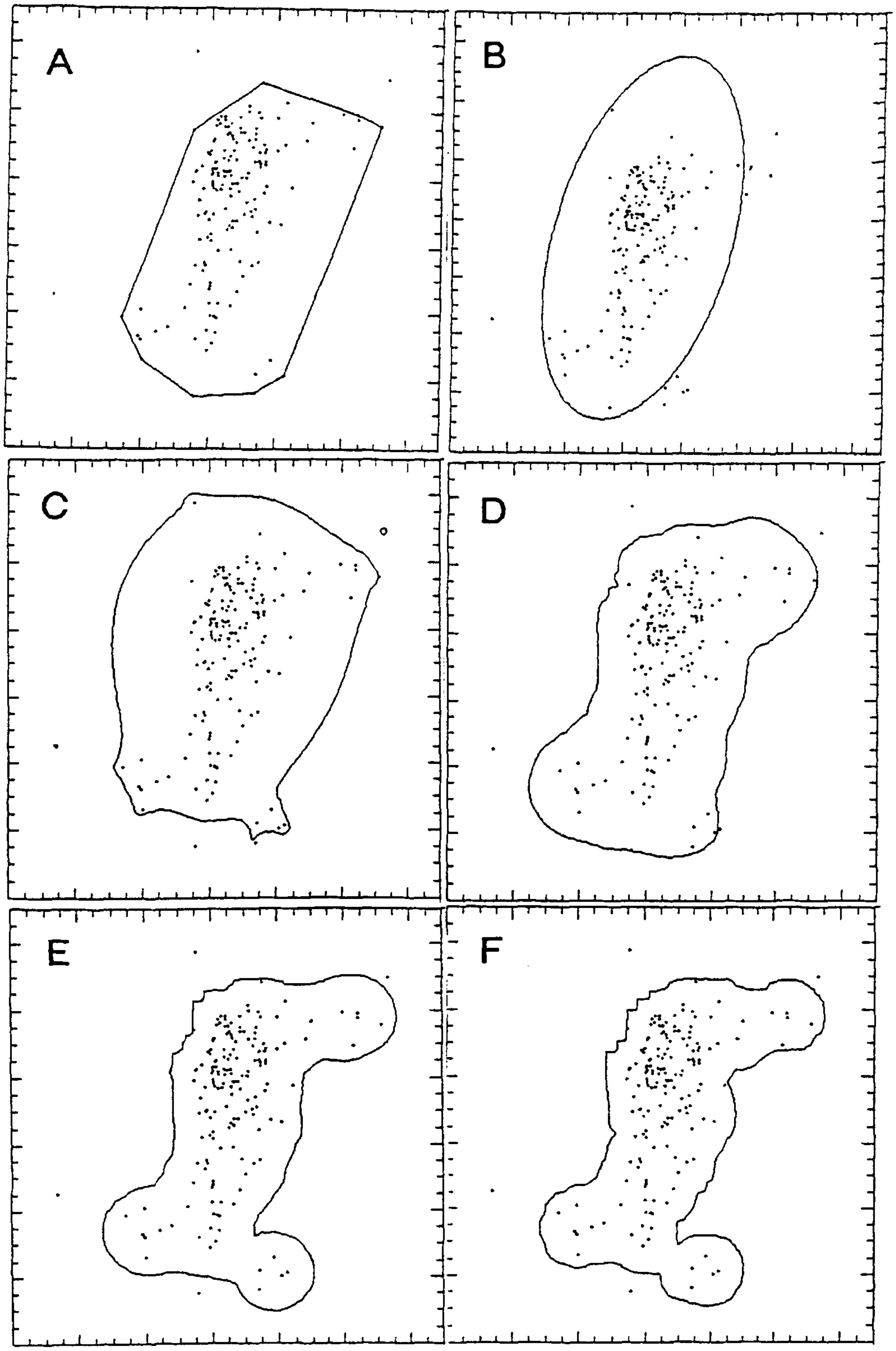


Fig. 4. A unimodal utilization distribution estimated from 98P% minimum convex polygon (A), 98V% bivariate normal (B), 98P% harmonic mean (C), and 98P% adaptive kernel (D-F) home range methods in the CALHOME home range analysis program (Kie et al. 1994). Bandwidth = 1,363 m (program default, optimum) in D, 900 in E, and 700 in F. Home range estimates (ha) = 4,499 (A), 6,266 (B), 5,880 (C), 5,165 (D), 4,411 (E), and 4,135 (F). Axis scaling not the same in all Figs.

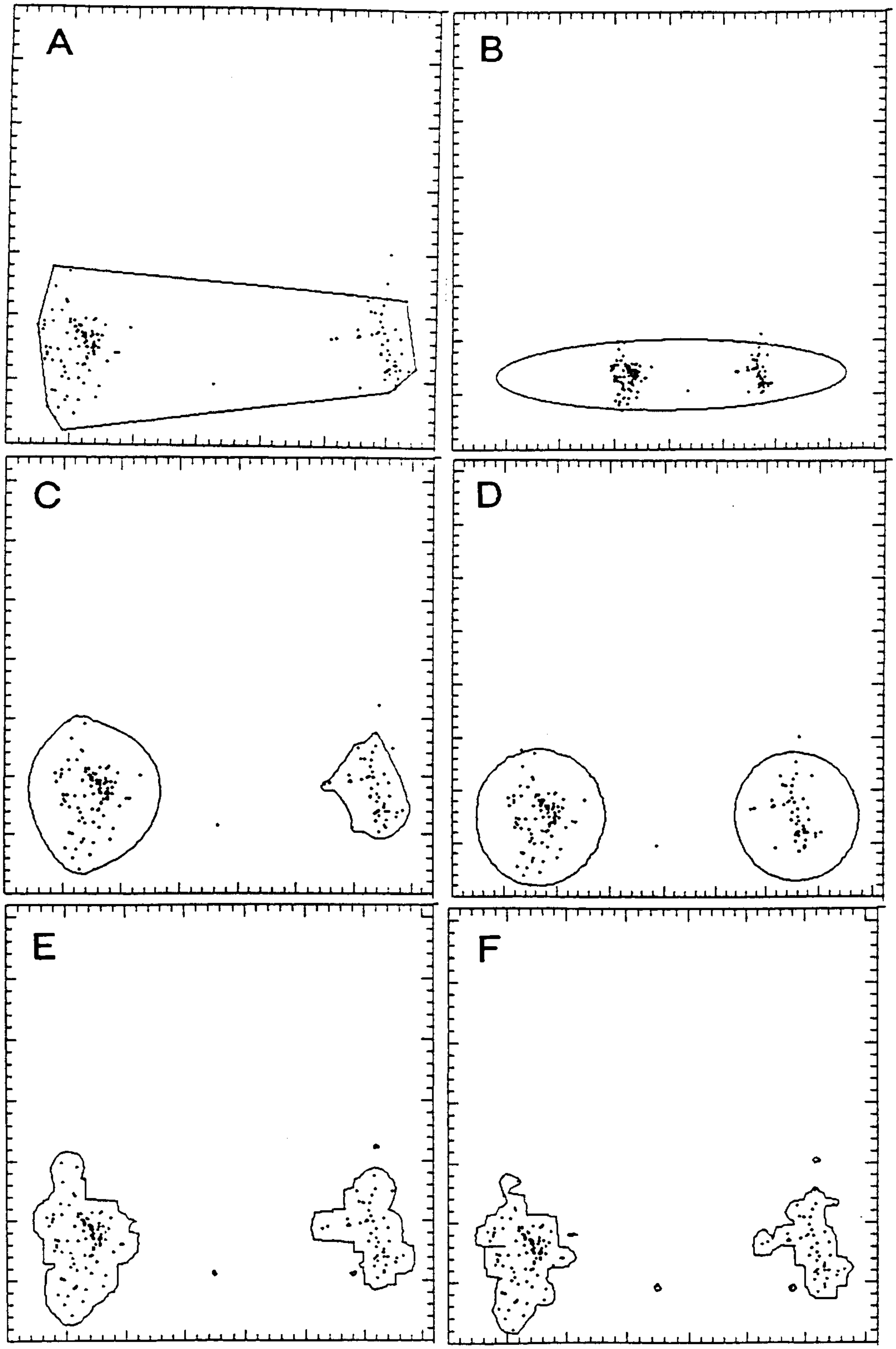


Fig. 5. A bimodal utilization distribution estimated from 98P% minimum convex polygon (A), 98V% bivariate normal (B), 98P% harmonic mean (C), and 98P% adaptive kernel (D-F) home range methods in the CALHOME home range analyses program (Kie et al. 1994). Bandwidth = 6,405 m (program default, optimum) in D, 900 in E, and 700 in F. Home range estimates (ha) = 28,690 (A), 65,790 (B), 15,160 (C), 23,570 (D), 12,050 (E), and 9,193 (F). Axis scaling not the same in all Figs.

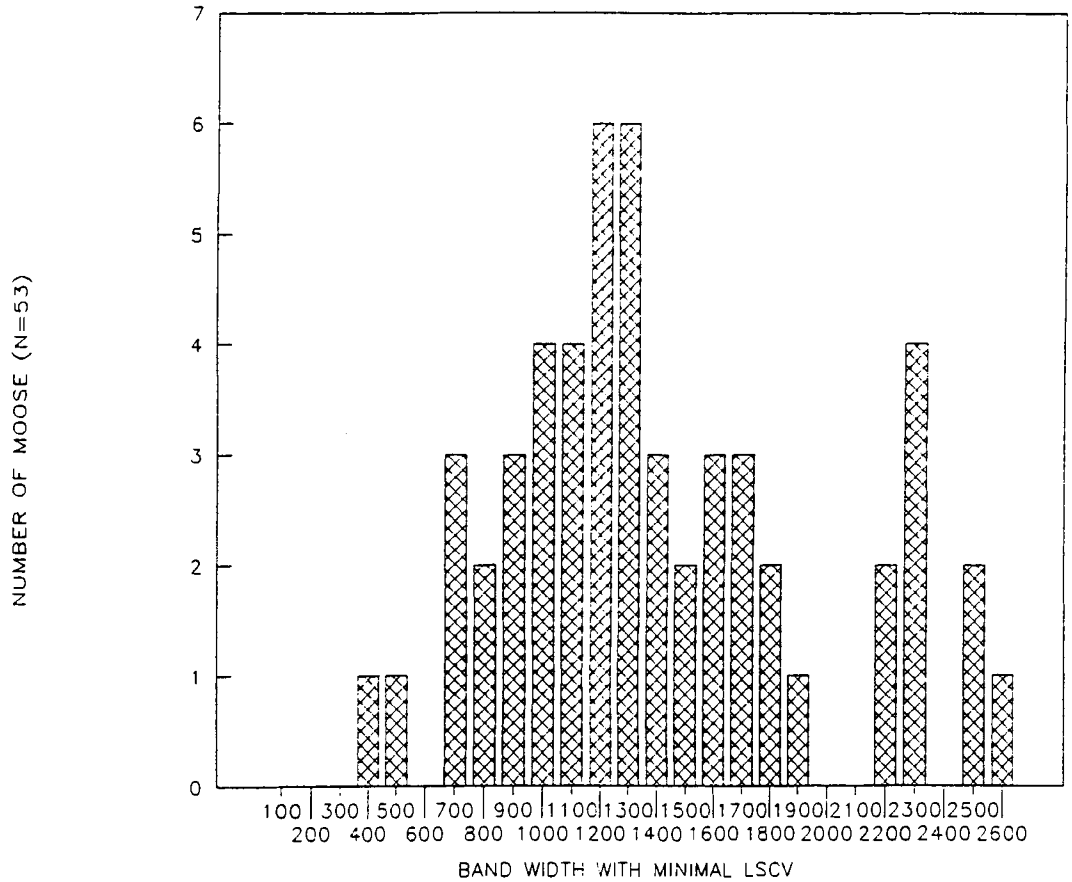


Fig. 6. Frequency distribution of bandwidths (m) selected for use in CALHOME adaptive kernel home range analyses performed on moose point location data. Bandwidth selection was based on minimizing the LSCV value.

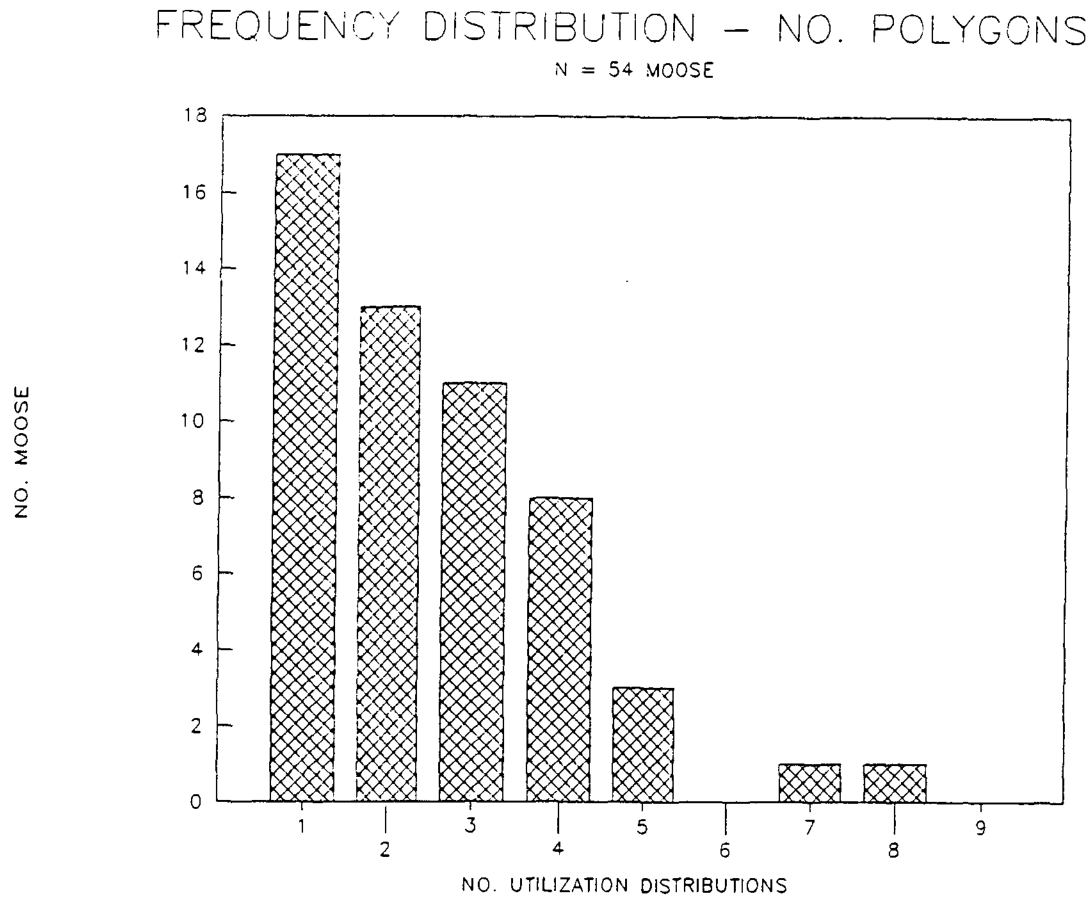


Fig. 7. Frequency distribution of the number of utilization distribution polygons delieneated in CALHOME adaptive kernel home range analyses performed on moose point location data. Utilization distribtuion polygon = a polygon encompassing >2 point locations.

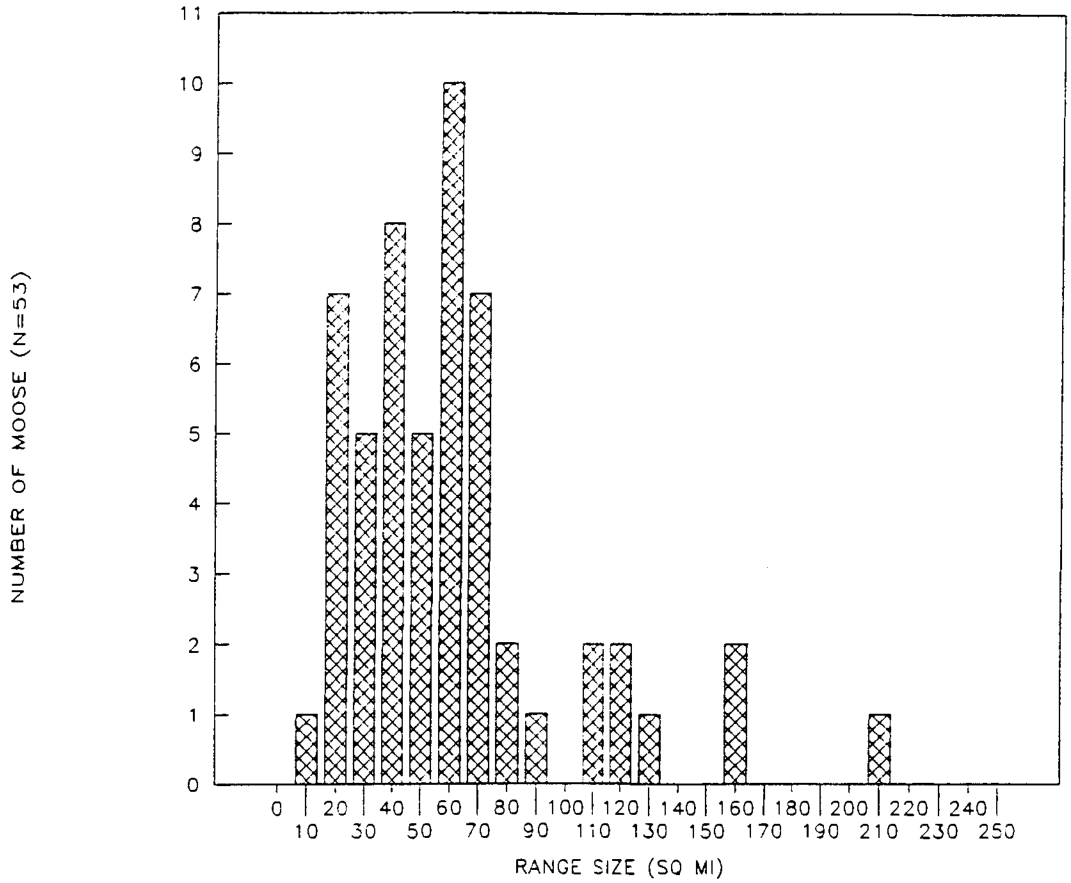


Fig. 8. Frequency distribution of estimates of home range size (mi^2) obtained in CALHOME adaptive kernel home range analyses performed on moose point location data.

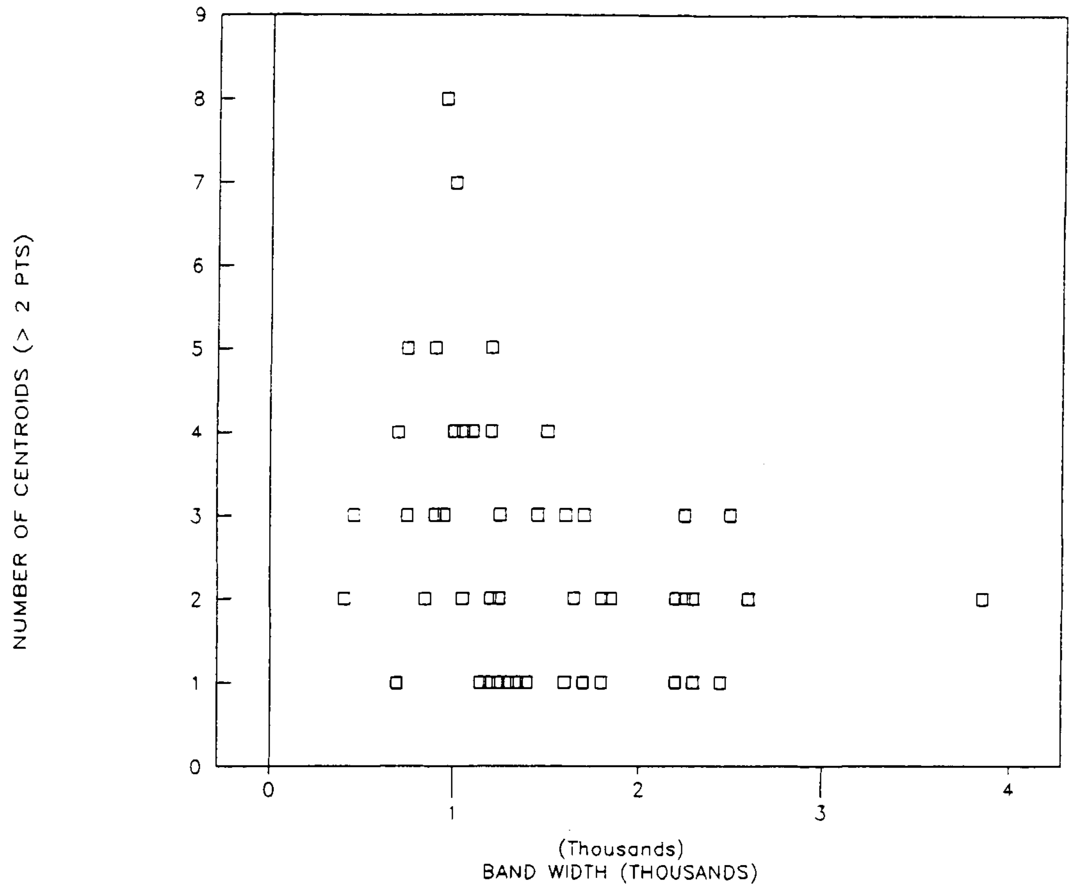


Fig. 9. Relationship between bandwidth (m) and number of utilization distribution polygons (centroids). Utilization distribution polygon = a polygon encompassing >2 point locations. Data obtained from CALHOME adaptive kernel analyses performed on moose point location data. Bandwidth selection was based on minimizing the LSCV value.

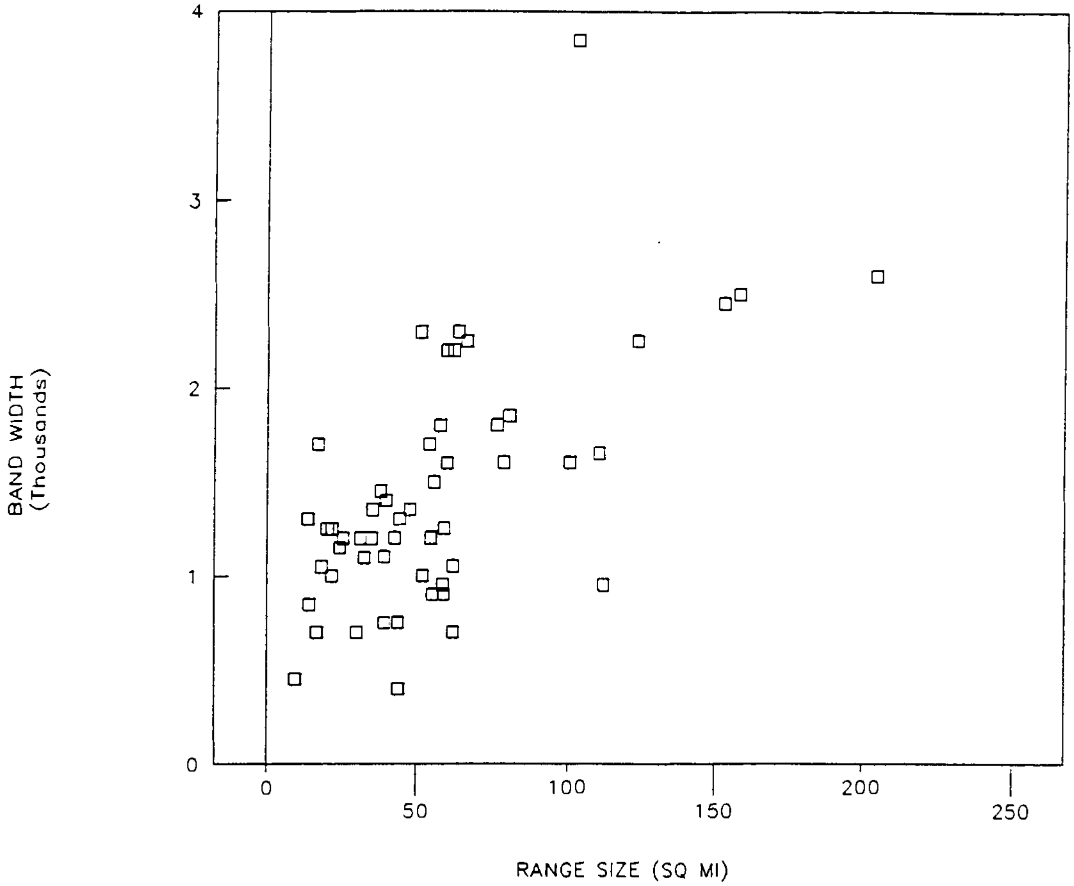


Fig. 10. Relationship between bandwidth (m) and moose home range size (mi^2). Data obtained from CALHOME adaptive kernel analyses performed on moose point location data. Bandwidth selection was based on minimizing the LSCV value.

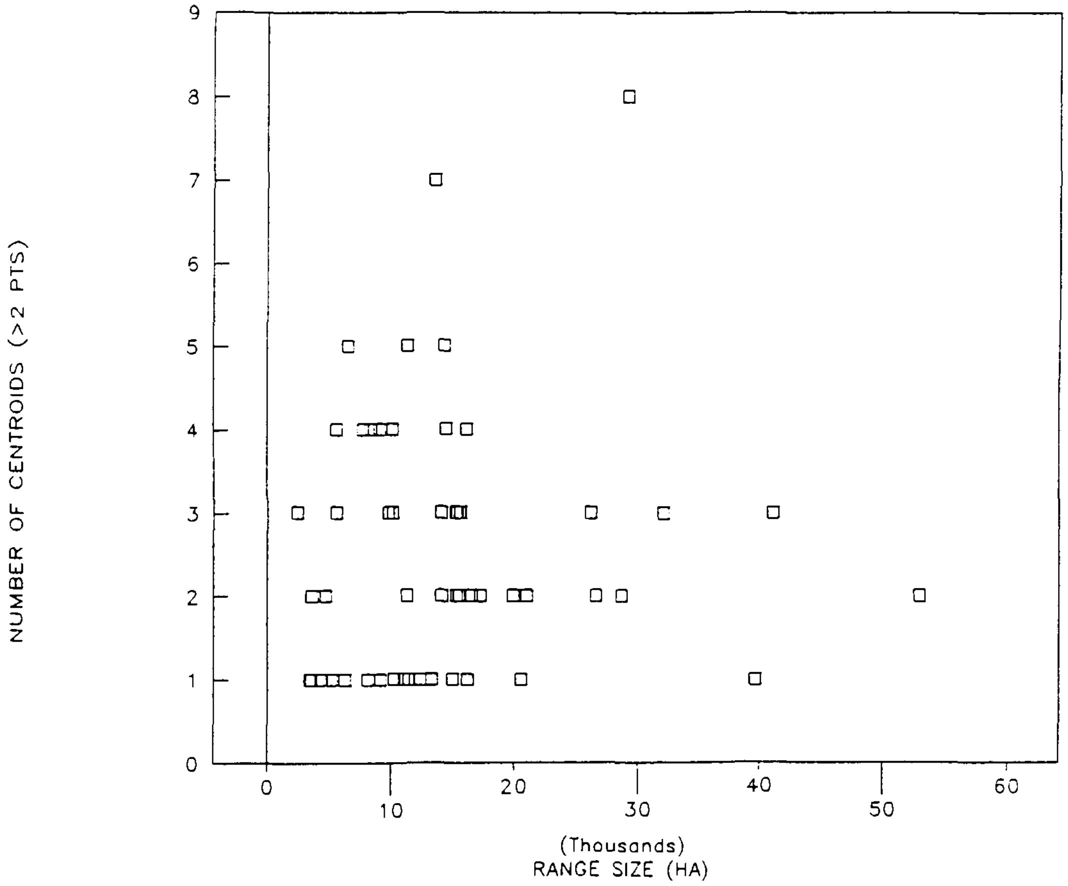


Fig. 11. Relationship between range size and number of utilization distribution polygons (centroids) delieneated in CALHOME adaptive kernel home range analyses performed on moose point location data. Utilization distribtuion polygon = a polygon encompassing >2 point locations.

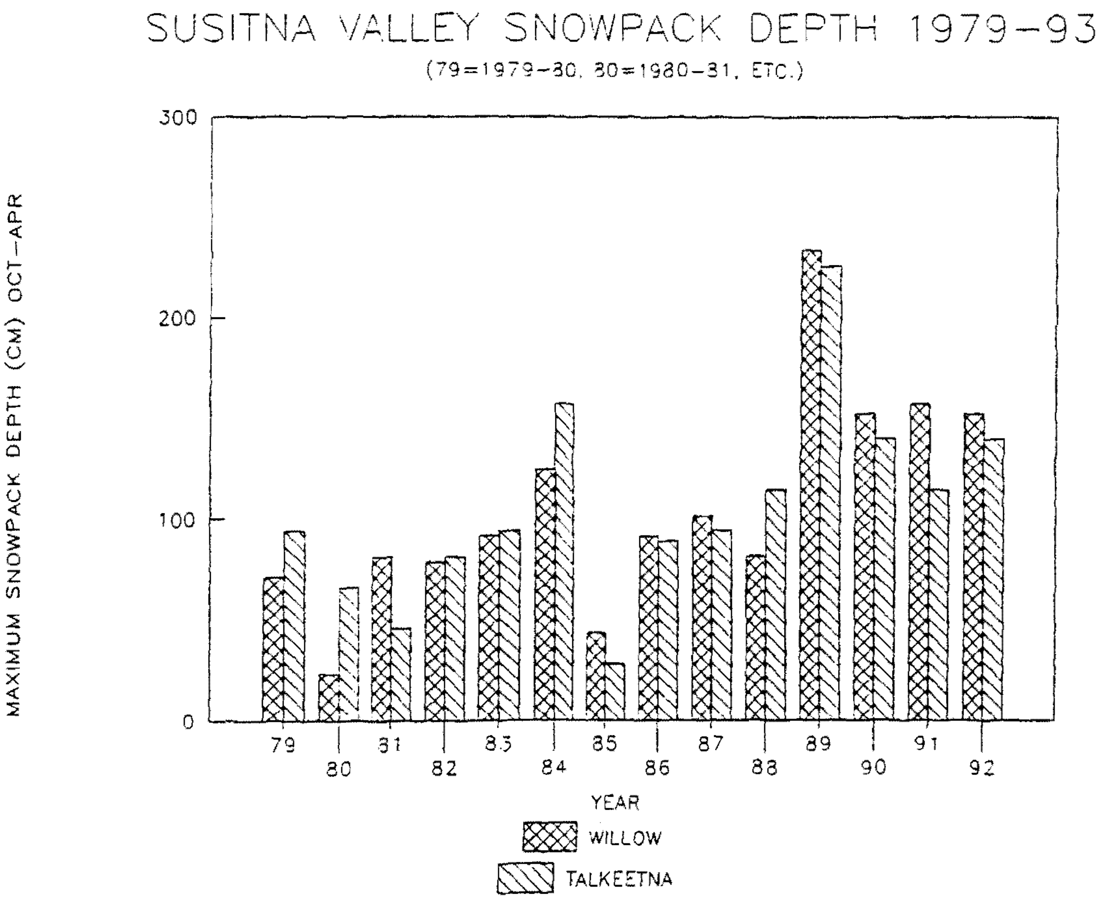


Fig. 12. Maximum snowpack depth (cm) measured during October through April in Willow and Talkeetna in lower Susitna River valley, south-central Alaska, 1979-93.

Table 1. Coarse and fine grain calendar and Julian date periods delineating important events in management and life history of moose in lower Susitna River valley in Southcentral Alaska.

Grain	Event	Period	Calendar date[1]	Julian date[2]	No. days
Coarse					
	Life history				
		Calving	7 May to 15 Jun	1 to 40	40
		Summer	13 Jul to 15 Aug	56 to 101	46
		Rut	7 Sep to 10 Oct	124 to 157	34
		Postrut	11 Oct to 1 Dec	158 to 209	52
		Winter	15 Nov to 30 Apr	193 to 360	178
	Management[3]				
		Fall hunt	20 Aug to 30 Sep	106 to 147	42
		Winter hunt	1 Jan to 28 Feb	240-298	59
		Survey	7 Nov to 21 Dec	185 to 229	45

Table 1. Continued.

Grain	Event	Period	Calendar date[1]	Julian date[2]	No. days
Fine					
	Life history				
		Calving	16 May to 31 May	10 to 25	16
		Summer	13 Jul to 15 Aug	56 to 101	46
		Rut	15 Sep to 5 Oct	132 to 152	21
		Postrut	14 Oct to 1 Nov	161 to 179	19
		Winter	10 Jan to 1 Mar	249 to 300	52

[1] Calendar year = 7 May to 6 May the following year.

[2] Julian day 1 = 7 May.

[3] Periods and dates for management the same in fine grain.

APPENDIX A. JULIAN DAY NUMBER (CJDAY NO.) AND CALENDAR DATES FOR PROMINENT EVENTS IN LIFE HISTORY (SEASONS) AND MANAGEMENT (PERIODS) OF MOOSE

FILE: D:CJDAY.WK1 29 SEPTEMBER 1994

WHERE: FINE CENTROID=CENTROID AND COARSE CENTROID=MAXRANGE

CJDAY	CALENDAR DATE	SEASON DATES	FINE CENTROID DATES	COARSE CENTROID DATES	PERIOD DATES	NO. DAYS IN SEASON
1	07-May-83	CALVING				1
2	08-May-83	CALVING				2
3	09-May-83	CALVING				3
4	10-May-83	CALVING		C-4		4
5	11-May-83	CALVING		C		5
6	12-May-83	CALVING		C		6
7	13-May-83	CALVING		C		7
8	14-May-83	CALVING		C		8
9	15-May-83	CALVING		C		9
10	16-May-83	CALVING	C-10	C		10
11	17-May-83	CALVING	C	C		11
12	18-May-83	CALVING	C	C		12
13	19-May-83	CALVING	C	C		13
14	20-May-83	CALVING	C	C		14
15	21-May-83	CALVING	C	C		15
16	22-May-83	CALVING	C	C		16
17	23-May-83	CALVING	C-40 DAYS	C		17
18	24-May-83	CALVING	C	C		18
19	25-May-83	CALVING	C	C		19
20	26-May-83	CALVING	C	C		20
21	27-May-83	CALVING	C	C		21
22	28-May-83	CALVING	C	C		22
23	29-May-83	CALVING	C	C		23
24	30-May-83	CALVING	C	C		24
25	31-May-83	CALVING	C-25	C-25		25
26	01-Jun-83	CALVING				26
27	02-Jun-83	CALVING				27
28	03-Jun-83	CALVING				28
29	04-Jun-83	CALVING				29
30	05-Jun-83	CALVING				30
31	06-Jun-83	CALVING				31
32	07-Jun-83	CALVING				32
33	08-Jun-83	CALVING				33
34	09-Jun-83	CALVING				34
35	10-Jun-83	CALVING				35
36	11-Jun-83	CALVING				36
37	12-Jun-83	CALVING				37
38	13-Jun-83	CALVING				38
39	14-Jun-83	CALVING				39
40	15-Jun-83	CALVING				40

SEASON=REPLACE SEASON WITH 'CALVING' FOR CJDAY <=40; N=758; DAYS = 40

FINE CENTROID=REPLACE CENTROID WITH 'C' FOR CJDAY >=10 AND CJDAY<=309; N=25; DAYS =16

COARSE CENTROID=REPLACE MAXRANGE WITH 'C' FOR CJDAY >=4 AND CJDAY<=25; N=956; DAYS = 22

TOTAL SEASON ='TRANS'; N=673
TOTAL CENTROID='T'; N=6267
TOTAL MAXRANGE='T'; N=4799

PERIOD = NO = 7929
SURV N= 934
FHUNT N= 997
WHUNT N=1728

41	16-Jun-83	TRANS			1	
42	17-Jun-83	TRANS			2	
43	18-Jun-83	TRANS			3	
44	19-Jun-83	TRANS			4	
45	20-Jun-83	TRANS			5	
46	21-Jun-83	TRANS			6	
47	22-Jun-83	TRANS			7	
48	23-Jun-83	TRANS			8	
49	24-Jun-83	TRANS			9	
50	25-Jun-83	TRANS			10	
51	26-Jun-83	TRANS			11	
52	27-Jun-83	TRANS			12	
53	28-Jun-83	TRANS			13	
54	29-Jun-83	TRANS			14	
55	30-Jun-83	TRANS			15	
56	01-Jul-83	SUMMER			1	
57	02-Jul-83	SUMMER			2	
58	03-Jul-83	SUMMER			3	
59	04-Jul-83	SUMMER			4	
60	05-Jul-83	SUMMER			5	
61	06-Jul-83	SUMMER			6	
62	07-Jul-83	SUMMER			7	
63	08-Jul-83	SUMMER			8	
64	09-Jul-83	SUMMER			9	
65	10-Jul-83	SUMMER			10	
66	11-Jul-83	SUMMER			11	
67	12-Jul-83	SUMMER			12	
68	13-Jul-83	SUMMER	S-68	S-68	13	
69	14-Jul-83	SUMMER	S	S	14	
70	15-Jul-83	SUMMER	S	S	15	
71	16-Jul-83	SUMMER	S	S	16	
72	17-Jul-83	SUMMER	S	S	17	
73	18-Jul-83	SUMMER	S	S	18	
74	19-Jul-83	SUMMER	S	S	19	
75	20-Jul-83	SUMMER	S	S	20	
76	21-Jul-83	SUMMER	S	S	21	
77	22-Jul-83	SUMMER	S	S	22	
78	23-Jul-83	SUMMER	S	S	23	SEASON=REPALCE SEASON WITH 'SUMMER' FOR CJDAY
79	24-Jul-83	SUMMER	S	S	24	CJDAY <=101; N=937; DAYS = 46
80	25-Jul-83	SUMMER	S	S	25	FINE CENTROID=REPLACE CENTROID WITH 'S' FOR
81	26-Jul-83	SUMMER	S	S	26	CJDAY >=68 AND CJDAY <=101; N=696; DAYS = 34
82	27-Jul-83	SUMMER	S	S	27	COARSE CENTROID=REPLACE MAXRANGE WITH 'S' FOR
83	28-Jul-83	SUMMER	S	S	28	CJDAY >=68 AND CJDAY <=101; N=696; DAYS = 34
84	29-Jul-83	SUMMER	S	S	29	
85	30-Jul-83	SUMMER	S-46 DAYS	S	30	
86	31-Jul-83	SUMMER	S	S	31	
87	01-Aug-83	SUMMER	S	S	32	
88	02-Aug-83	SUMMER	S	S	33	
89	03-Aug-83	SUMMER	S	S	34	
90	04-Aug-83	SUMMER	S	S	35	

91	05-Aug-83	SUMMER	S	S		36
92	06-Aug-83	SUMMER	S	S		37
93	07-Aug-83	SUMMER	S	S		38
94	08-Aug-83	SUMMER	S	S		39
95	09-Aug-83	SUMMER	S	S		40
96	10-Aug-83	SUMMER	S	S		41
97	11-Aug-83	SUMMER	S	S		42
98	12-Aug-83	SUMMER	S	S		43
99	13-Aug-83	SUMMER	S	S		44
100	14-Aug-83	SUMMER	S	S		45
101	15-Aug-83	SUMMER	S-101	S-101		46
102	16-Aug-83	TRANS				1
103	17-Aug-83	TRANS				2
104	18-Aug-83	TRANS				3
105	19-Aug-83	TRANS				4
106	20-Aug-83	TRANS			FH-106	5
107	21-Aug-83	TRANS			FH	6
108	22-Aug-83	TRANS			FH	7
109	23-Aug-83	TRANS			FH	8
110	24-Aug-83	TRANS			FH	9
111	25-Aug-83	TRANS			FH	10
112	26-Aug-83	TRANS			FH	11
113	27-Aug-83	TRANS			FH	12
114	28-Aug-83	TRANS			FH	13
115	29-Aug-83	TRANS			FH	14
116	30-Aug-83	TRANS			FH	15
117	31-Aug-83	TRANS			FH	16
118	01-Sep-83	TRANS			FH	17
119	02-Sep-83	TRANS			FH	18
120	03-Sep-83	TRANS			FH	19
121	04-Sep-83	TRANS			FH	20
122	05-Sep-83	TRANS			FH	21
123	06-Sep-83	TRANS			FH	22
124	07-Sep-83	RUT			FH	1
125	08-Sep-83	RUT			FH	2
126	09-Sep-83	RUT			FH	3
127	10-Sep-83	RUT			FH	4
128	11-Sep-83	RUT			FH	5
129	12-Sep-83	RUT			FH	6
130	13-Sep-83	RUT			FH	7
131	14-Sep-83	RUT			FH	8
132	15-Sep-83	RUT	R-132	R-132	FH	9
133	16-Sep-83	RUT	R	R	FH	10
134	17-Sep-83	RUT	R	R	FH	11
135	18-Sep-83	RUT	R	R	FH	12
136	19-Sep-83	RUT	R	R	FH	13
137	20-Sep-83	RUT	R	R	FH	14
138	21-Sep-83	RUT	R	R	FH	15
139	22-Sep-83	RUT	R	R	FH	16
140	23-Sep-83	RUT	R	R	FH	17

PERIOD=REPLACE PERIOD WITH 'FH' FOR CJDAY >=1
CJDAY <=147; N=997; DAYS = 42

141	24-Sep-83	RUT	R	R	FH	18	SEASON=REPLACE SEASON WITH 'RUT' FOR CJDAY >=
142	25-Sep-83	RUT	R-34 DAYS	R	FH	19	CJDAY <=157; N=796; DAYS = 34
143	26-Sep-83	RUT	R	R	FH	20	FINE CENTROID=REPLACE CENTROID WITH 'R' FOR C
144	27-Sep-83	RUT	R	R	FH	21	CJDAY <=152; N=628; DAYS = 21
145	28-Sep-83	RUT	R	R	FH	22	COARSE CENTROID=REPLACE MAXRANGE WITH 'R' FOR
146	29-Sep-83	RUT	R	R	FH	23	CJDAY <=152; N=628; DAYS = 21
147	30-Sep-83	RUT	R	R	FH-147	24	
148	01-Oct-83	RUT	R	R		25	
149	02-Oct-83	RUT	R	R		26	
150	03-Oct-83	RUT	R	R		27	
151	04-Oct-83	RUT	R	R		28	
152	05-Oct-83	RUT	R-152	R-152		29	
153	06-Oct-83	RUT				30	
154	07-Oct-83	RUT				31	
155	08-Oct-83	RUT				32	
156	09-Oct-83	RUT				33	
157	10-Oct-83	RUT				34	
158	11-Oct-83	POST RUT		P-158		35	
159	12-Oct-83	POST RUT		P		36	
160	13-Oct-83	POST RUT		P		37	
161	14-Oct-83	POST RUT	P-161	P		38	
162	15-Oct-83	POST RUT	P	P		1	
163	16-Oct-83	POST RUT	P	P		2	
164	17-Oct-83	POST RUT	P	P		3	
165	18-Oct-83	POST RUT	P	P		4	
166	19-Oct-83	POST RUT	P	P		5	
167	20-Oct-83	POST RUT	P	P		1	
168	21-Oct-83	POST RUT	P	P		2	
169	22-Oct-83	POST RUT	P	P		3	
170	23-Oct-83	POST RUT	P	P		4	
171	24-Oct-83	POST RUT	P	P		5	
172	25-Oct-83	POST RUT	P	P		6	
173	26-Oct-83	POST RUT	P	P		7	
174	27-Oct-83	POST RUT	P	P		8	
175	28-Oct-83	POST RUT	P	P		9	
176	29-Oct-83	POST RUT	P	P		10	
177	30-Oct-83	POST RUT	P	P		11	
178	31-Oct-83	POST RUT	P	P		12	
179	01-Nov-83	POST RUT	P	P		13	SEASON=REPLACE SEASON WITH 'POSTRUT' FOR D
180	02-Nov-83	POST RUT	P	P		14	CJDAY >=198 AND CJDAY <=198; N=730; DAYS = 41
181	03-Nov-83	POST RUT	P	P		15	FINE CENTROID=REPLACE CENTROID WITH 'P' FOR
182	04-Nov-83	POST RUT	P-182	P		16	CJDAY >=167 AND CJDAY<=185; N=314; DAYS = 19
183	05-Nov-83	POST RUT		P		17	COARSE CENTROID=REPLACE MAXRANGE WITH 'P' FOR
184	06-Nov-83	POST RUT		P		18	CJDAY >=158 AND CJDAY<=185; N=405; DAYS = 28
185	07-Nov-83	POST RUT		P-185	SURV-185	19	
186	08-Nov-83	POST RUT			SURV	20	
187	09-Nov-83	POST RUT			SURV	21	
188	10-Nov-83	POST RUT			SURV	22	
189	11-Nov-83	POST RUT			SURV	23	
190	12-Nov-83	POST RUT			SURV	24	

191	13-Nov-83	POST RUT	SURV	25	
192	14-Nov-83	POST RUT	SURV	26	
193	15-Nov-83	POST RUT	SURV	27	
194	16-Nov-83	POST RUT	SURV	28	
195	17-Nov-83	POST RUT	SURV	29	
196	18-Nov-83	POST RUT	SURV	30	
197	19-Nov-83	POST RUT	SURV	31	
198	20-Nov-83	POST RUT	SURV	32	
199	21-Nov-83	WINTER	SURV	1	
200	22-Nov-83	WINTER	SURV	2	
201	23-Nov-83	WINTER	SURV	3	
202	24-Nov-83	WINTER	SURV	4	
203	25-Nov-83	WINTER	SURV	5	
204	26-Nov-83	WINTER	SURV	1	
205	27-Nov-83	WINTER	SURV	2	
206	28-Nov-83	WINTER	SURV	3	
207	29-Nov-83	WINTER	SURV	4	PERIOD=REPLACE PERIOD WITH 'SURV' FOR CJDAY >
208	30-Nov-83	WINTER	SURV	5	CJDAY >= 185 AND CJDAY <=229; N=934
209	01-Dec-83	WINTER	SURV	6	
210	02-Dec-83	WINTER	SURV	7	
211	03-Dec-83	WINTER	SURV	8	
212	04-Dec-83	WINTER	SURV	9	
213	05-Dec-83	WINTER	SURV	10	
214	06-Dec-83	WINTER	SURV	11	
215	07-Dec-83	WINTER	SURV	12	
216	08-Dec-83	WINTER	SURV	13	
217	09-Dec-83	WINTER	SURV	14	
218	10-Dec-83	WINTER	SURV	15	
219	11-Dec-83	WINTER	SURV	16	
220	12-Dec-83	WINTER	SURV	17	
221	13-Dec-83	WINTER	SURV	18	
222	14-Dec-83	WINTER	SURV	19	
223	15-Dec-83	WINTER	SURV	20	
224	16-Dec-83	WINTER	SURV	21	
225	17-Dec-83	WINTER	SURV	22	
226	18-Dec-83	WINTER	SURV	23	
227	19-Dec-83	WINTER	SURV	24	
228	20-Dec-83	WINTER	SURV	25	
229	21-Dec-83	WINTER	SURV-229	26	
230	22-Dec-83	WINTER		27	
231	23-Dec-83	WINTER		28	
232	24-Dec-83	WINTER		29	
233	25-Dec-83	WINTER		30	
234	26-Dec-83	WINTER		31	
235	27-Dec-83	WINTER		32	
236	28-Dec-83	WINTER		33	
237	29-Dec-83	WINTER		34	
238	30-Dec-83	WINTER		35	
239	31-Dec-83	WINTER		36	
240	01-Jan-84	WINTER	WH-240	37	

241	02-Jan-84	WINTER			WH	38	
242	03-Jan-84	WINTER			WH	39	
243	04-Jan-84	WINTER			WH	40	
244	05-Jan-84	WINTER			WH	41	
245	06-Jan-84	WINTER			WH	42	
246	07-Jan-84	WINTER			WH	43	
247	08-Jan-84	WINTER			WH	44	
248	09-Jan-84	WINTER			WH	45	
249	10-Jan-84	WINTER			WH	46	
250	11-Jan-84	WINTER			WH	47	
251	12-Jan-84	WINTER			WH	48	
252	13-Jan-84	WINTER			WH	49	
253	14-Jan-84	WINTER			WH	50	
254	15-Jan-84	WINTER			WH	51	
255	16-Jan-84	WINTER			WH	52	
256	17-Jan-84	WINTER			WH	53	
257	18-Jan-84	WINTER			WH	54	
258	19-Jan-84	WINTER		W-258	WH	55	
259	20-Jan-84	WINTER		W	WH	56	
260	21-Jan-84	WINTER		W	WH	57	
261	22-Jan-84	WINTER		W	WH	58	
262	23-Jan-84	WINTER		W	WH	59	PERIOD=REPLACE PERIOD WITH 'WH' FOR
263	24-Jan-84	WINTER		W	WH	60	CJDAY >=240 AND CJDAY <=298; N=1728
264	25-Jan-84	WINTER		W	WH	61	
265	26-Jan-84	WINTER		W	WH	62	
266	27-Jan-84	WINTER		W	WH	63	
267	28-Jan-84	WINTER		W	WH	64	
268	29-Jan-84	WINTER		W	WH	65	
269	30-Jan-84	WINTER		W	WH	66	
270	31-Jan-84	WINTER		W	WH	67	
271	01-Feb-84	WINTER		W	WH	68	
272	02-Feb-84	WINTER		W	WH	69	
273	03-Feb-84	WINTER		W	WH	70	
274	04-Feb-84	WINTER		W	WH	71	
275	05-Feb-84	WINTER		W	WH	72	
276	06-Feb-84	WINTER		W	WH	73	
277	07-Feb-84	WINTER		W	WH	74	
278	08-Feb-84	WINTER		W	WH	75	
279	09-Feb-84	WINTER	W-279	W	WH	76	
280	10-Feb-84	WINTER	W	W	WH	77	
281	11-Feb-84	WINTER	W	W	WH	78	
282	12-Feb-84	WINTER	W	W	WH	79	
283	13-Feb-84	WINTER	W	W	WH	80	
284	14-Feb-84	WINTER	W	W	WH	81	
285	15-Feb-84	WINTER	W	W	WH	82	
286	16-Feb-84	WINTER	W	W	WH	83	
287	17-Feb-84	WINTER	W	W	WH	84	
288	18-Feb-84	WINTER	W	W	WH	85	
289	19-Feb-84	WINTER	W	W	WH	86	SEASON=REPLACE SEASON WITH 'WINTER' FOR
290	20-Feb-84	WINTER	W	W	WH	87	CJDAY >=199 AND CJDAY <=360; N=4703; DAYS = 1

291	21-Feb-84	WINTER	W	W	WH	88
292	22-Feb-84	WINTER	W	W	WH	89
293	23-Feb-84	WINTER	W	W	WH	90
294	24-Feb-84	WINTER	W	W	WH	91
295	25-Feb-84	WINTER	W	W	WH	92
296	26-Feb-84	WINTER	W	W	WH	93
297	27-Feb-84	WINTER	W	W	WH	94
298	28-Feb-84	WINTER	W	W	WH-298	95
299	29-Feb-84	WINTER	W	W		96
300	01-Mar-84	WINTER	W	W		97
301	02-Mar-84	WINTER	W	W		98
302	03-Mar-84	WINTER	W	W		99
303	04-Mar-84	WINTER	W	W		100
304	05-Mar-84	WINTER	W	W		101
305	06-Mar-84	WINTER	W	W		102
306	07-Mar-84	WINTER	W	W		103
307	08-Mar-84	WINTER	W	W		104
308	09-Mar-84	WINTER	W	W		105
309	10-Mar-84	WINTER	W-309	W		106
310	11-Mar-84	WINTER		W		107
311	12-Mar-84	WINTER		W		108
312	13-Mar-84	WINTER		W		109
313	14-Mar-84	WINTER		W		110
314	15-Mar-84	WINTER		W		111
315	16-Mar-84	WINTER		W		112
316	17-Mar-84	WINTER		W		113
317	18-Mar-84	WINTER		W		114
318	19-Mar-84	WINTER		W		115
319	20-Mar-84	WINTER		W		116
320	21-Mar-84	WINTER		W		1
321	22-Mar-84	WINTER		W		2
322	23-Mar-84	WINTER		W		3
323	24-Mar-84	WINTER		W		4
324	25-Mar-84	WINTER		W		5
325	26-Mar-84	WINTER		W		6
326	27-Mar-84	WINTER		W		7
327	28-Mar-84	WINTER		W		8
328	29-Mar-84	WINTER		W		9
329	30-Mar-84	WINTER		W		10
330	31-Mar-84	WINTER		W-330		11
331	01-Apr-84	WINTER				12
332	02-Apr-84	WINTER				13
333	03-Apr-84	WINTER				14
334	04-Apr-84	WINTER				15
335	05-Apr-84	WINTER				16
336	06-Apr-84	WINTER				17
337	07-Apr-84	WINTER				18
338	08-Apr-84	WINTER				19
339	09-Apr-84	WINTER				20
340	10-Apr-84	WINTER				21

FINE CENTROID=REPLACE CENTROID WITH 'W' FOR
CJDAY >=297 AND CJDAY<=309; N=973; DAYS = 31
COARSE CENTROID=REPLACE MAXRANGE WITH 'W' FOR
CJDAY >=258 AND CJDAY<=330; N=2376; DAYS = 52

341	11-Apr-84	WINTER	22
342	12-Apr-84	WINTER	23
343	13-Apr-84	WINTER	24
344	14-Apr-84	WINTER	25
345	15-Apr-84	WINTER	26
346	16-Apr-84	WINTER	27
347	17-Apr-84	WINTER	28
348	18-Apr-84	WINTER	29
349	19-Apr-84	WINTER	30
350	20-Apr-84	WINTER	31
351	21-Apr-84	WINTER	32
352	22-Apr-84	WINTER	33
353	23-Apr-84	WINTER	34
354	24-Apr-84	WINTER	35
355	25-Apr-84	WINTER	36
356	26-Apr-84	WINTER	37
357	27-Apr-84	WINTER	38
358	28-Apr-84	WINTER	39
359	29-Apr-84	WINTER	40
360	30-Apr-84	WINTER	41
361	01-May-84	TRANS	42
362	02-May-84	TRANS	43
363	03-May-84	TRANS	44
364	04-May-84	TRANS	45
365	05-May-84	TRANS	46
366	06-May-84	TRANS	47

APPENDIX B. Sample of results of trial and error process used to select bandwidth for use in CALHOME adaptive kernel home range analysis of moose point location data.

D:\CALHOME\BANDSUMM.WK1

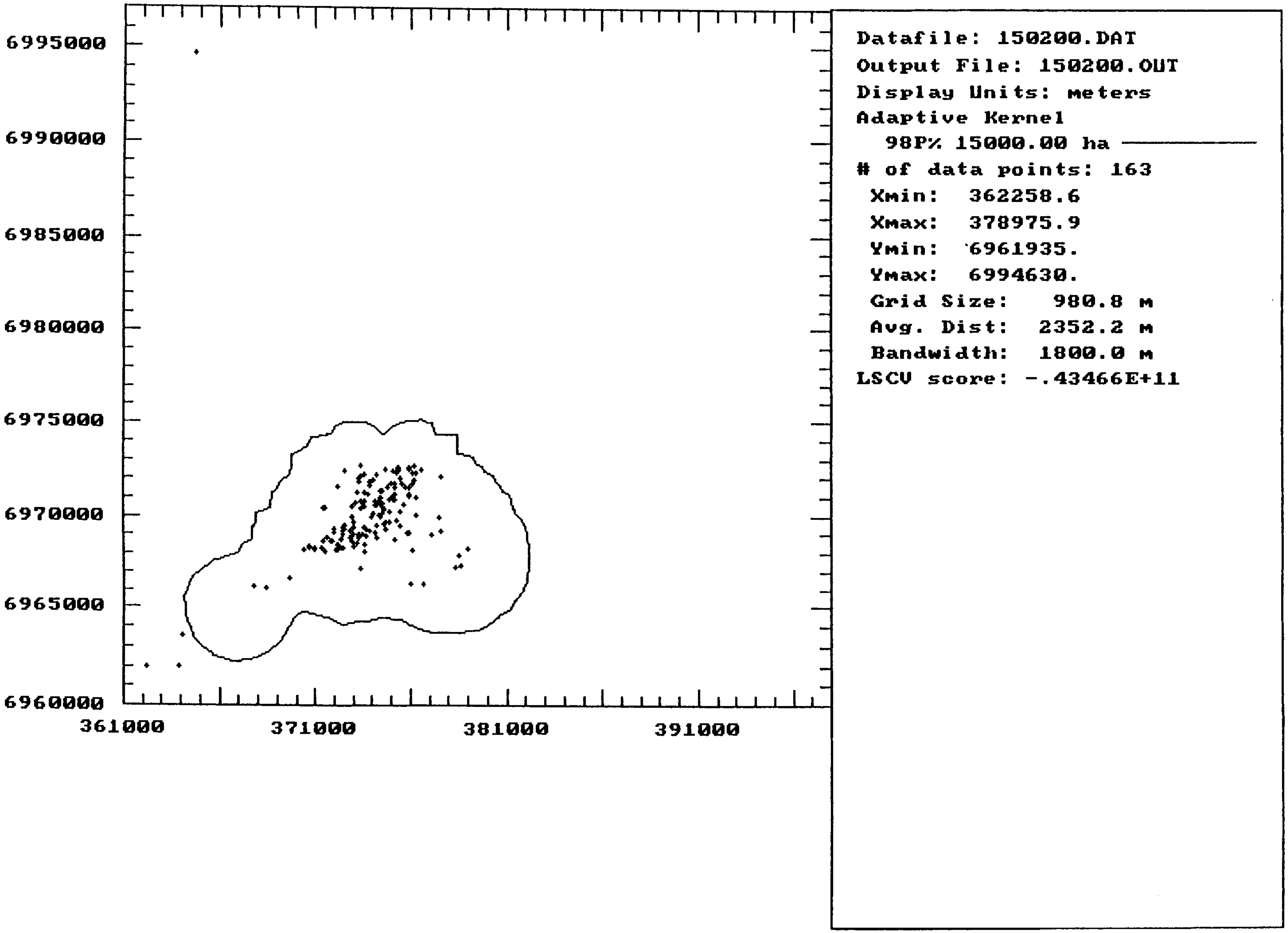
RESULTS OF TRIAL PROCESS USED TO IDENTIFY AND SELECT BAND WIDTHS ASSOCIATED WITH MINIMIZED LSCV VALUES

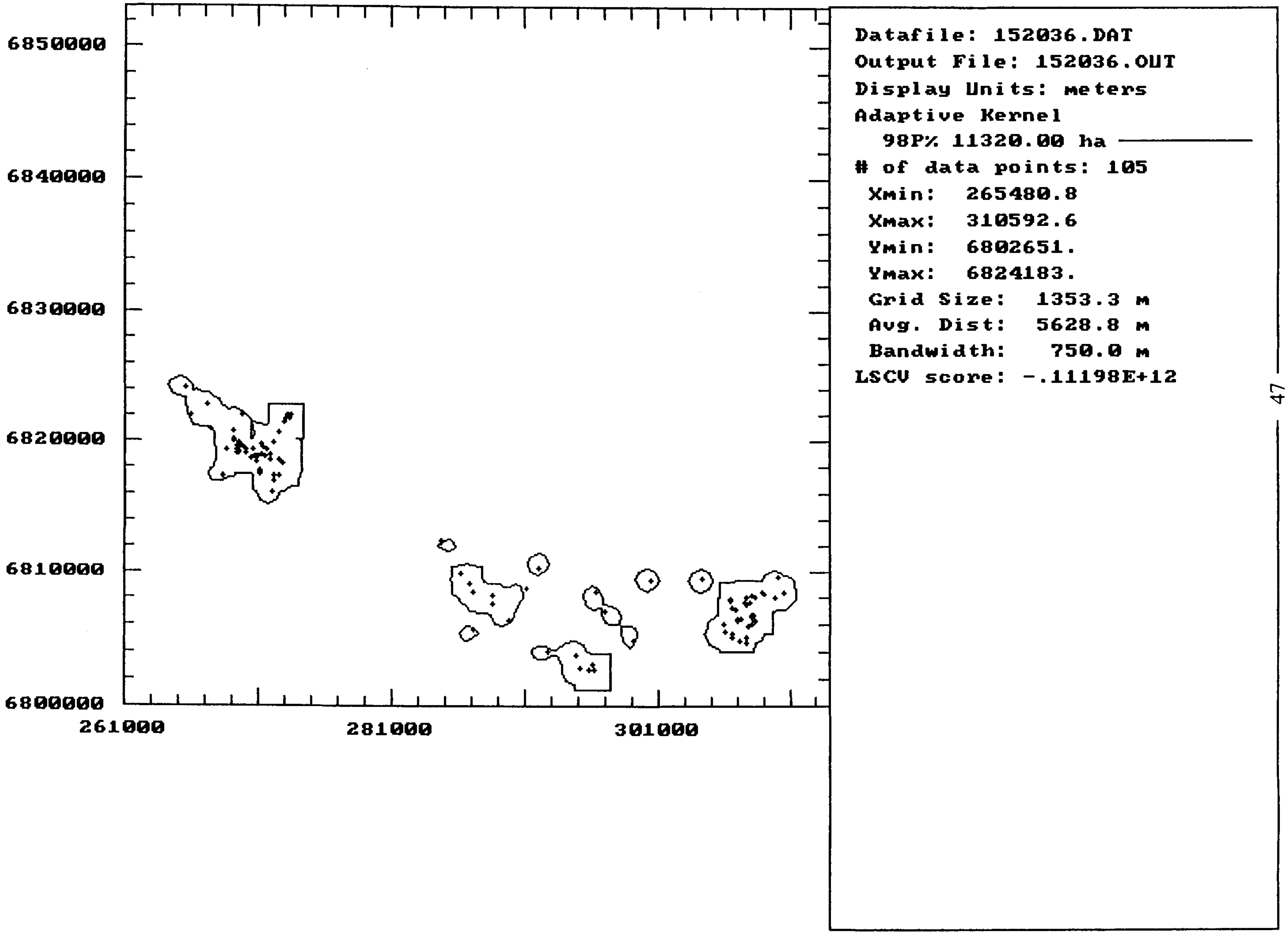
MOOSE ID	BAND WIDTH	P%	CELL SIZE	LSCV SCORE	RANGE SIZE (HA)	(SQ MI)	NO. POLYS/ >2 PTS	MINIMUM LVSC
153140	1900	98	-50	-0.49690 E+10	21340	82.39		
153140	1800	98	-50	-0.49719 E+10	20570	79.42		
153140	1700	98	-50	-0.49625 E+10	19820	76.52		
153140	1600	98	-50	-0.49116 E+10	19110	73.78		
153140	1500	98	-50	-0.48593 E+10	17900	69.11		
153140	1400	98	-50	-0.48031 E+10	16580	64.01		
153140	1300	98	-50	-0.47199 E+10	16170	62.43		
153140	1200	98	-50	-0.45479 E+10	15800	61.00		
153140	1100	98	-50	-0.42128 E+10	14330	55.32		
153140	1850	98	-50	-0.49747 E+10	20970	80.96	2	***
153140	1850	97	-50	-0.49747 E+10	15120	58.37		***
153140	1850	95	-50	-0.49747 E+10	11040	42.62		***
153252	2700	98	-50	-0.42913 E+11	51830	200.1		
153252	2500	98	-50	-0.42809 E+11	52320	202.0		
153252	2400	98	-50	-0.42399 E+11	50660	195.5		
153252	2300	98	-50	-0.41629 E+11	49220	190.0		
153252	2200	98	-50	-0.40470 E+11	47890	184.9		
153252	2100	98	-50	-0.393 E+11	46500	179.5		
153252	2000	98	-50	-0.38398 E+11	44000	169.8		
153252	1900	98	-50	-0.37222 E+11	41950	161.9		
153252	1800	98	-50	-0.37 E+11	39200	151.3		
153252	2650	98	-50	-0.42993 E+11	52130	201.2		
153252	2550	98	-50	-0.42929 E+11	53250	205.5		
153252	2600	98	-50	-0.43002 E+11	52960	204.4	2	***
153252	2600	97	-50	-0.43002 E+11	39630	153.0		***
153252	2600	95	-50	-0.43002 E+11	28010	108.1		***
153640	1200	98	-50	-0.20303 E+11	18610	71.85		
153640	1300	98	-50	-0.27025 E+11	17410	67.22		
153640	1400	98	-50	-0.3192 E+11	18360	70.88		
153640	1500	98	-50	-0.3528 E+11	19190	74.09		
153640	1600	98	-50	-0.3797 E+11	20110	77.64		
153640	1700	98	-50	-0.41152 E+11	21530	83.12		
153640	1800	98	-50	-0.43814 E+11	23480	90.65		
153640	1900	98	-50	-0.46145 E+11	25430	98.18		
153640	2000	98	-50	-0.47625 E+11	27340	105.5		
153640	2100	98	-50	-0.48703 E+11	29220	112.8		
153640	2200	98	-50	-0.49305 E+11	31110	120.1		

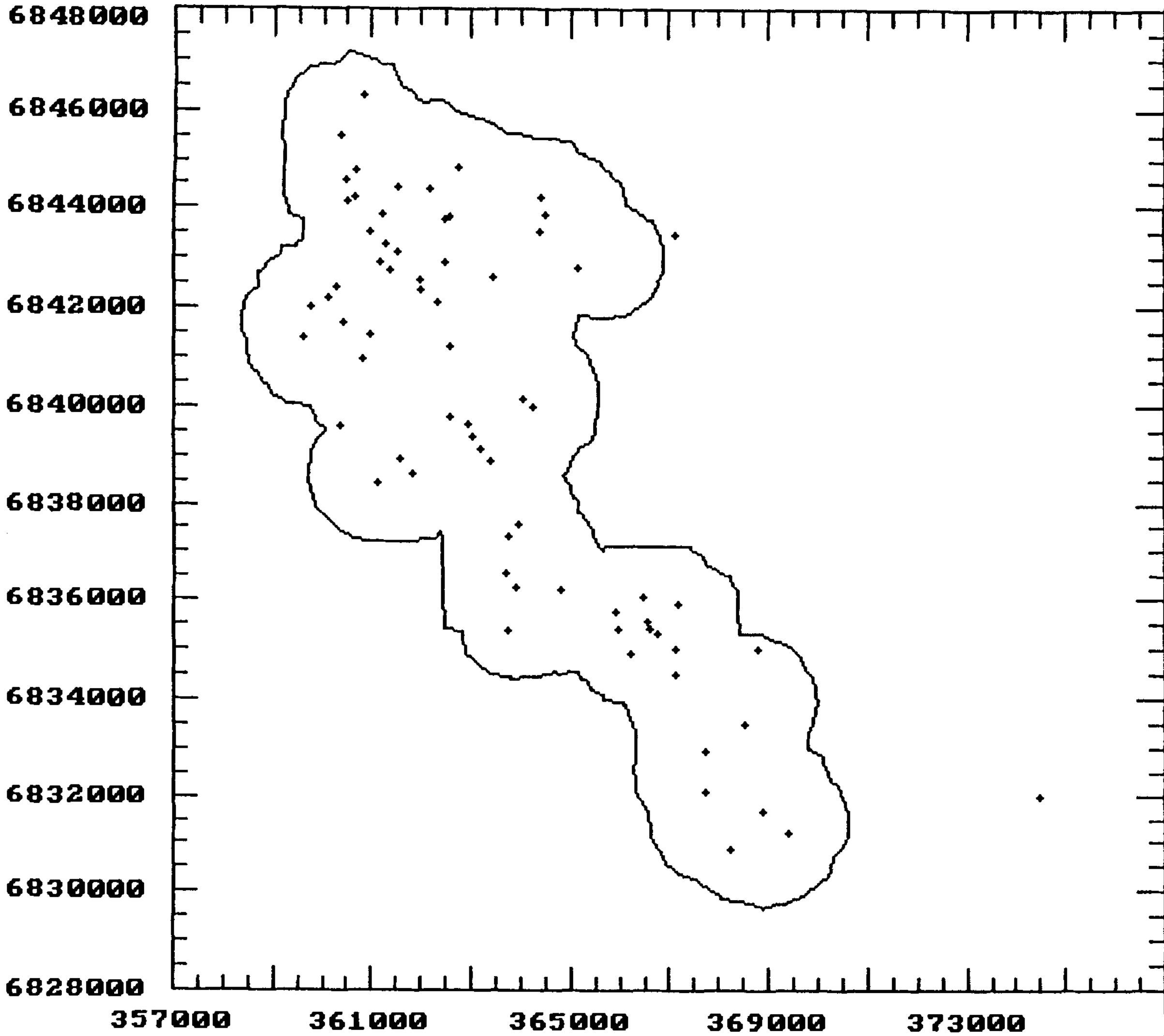
153640	2300	98	-50	-0.4928	E+11	32930	127.1		
153640	2250	98	-50	-0.49347	E+11	31990	123.5	3	***
153640	2250	97	-50	-0.49347	E+11	31900	123.1		***
153640	2250	95	-50	-0.49347	E+11	31320	120.9		***
153761	1200	98	-50	-0.75093	E+11	17640	68.10		
153761	1100	98	-50	-0.77642	E+11	16420	63.39		
153761	1000	98	-50	-0.73415	E+11	15810	61.04		
153761	1150	98	-50	-0.76455	E+11	17190	66.37		
153761	1050	98	-50	-0.7809	E+11	16110	62.20	4	***
153761	1050	97	-50	-0.7809	E+11	15360	59.30		***
153761	1050	95	-50	-0.7809	E+11	14360	55.44		***
153721	1600	98	-50	-0.8146	E+09	11470	44.28		
153721	1500	98	-50	-0.82618	E+09	10920	42.16		
153721	1300	98	-50	-0.81991	E+09	9697	37.44		
153721	1350	98	-50	-0.83218	E+09	9948	38.40		
153721	1450	98	-50	-0.83373	E+09				
153721	1400	98	-50	-0.83616	E+09	10240	39.53	1	***
153721	1400	97	-50	-0.83616	E+09	9681	37.37		***
153721	1400	95	-50	-0.83616	E+09	7805	30.13		***
153730	1300	98	-50	-0.26721	E+10	5897	22.76		
153730	1200	98	-50	-0.26824	E+10	5129	19.80		
153730	1100	98	-50	-0.25915	E+10	5000	19.30		
153730	1250	98	-50	-0.26908	E+10	5489	21.19	3	***
153730	1250	97	-50	-0.26908	E+10	5234	20.20		***
153730	1250	95	-50	-0.26908	E+10	4764	18.39		***
153839	1300	98	-50	-0.46993	E+10	4752	18.34		
153839	1250	98	-50	-0.47416	E+10	4621	17.84		
153839	1150	98	-50	-0.47137	E+10	4316	16.66		
153839	1100	98	-50	-0.46373	E+10	4126	15.93		
153839	1200	98	-50	-0.46562	E+10	4496	17.35		***
153839	1200	97	-50	-0.46562	E+10	4264	16.46		***
153839	1200	95	-50	-0.46562	E+10	3974	15.34		***
153070	1100	98	-50	-0.99186	E+10	5788	22.34		
153070	1200	98	-50	-0.1057	E+10	6793	26.22		
153070	1300	98	-50	-0.11476	E+10	7959	30.72		
153070	1400	98	-50	-0.12479	E+10	9049	34.93		
153070	1450	98	-50	-0.13166	E+10	9761	37.68		
153070	1500	98	-50	-0.13518	E+10	NO POLY @ -50			
153070	1500	98	-49	-0.13427	E+10	10560	40.77		
153070	1450	98	-49	-0.13166	E+10	9761	37.68	3	***
153070	1450	97	-49	-0.13166	E+10	9752	37.65		***
153070	1450	95	-49	-0.13166	E+10	9722	37.53		***
153070	1550	98	-47	-0.1363	E+10	11540	44.55		

153070	1500	98	-47	-0.13215	E+10	10590	40.88		
153070	1600	98	-46	-0.14013	E+10	12370	47.76		
153070	1700	98	-46	-0.14593	E+10	14070	54.32	3	***
153070	1500	98	-46	-0.13215	E+10	10590	40.88		
153070	1400	98	-46	-0.12394	E+10	9134	35.26		
153070	1100	98	-46	-0.10981	E+10	5935	22.91		
153620	1400	98	-50	-0.1188	E+10	12800	49.42		
153620	1350	98	-50	-0.11917	E+10	12180	47.02		
153620	1250	98	-50	-0.1187	E+10	10650	41.11		
153620	1200	98	-50	0.11823	E+10	9943	38.38		
153620	1300	98	-50	-0.11941	E+10	11440	44.16	1	***
153620	1300	97	-50	-0.11941	E+10	11320	43.70		***
153620	1300	95	-50	-0.11941	E+10	10740	41.46		***
153582	1300	98	-50	-0.66838	E+11	20560	79.38		
153582	1200	98	-50	-0.68723	E+11	18900	72.97		
153582	1100	98	-50	-0.6923	E+11	17030	65.75		
153582	1000	98	-50	-0.70311	E+11	16240	62.70		
153582	950	98	-50	-0.70544	E+11	16200	62.54		
153582	850	98	-50	-0.70327	E+11	14020	54.13		
153582	800	98	-50	-0.70534	E+11	13080	50.50		
153582	900	98	-50	-0.71179	E+11	15320	59.15	3	***
153582	900	97	-50	-0.71179	E+11	13630	52.62		***
153582	900	95	-50	-0.71179	E+11	12170	46.98		***

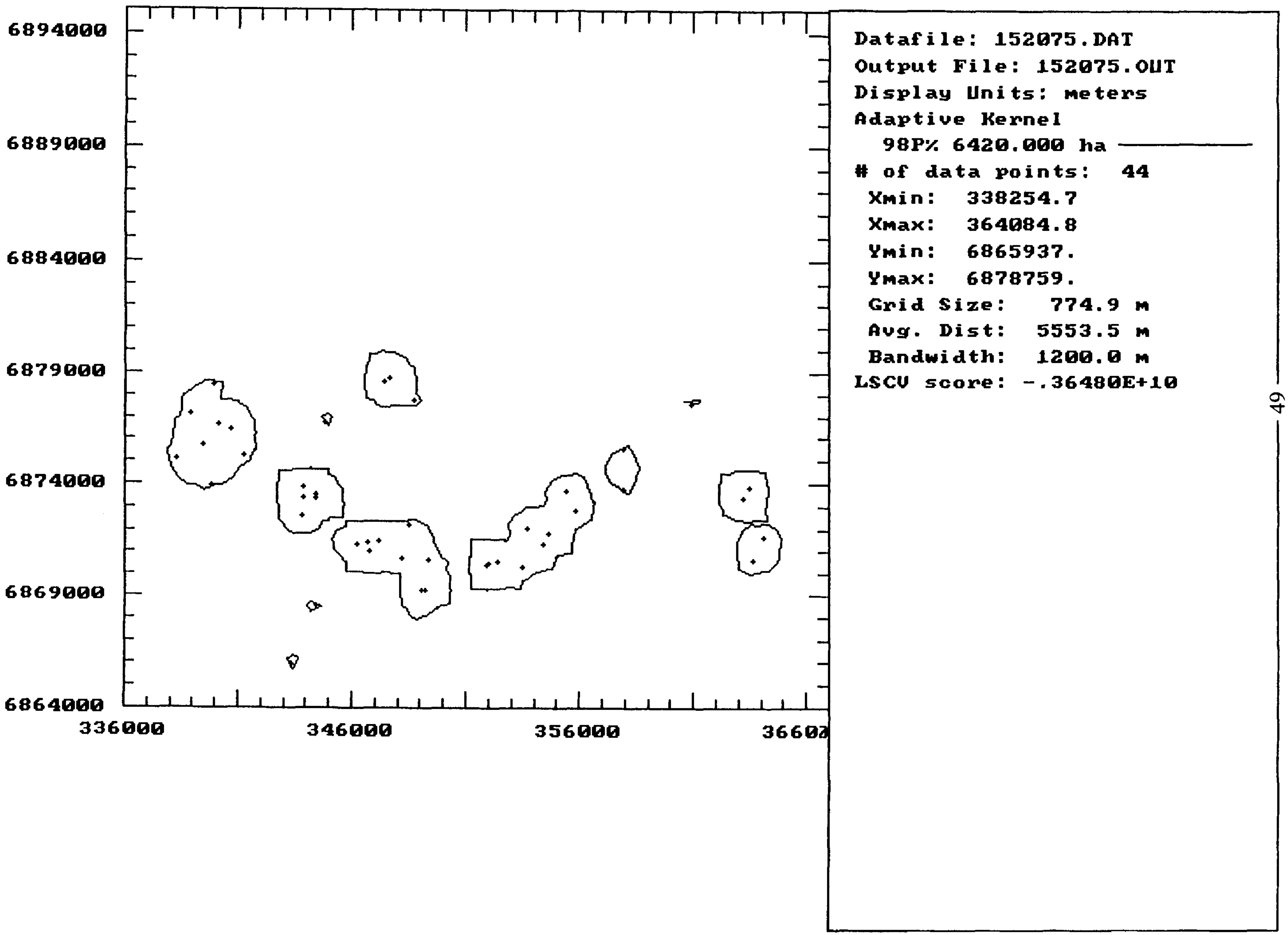
APPENDIX C. Plots of CALHOME adaptive kernel home range analyses of moose point-location data.



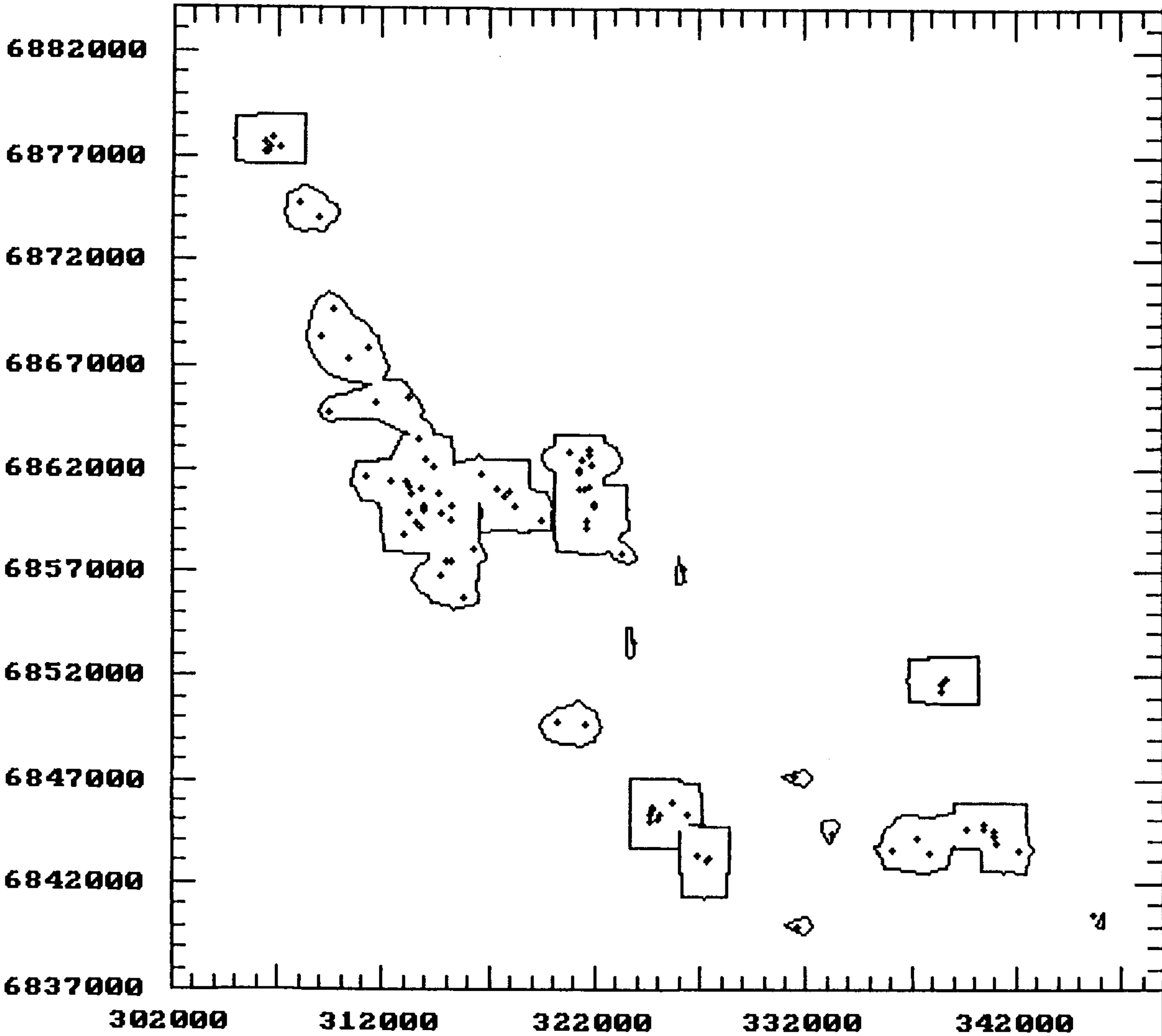

6850000
6840000
6830000
6820000
6810000
6800000
261000
281000
301000
Datafile: 152036.DAT
Output File: 152036.OUT
Display Units: meters
Adaptive Kernel
98P% 11320.00 ha
# of data points: 105
Xmin: 265480.8
Xmax: 310592.6
Ymin: 6802651.
Ymax: 6824183.
Grid Size: 1353.3 m
Avg. Dist: 5628.8 m
Bandwidth: 750.0 m
LSCV score: -.11198E+12



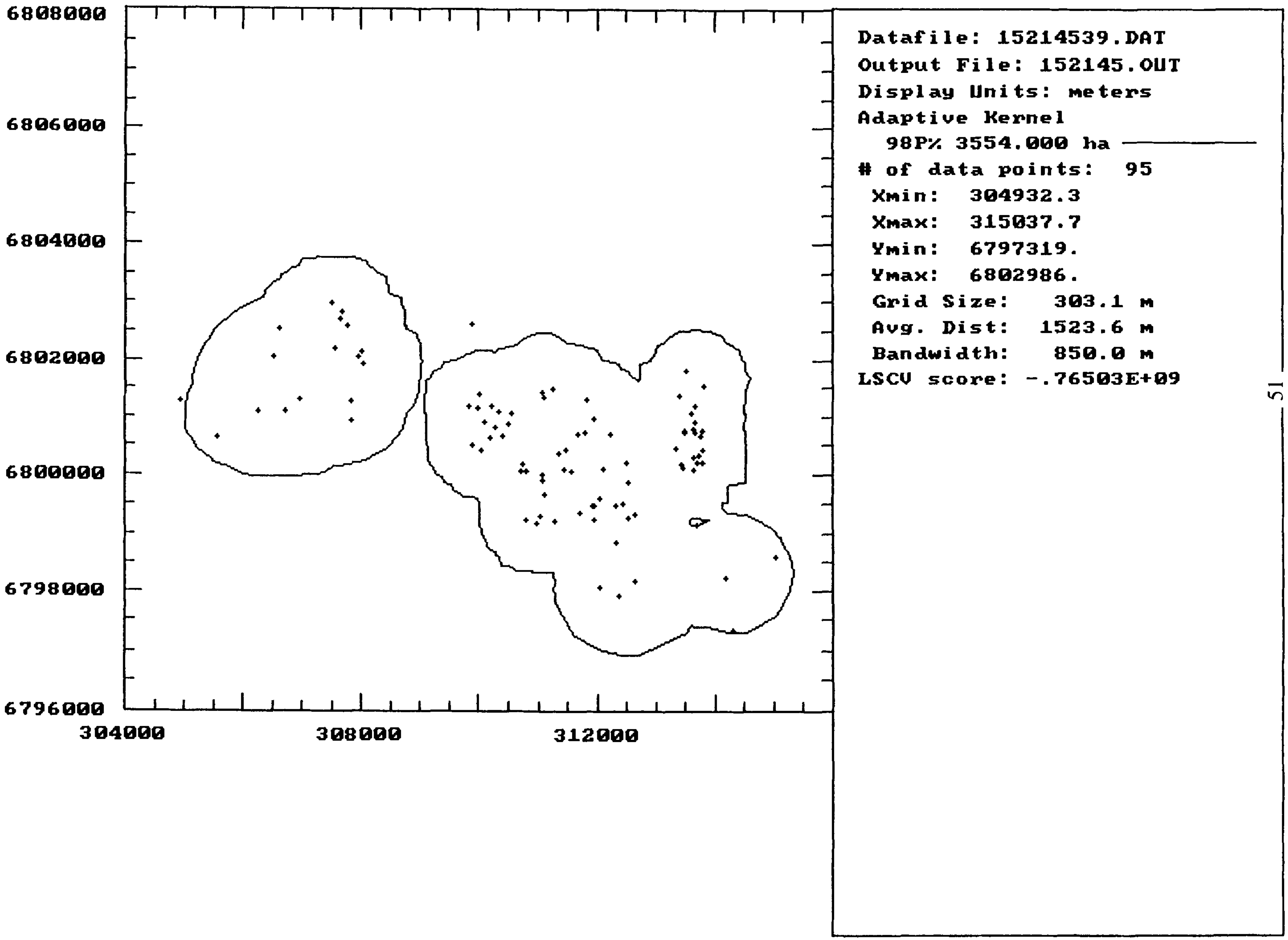
Datafile: 15204527.DAT
Output File: 152045.OUT
Display Units: meters
Adaptive Kernel
98P% 9085.000 ha
# of data points: 70
Xmin: 359596.3
Xmax: 374480.6
Ymin: 6830853.
Ymax: 6846299.
Grid Size: 463.3 m
Avg. Dist: 3867.2 m
Bandwidth: 1350.0 m
LSCV score: -.88652E+09

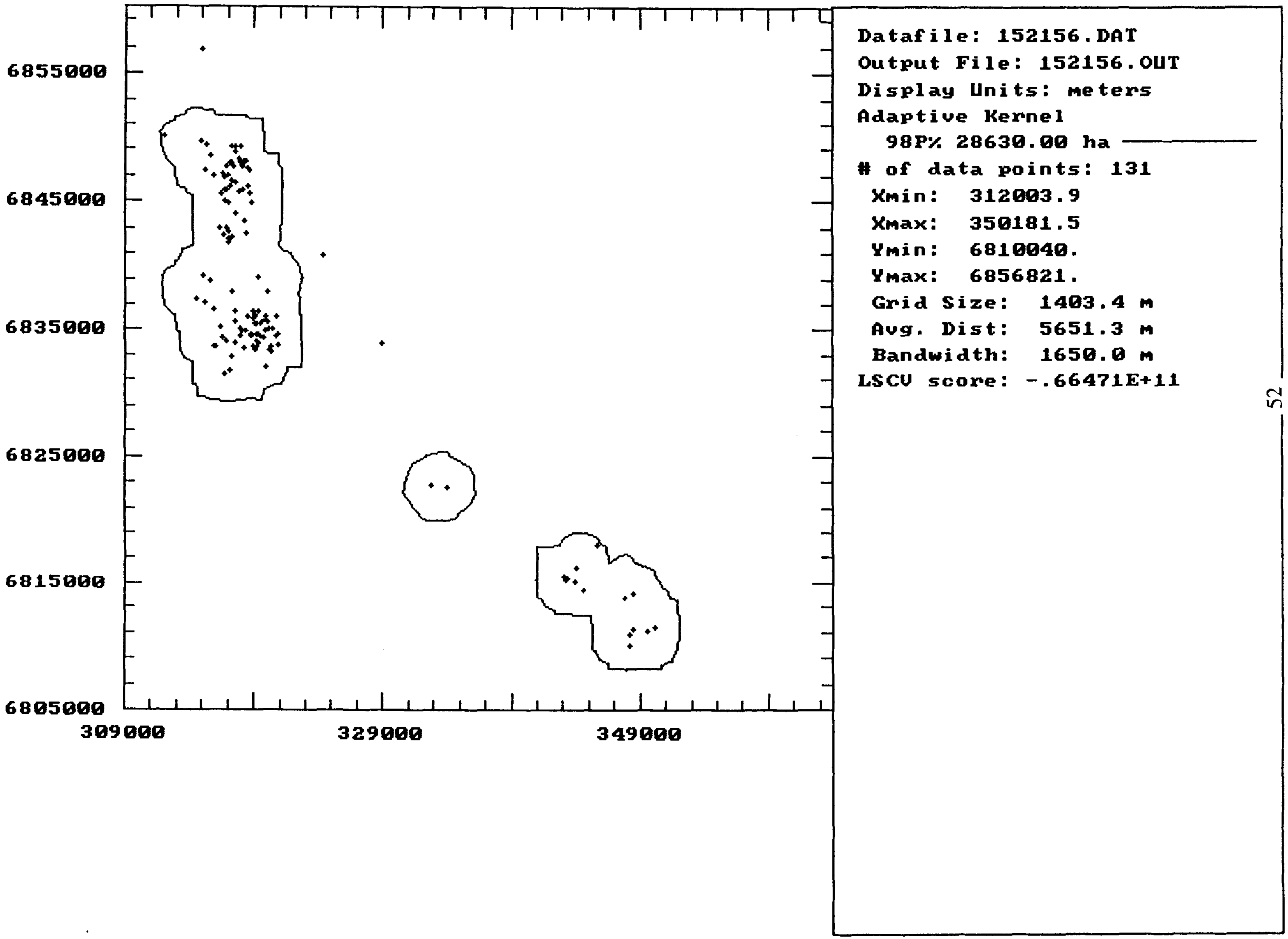


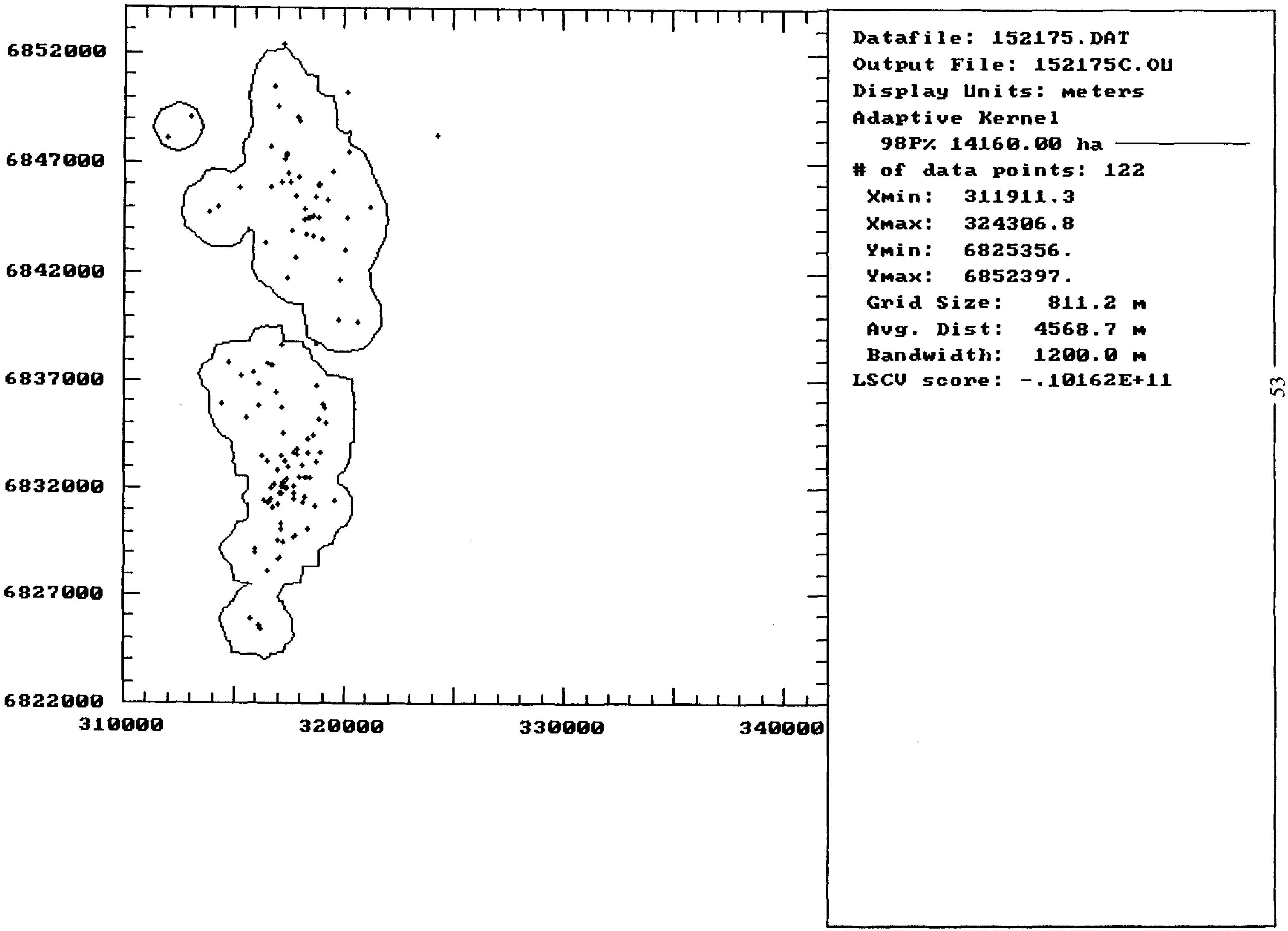
6894000
6889000
6884000
6879000
6874000
6869000
6864000
336000
346000
356000
3660
Datafile: 152075.DAT
Output File: 152075.OUT
Display Units: meters
Adaptive Kernel
98P% 6420.000 ha
# of data points: 44
Xmin: 338254.7
Xmax: 364084.8
Ymin: 6865937.
Ymax: 6878759.
Grid Size: 774.9 m
Avg. Dist: 5553.5 m
Bandwidth: 1200.0 m
LSCV score: -.36480E+10

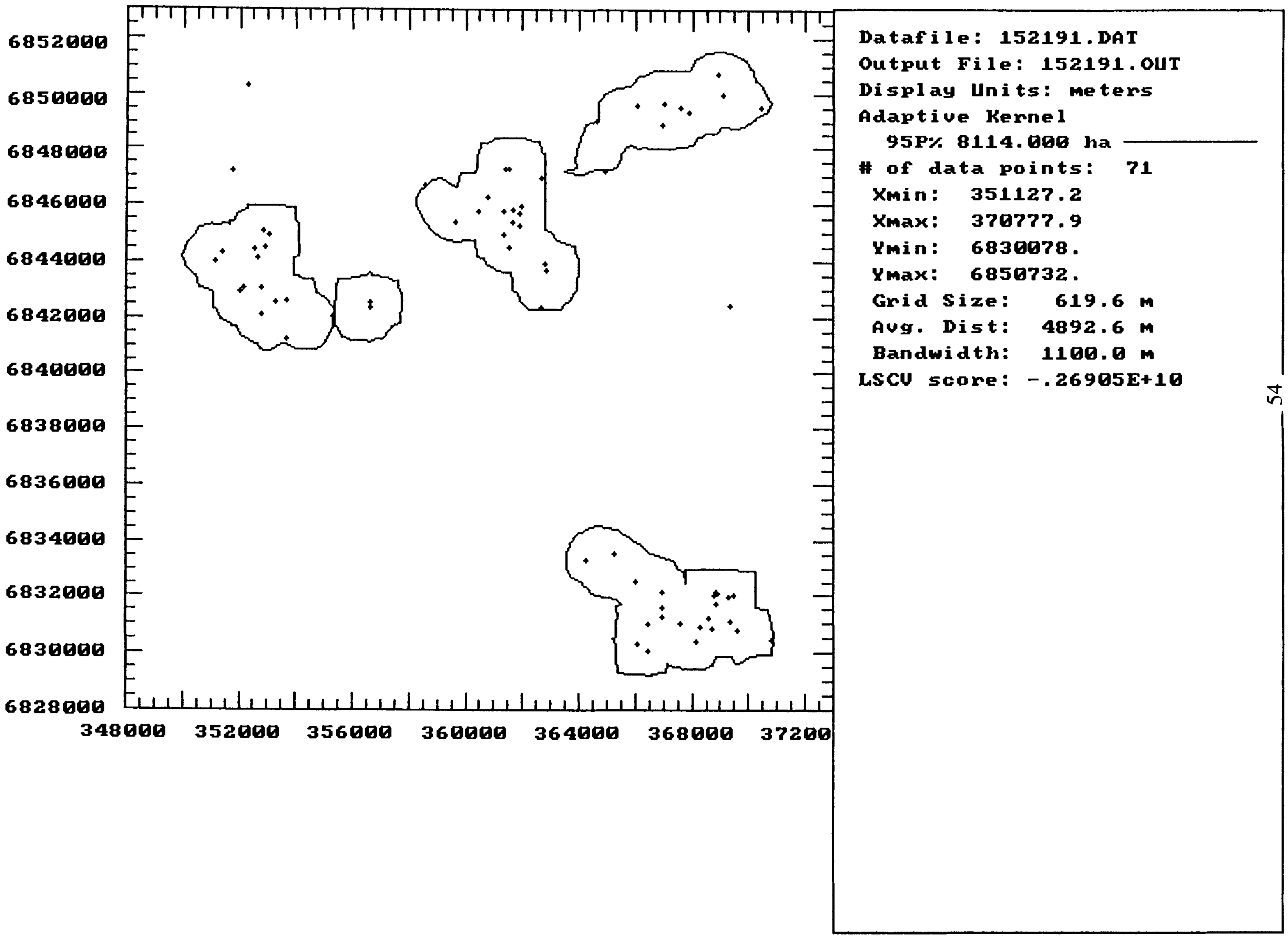


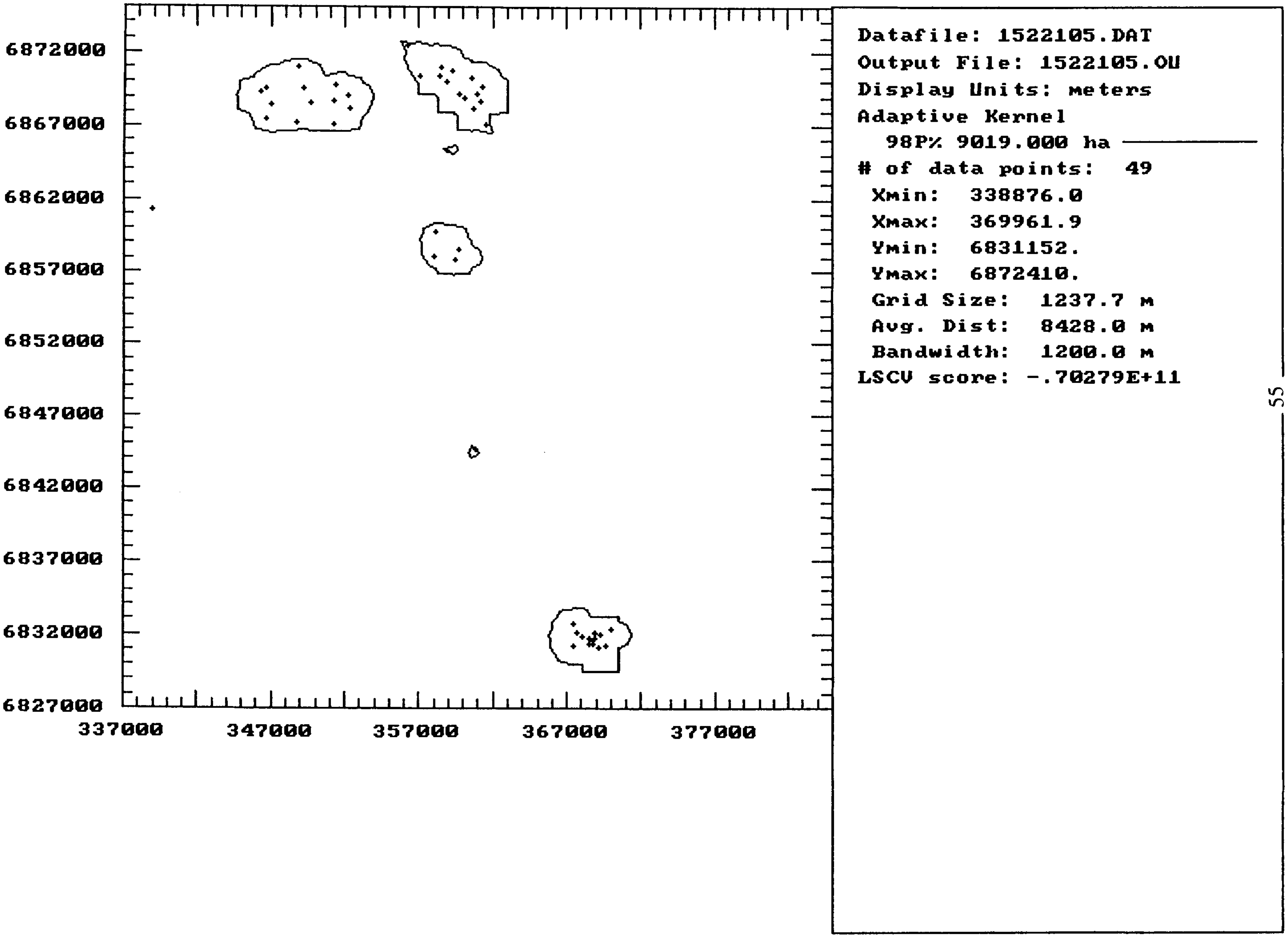
Datafile: 152076.DAT
Output File: 152076.OUT
Display Units: meters
Adaptive Kernel
98P% 14550.00 ha
# of data points: 95
Xmin: 306347.4
Xmax: 345718.4
Ymin: 6839958.
Ymax: 6877926.
Grid Size: 1181.1 m
Avg. Dist: 6734.9 m
Bandwidth: 1050.0 m
LSCV score: -.23922E+11

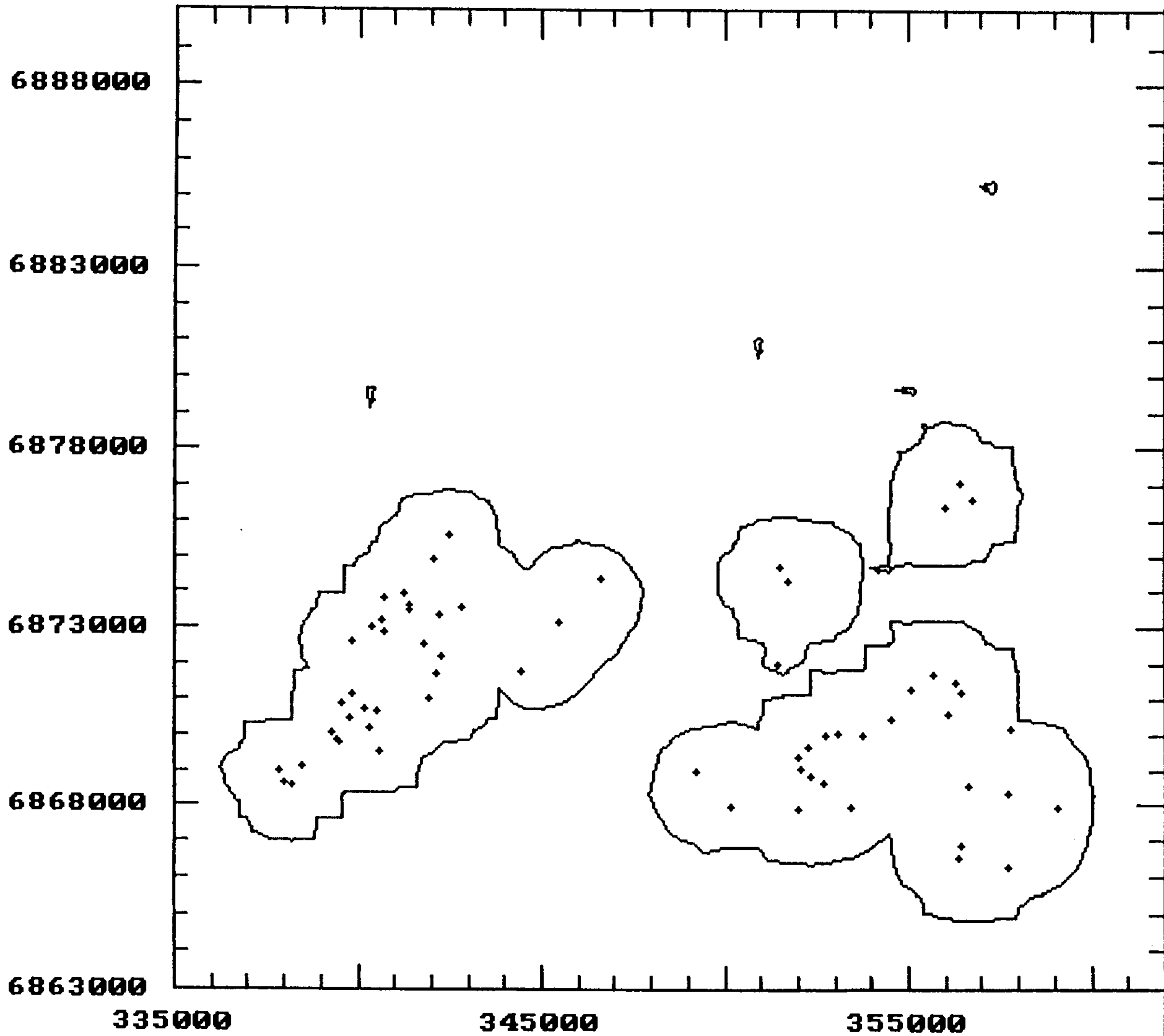

6808000
6806000
6804000
6802000
6800000
6798000
6796000
304000
308000
312000
Datafile: 15214539.DAT
Output File: 152145.OUT
Display Units: meters
Adaptive Kernel
98P% 3554.000 ha
# of data points: 95
Xmin: 304932.3
Xmax: 315037.7
Ymin: 6797319.
Ymax: 6802986.
Grid Size: 303.1 m
Avg. Dist: 1523.6 m
Bandwidth: 850.0 m
LSCV score: -.76503E+09


6855000
6845000
6835000
6825000
6815000
6805000
309000
329000
349000
Datafile: 152156.DAT
Output File: 152156.OUT
Display Units: meters
Adaptive Kernel
98P% 28630.00 ha
# of data points: 131
Xmin: 312003.9
Xmax: 350181.5
Ymin: 6810040.
Ymax: 6856821.
Grid Size: 1403.4 m
Avg. Dist: 5651.3 m
Bandwidth: 1650.0 m
LSCV score: -.66471E+11

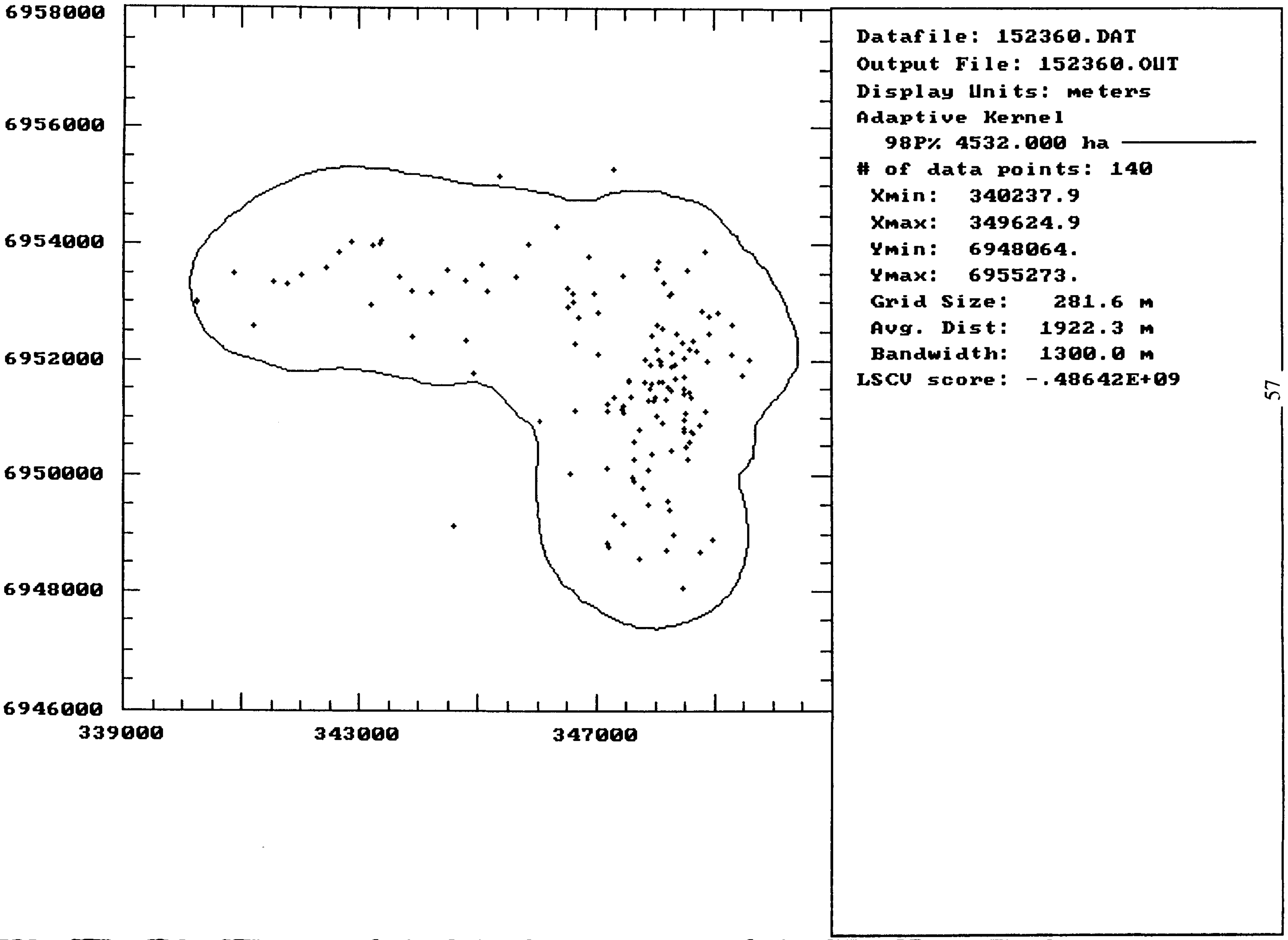

6852000
6847000
6842000
6837000
6832000
6827000
6822000
310000
320000
330000
340000
Datafile: 152175.DAT
Output File: 152175C.OU
Display Units: meters
Adaptive Kernel
98P% 14160.00 ha
# of data points: 122
Xmin: 311911.3
Xmax: 324306.8
Ymin: 6825356.
Ymax: 6852397.
Grid Size: 811.2 m
Avg. Dist: 4568.7 m
Bandwidth: 1200.0 m
LSCV score: -.10162E+11

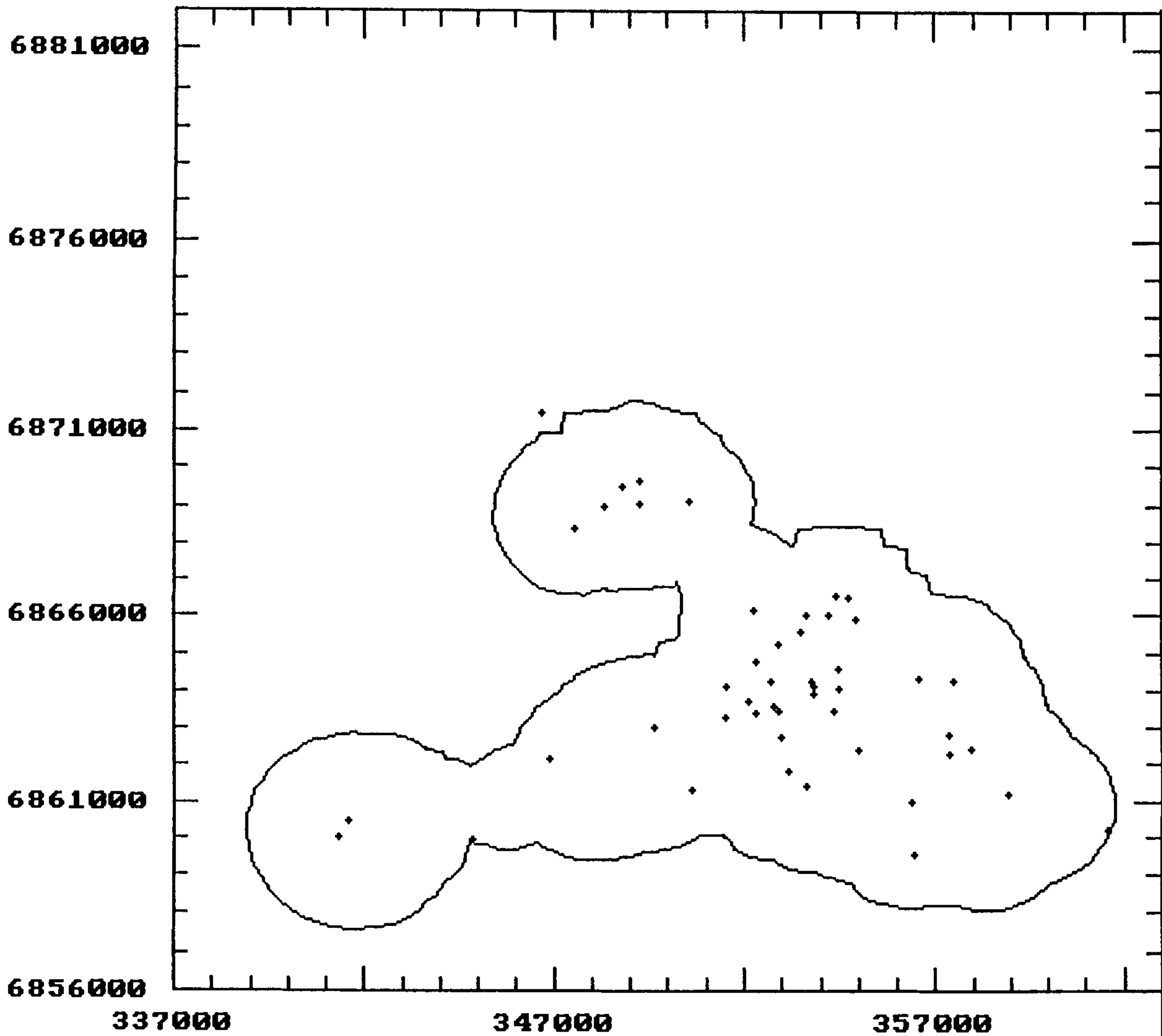

6852000
6850000
6848000
6846000
6844000
6842000
6840000
6838000
6836000
6834000
6832000
6830000
6828000
348000
352000
356000
360000
364000
368000
37200
Datafile: 152191.DAT
Output File: 152191.OUT
Display Units: meters
Adaptive Kernel
95P% 8114.000 ha
# of data points: 71
Xmin: 351127.2
Xmax: 370777.9
Ymin: 6830078.
Ymax: 6850732.
Grid Size: 619.6 m
Avg. Dist: 4892.6 m
Bandwidth: 1100.0 m
LSCV score: -.26905E+10


6872000
6867000
6862000
6857000
6852000
6847000
6842000
6837000
6832000
6827000
337000
347000
357000
367000
377000
Datafile: 1522105.DAT
Output File: 1522105.OU
Display Units: meters
Adaptive Kernel
98P% 9019.000 ha
# of data points: 49
Xmin: 338876.0
Xmax: 369961.9
Ymin: 6831152.
Ymax: 6872410.
Grid Size: 1237.7 m
Avg. Dist: 8428.0 m
Bandwidth: 1200.0 m
LSCV score: -.70279E+11

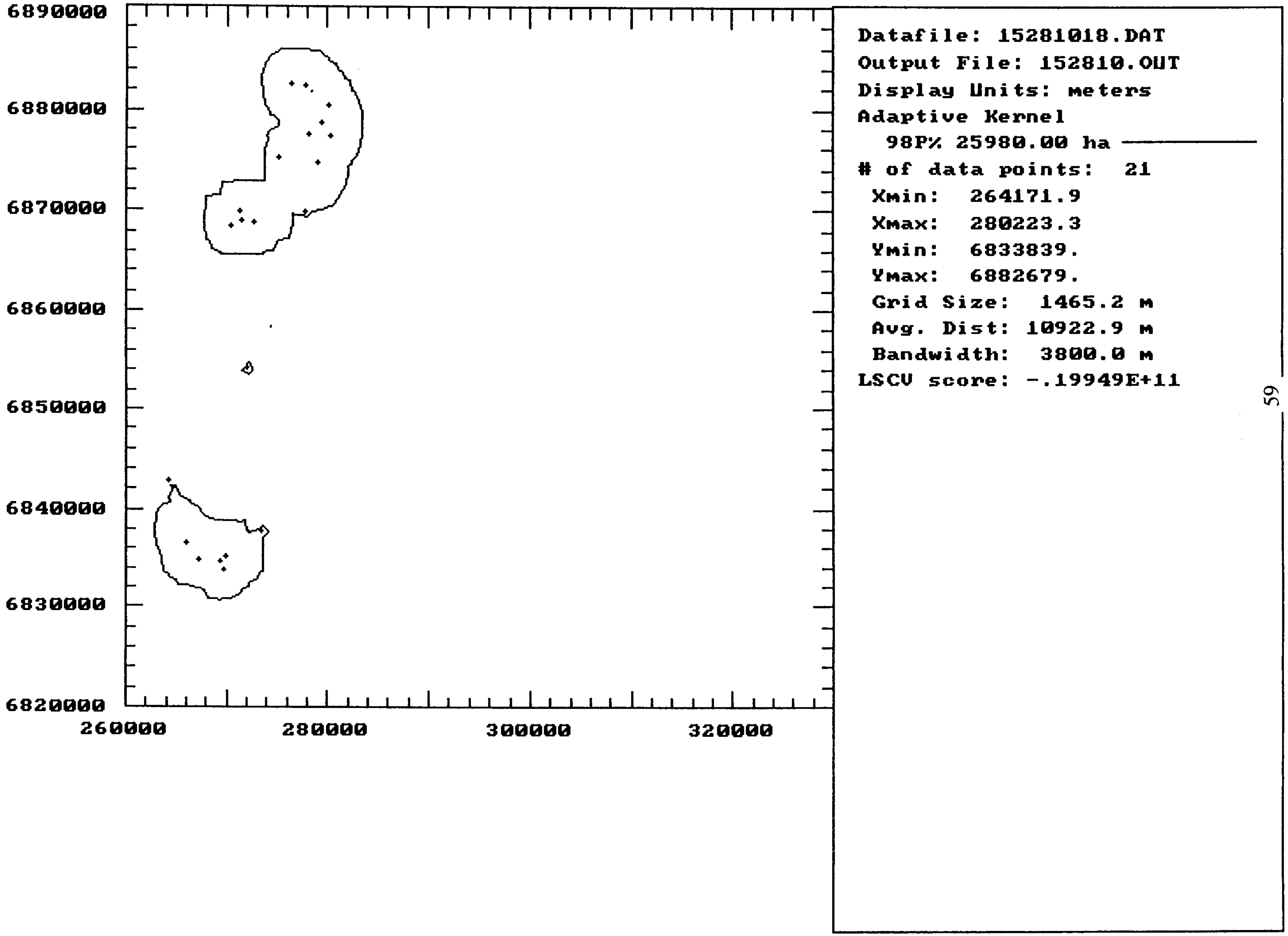


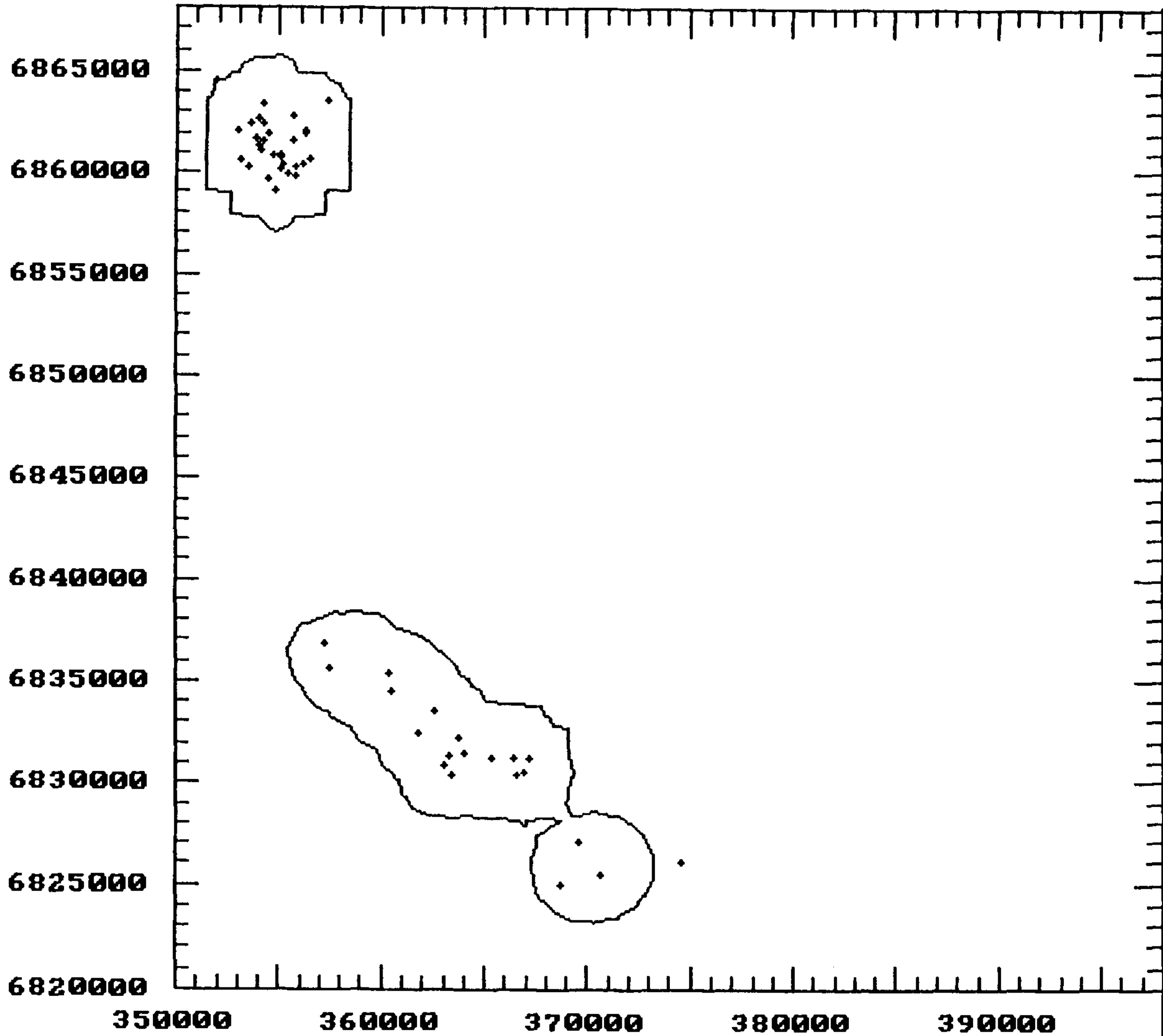
Datafile: 152330.DAT
Output File: 152330.OUT
Display Units: meters
Adaptive Kernel
98P% 14460.00 ha
# of data points: 70
Xmin: 337843.1
Xmax: 359048.3
Ymin: 6866262.
Ymax: 6885241.
Grid Size: 706.8 m
Avg. Dist: 4785.7 m
Bandwidth: 1500.0 m
LSCV score: -.22612E+10


6958000
6956000
6954000
6952000
6950000
6948000
6946000
339000
343000
347000
Datafile: 152360.DAT
Output File: 152360.OUT
Display Units: meters
Adaptive Kernel
98P% 4532.000 ha
# of data points: 140
Xmin: 340237.9
Xmax: 349624.9
Ymin: 6948064.
Ymax: 6955273.
Grid Size: 281.6 m
Avg. Dist: 1922.3 m
Bandwidth: 1300.0 m
LSCV score: -.48642E+09

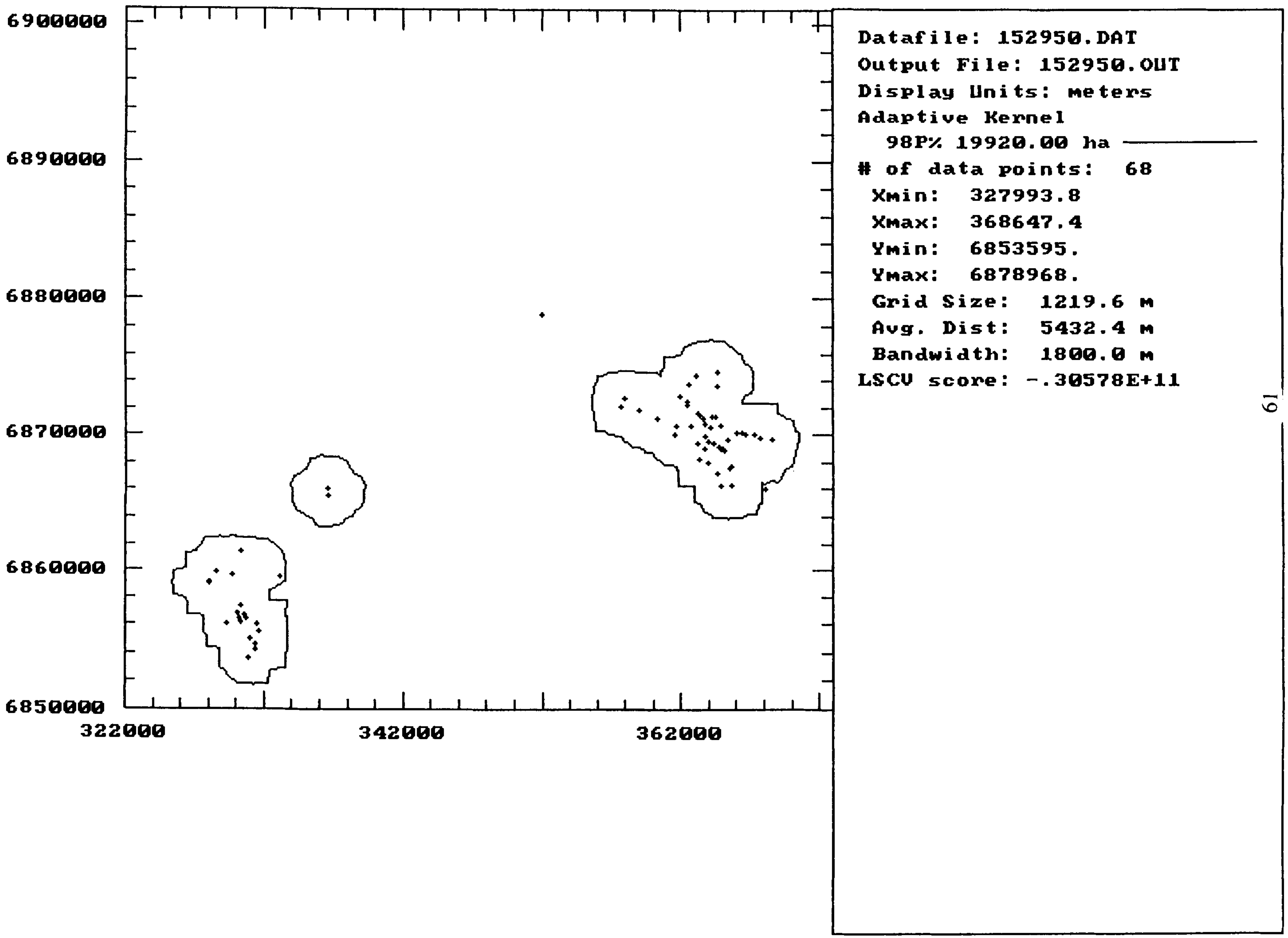


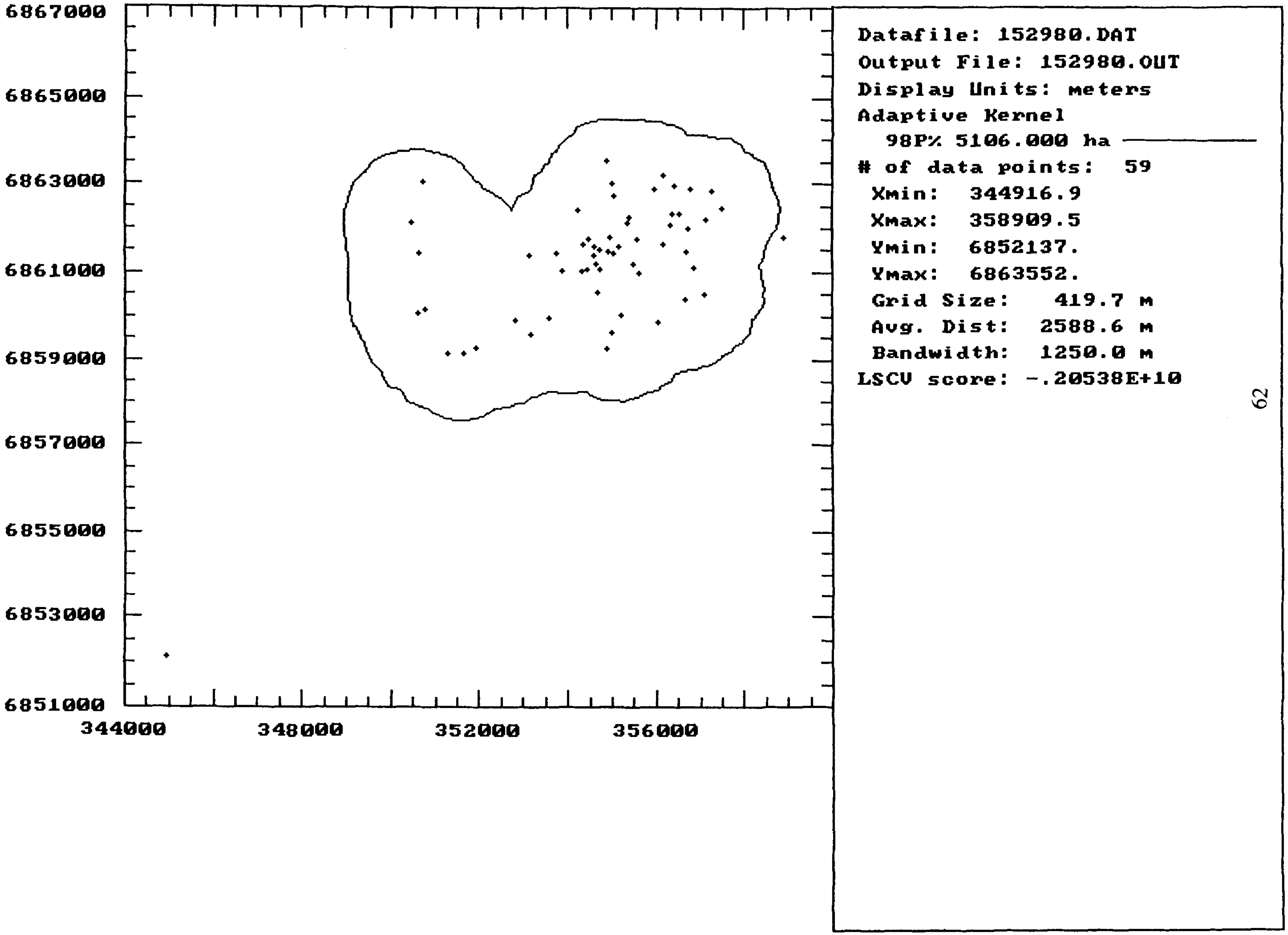
Datafile: 152750.DAT
Output File: 152750.OUT
Display Units: meters
Adaptive Kernel
98P% 16420.00 ha
# of data points: 48
Xmin: 341321.2
Xmax: 361591.0
Ymin: 6859529.
Ymax: 6871428.
Grid Size: 608.0 m
Avg. Dist: 3821.2 m
Bandwidth: 2200.0 m
LSCV score: -.22665E+10

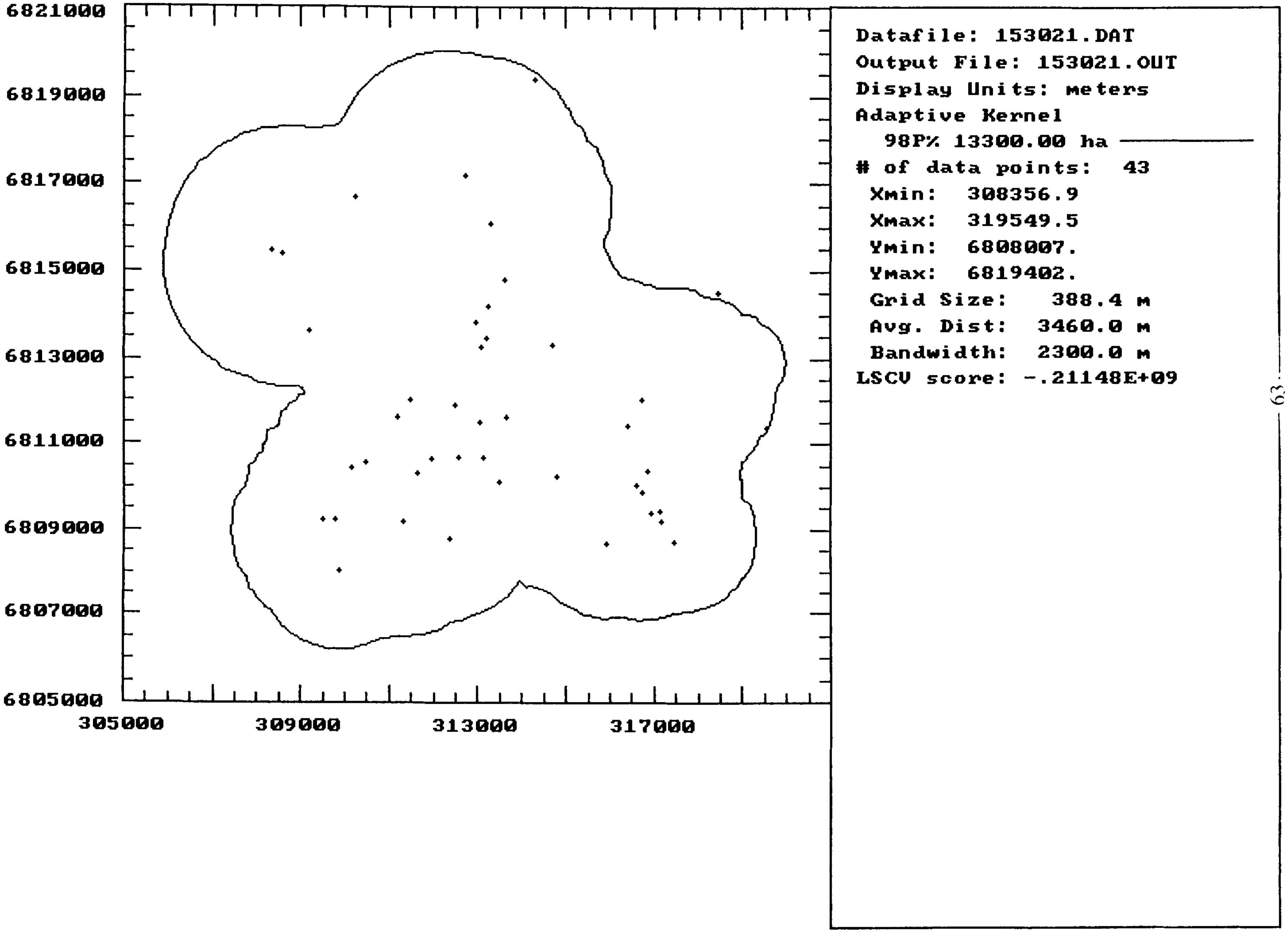

6890000
6880000
6870000
6860000
6850000
6840000
6830000
6820000
260000
280000
300000
320000
Datafile: 15281018.DAT
Output File: 152810.OUT
Display Units: meters
Adaptive Kernel
98P% 25980.00 ha
# of data points: 21
Xmin: 264171.9
Xmax: 280223.3
Ymin: 6833839.
Ymax: 6882679.
Grid Size: 1465.2 m
Avg. Dist: 10922.9 m
Bandwidth: 3800.0 m
LSCV score: -.19949E+11

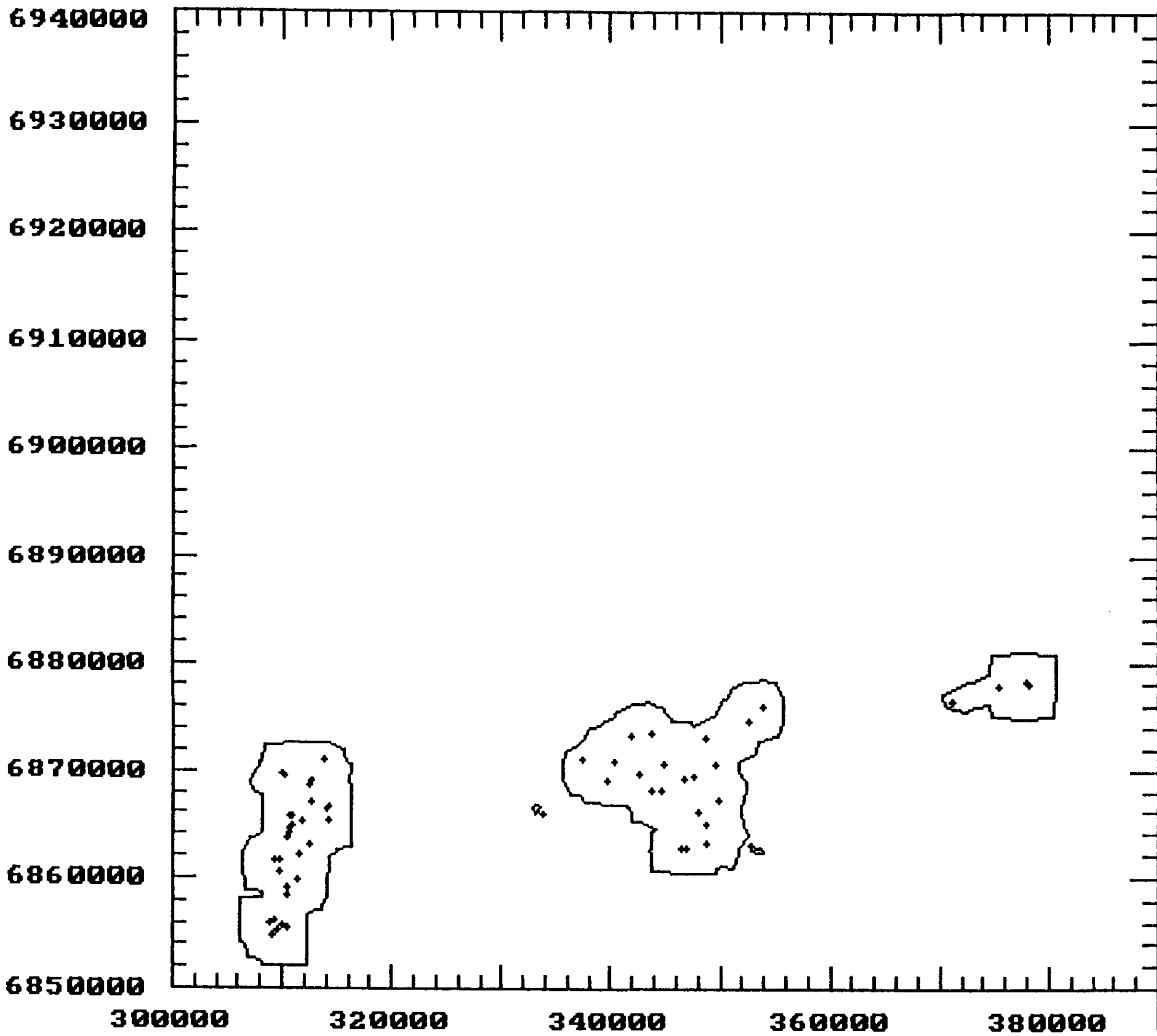


Datafile: 15281079.DAT
Output File: 15281079.O
Display Units: meters
Adaptive Kernel
98P% 15560.00 ha
# of data points: 50
Xmin: 351980.1
Xmax: 374517.1
Ymin: 6824977.
Ymax: 6864446.
Grid Size: 1184.0 m
Avg. Dist: 5981.6 m
Bandwidth: 2200.0 m
LSCV score: -.48313E+11

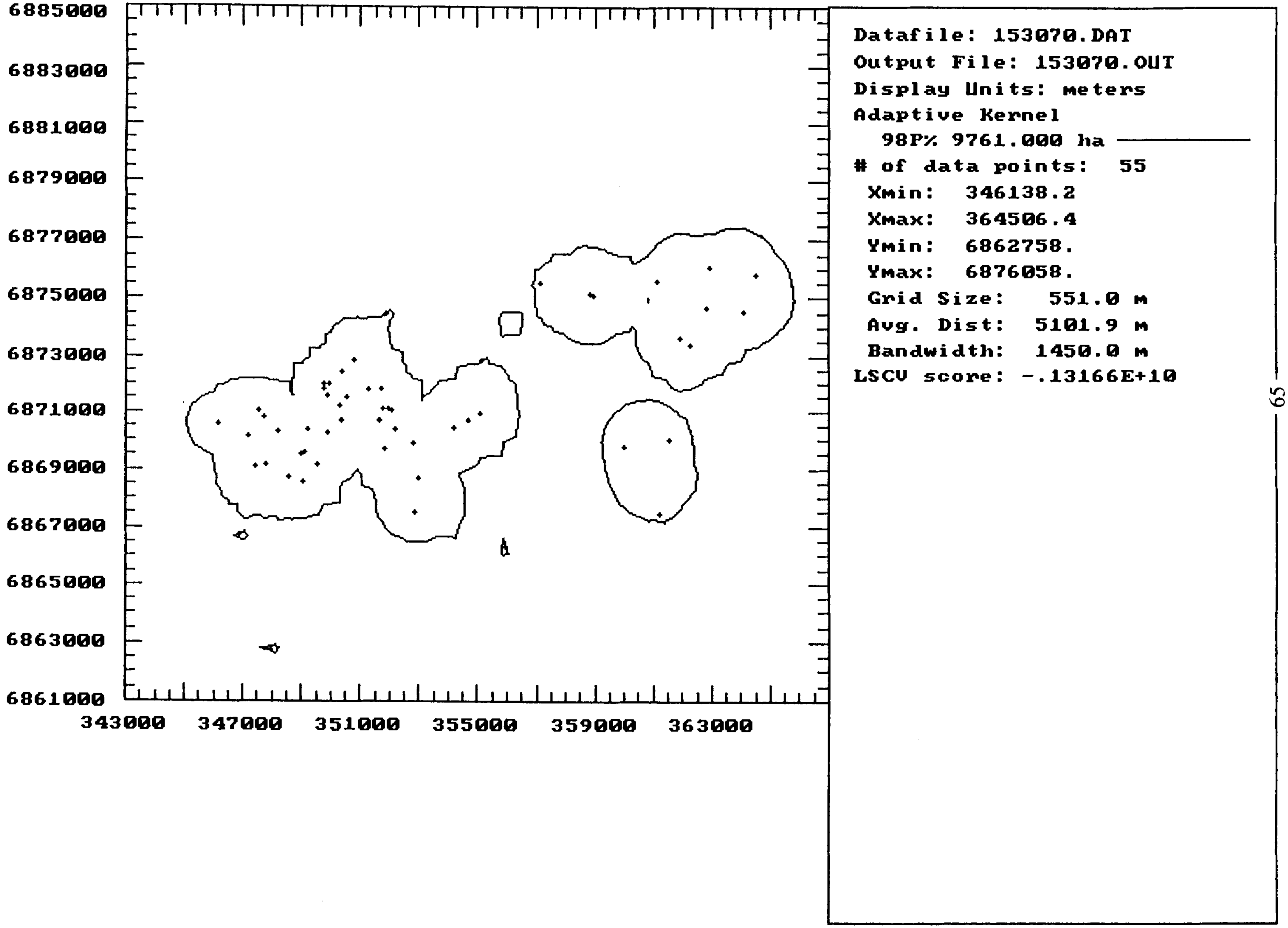

6900000
6890000
6880000
6870000
6860000
6850000
322000
342000
362000
Datafile: 152950.DAT
Output File: 152950.OUT
Display Units: meters
Adaptive Kernel
98P% 19920.00 ha
# of data points: 68
Xmin: 327993.8
Xmax: 368647.4
Ymin: 6853595.
Ymax: 6878968.
Grid Size: 1219.6 m
Avg. Dist: 5432.4 m
Bandwidth: 1800.0 m
LSCV score: -.30578E+11

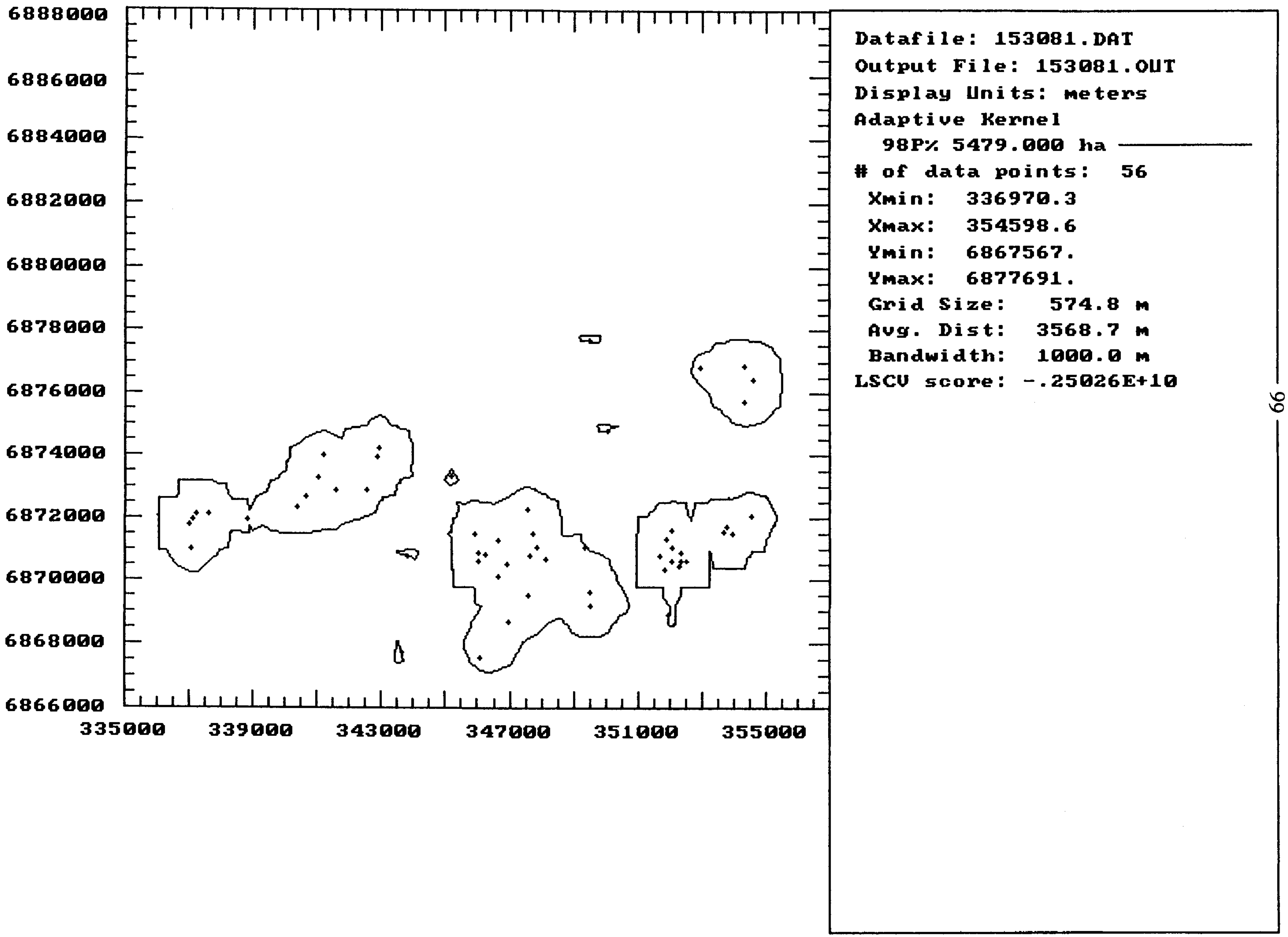

6867000
6865000
6863000
6861000
6859000
6857000
6855000
6853000
6851000
344000
348000
352000
356000
Datafile: 152980.DAT
Output File: 152980.OUT
Display Units: meters
Adaptive Kernel
98P% 5106.000 ha
# of data points: 59
Xmin: 344916.9
Xmax: 358909.5
Ymin: 6852137.
Ymax: 6863552.
Grid Size: 419.7 m
Avg. Dist: 2588.6 m
Bandwidth: 1250.0 m
LSCV score: -.20538E+10


6821000
6819000
6817000
6815000
6813000
6811000
6809000
6807000
6805000
305000
309000
313000
317000
Datafile: 153021.DAT
Output File: 153021.OUT
Display Units: meters
Adaptive Kernel
98P% 13300.00 ha
# of data points: 43
Xmin: 308356.9
Xmax: 319549.5
Ymin: 6808007.
Ymax: 6819402.
Grid Size: 388.4 m
Avg. Dist: 3460.0 m
Bandwidth: 2300.0 m
LSCV score: -.21148E+09

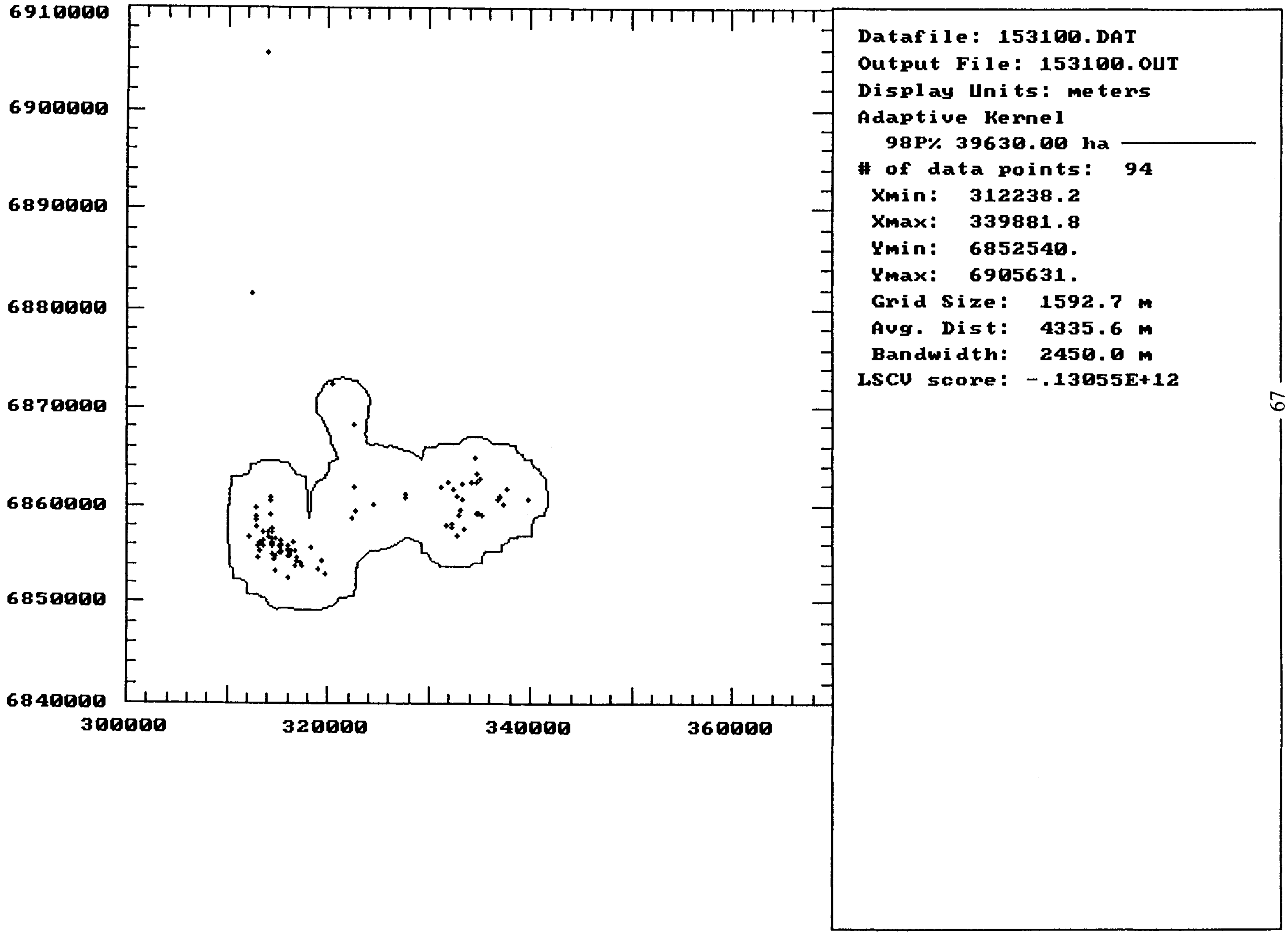


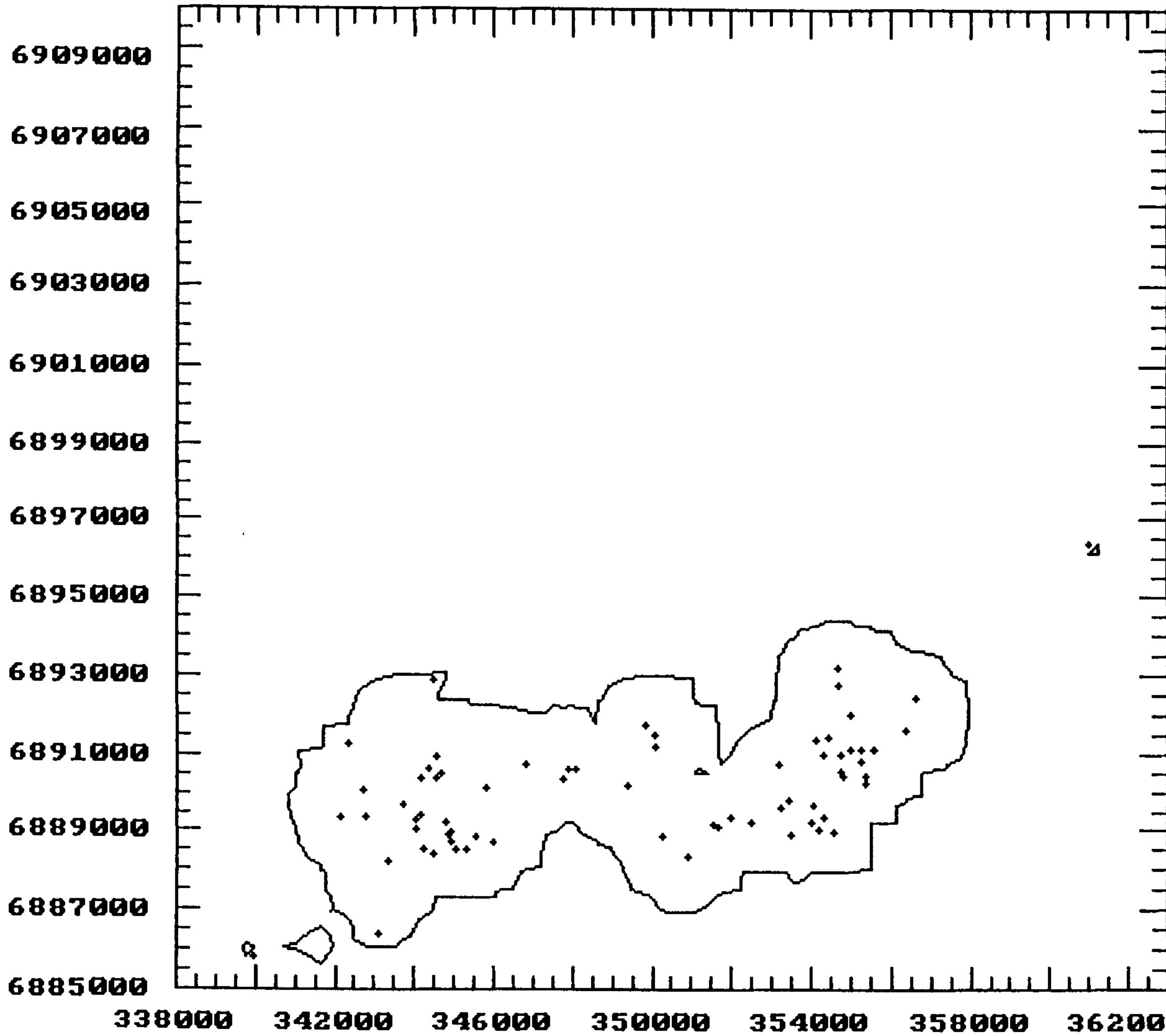
Datafile: 153031.DAT
Output File: 153031.OUT
Display Units: meters
Adaptive Kernel
98P% 40970.00 ha
# of data points: 57
Xmin: 308817.5
Xmax: 378115.0
Ymin: 6854871.
Ymax: 6878242.
Grid Size: 2078.9 m
Avg. Dist: 9625.1 m
Bandwidth: 2500.0 m
LSCV score: -.94986E+11


6885000
6883000
6881000
6879000
6877000
6875000
6873000
6871000
6869000
6867000
6865000
6863000
6861000
343000
347000
351000
355000
359000
363000
Datafile: 153070.DAT
Output File: 153070.OUT
Display Units: meters
Adaptive Kernel
98P% 9761.000 ha
# of data points: 55
Xmin: 346138.2
Xmax: 364506.4
Ymin: 6862758.
Ymax: 6876058.
Grid Size: 551.0 m
Avg. Dist: 5101.9 m
Bandwidth: 1450.0 m
LSCV score: -.13166E+10

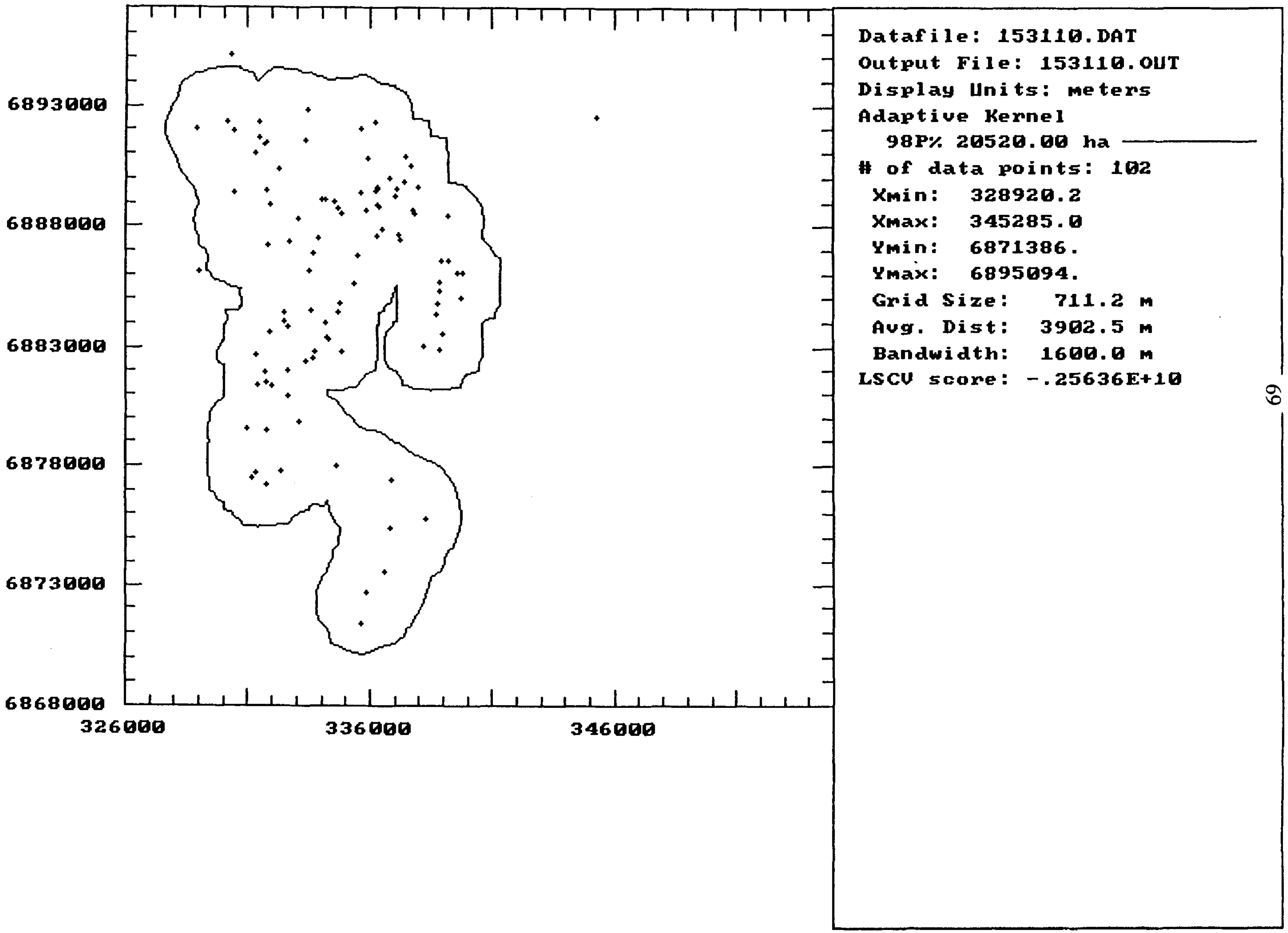


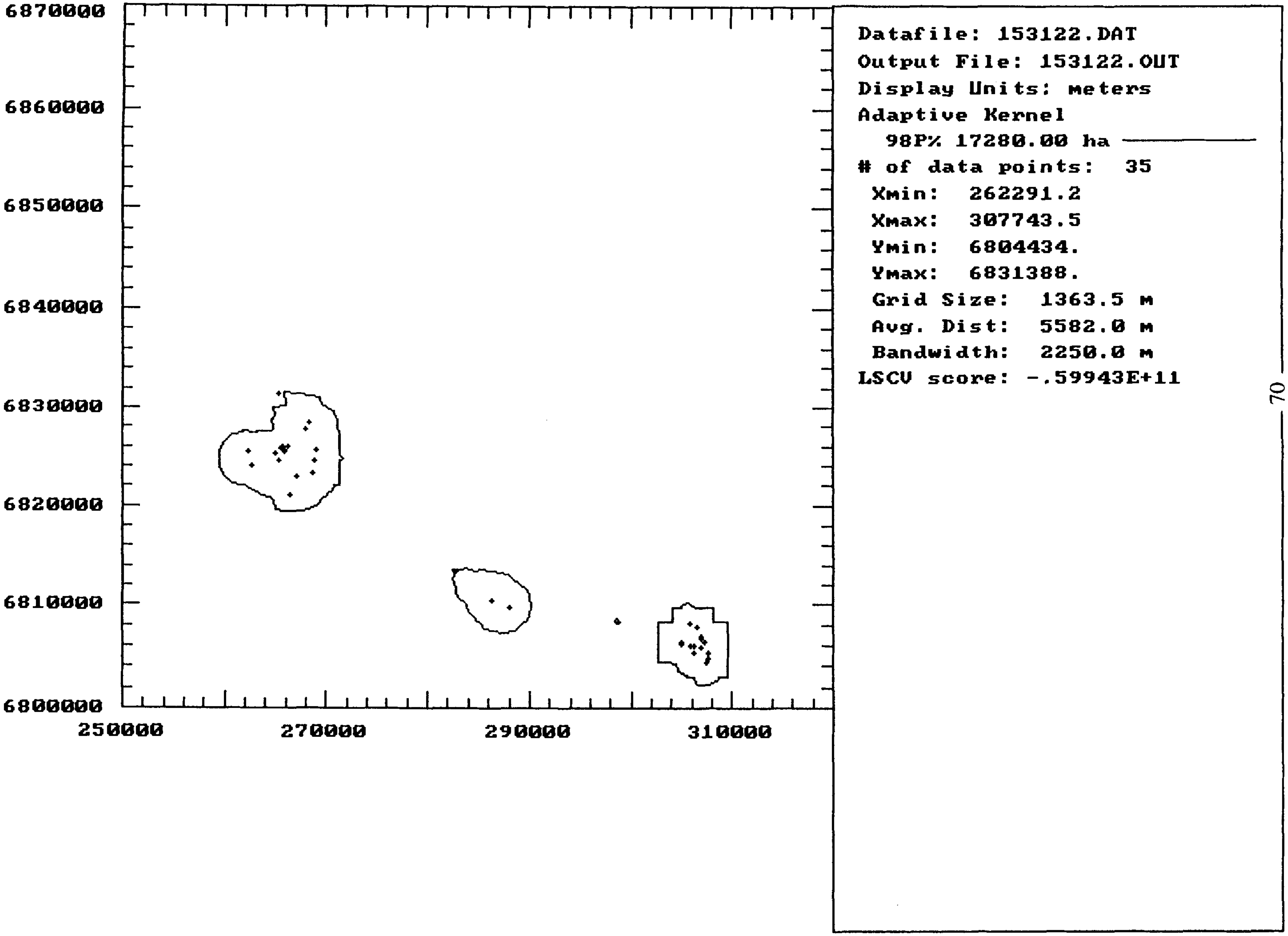
Datafile: 153081.DAT
Output File: 153081.OUT
Display Units: meters
Adaptive Kernel
98P% 5479.000 ha
# of data points: 56
Xmin: 336970.3
Xmax: 354598.6
Ymin: 6867567.
Ymax: 6877691.
Grid Size: 574.8 m
Avg. Dist: 3568.7 m
Bandwidth: 1000.0 m
LSCV score: -.25026E+10
6888000
6886000
6884000
6882000
6880000
6878000
6876000
6874000
6872000
6870000
6868000
6866000
335000
339000
343000
347000
351000
355000

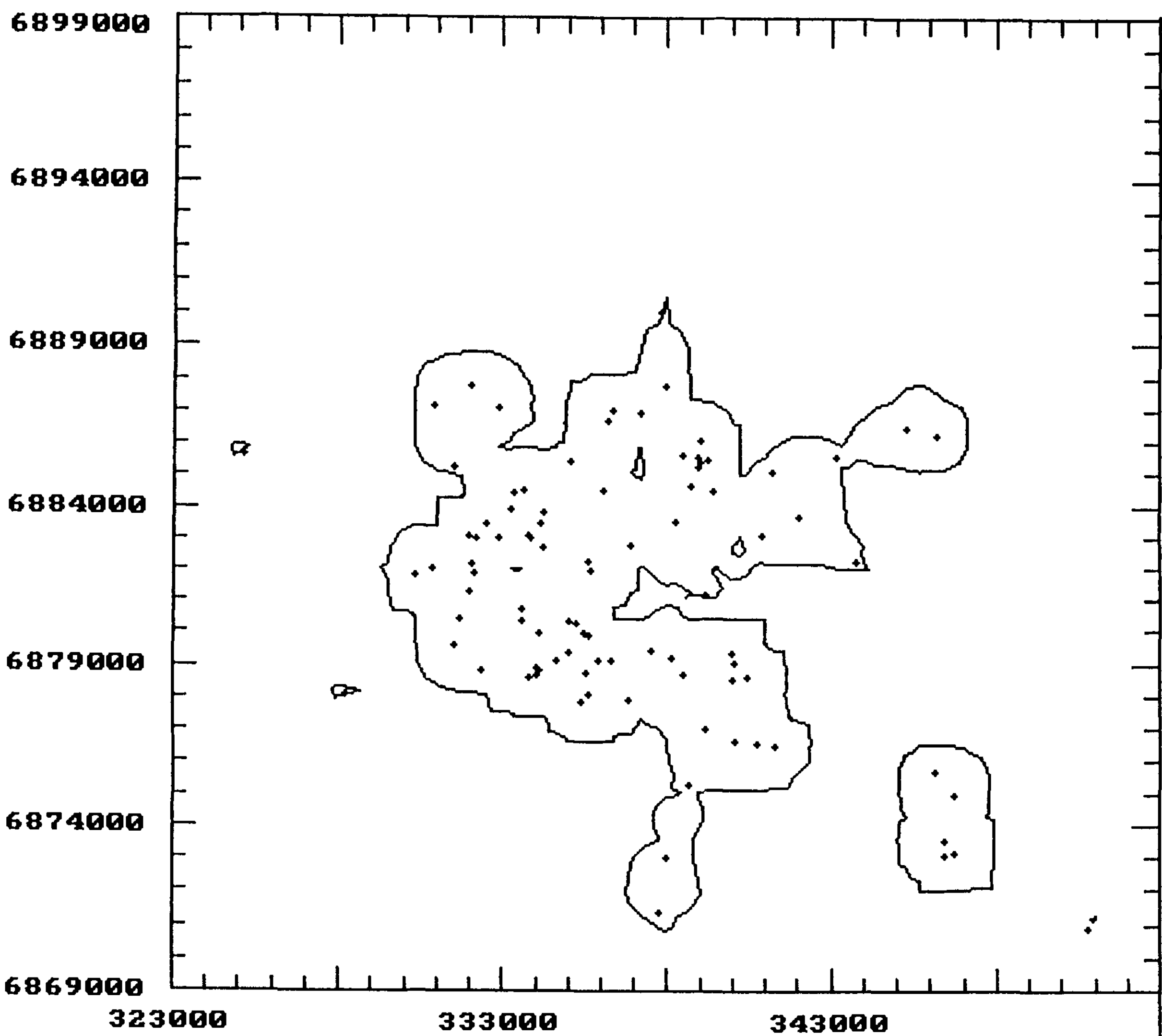

6910000
6900000
6890000
6880000
6870000
6860000
6850000
6840000
300000
320000
340000
360000
Datafile: 153100.DAT
Output File: 153100.OUT
Display Units: meters
Adaptive Kernel
98P% 39630.00 ha
# of data points: 94
Xmin: 312238.2
Xmax: 339881.8
Ymin: 6852540.
Ymax: 6905631.
Grid Size: 1592.7 m
Avg. Dist: 4335.6 m
Bandwidth: 2450.0 m
LSCV score: -.13055E+12



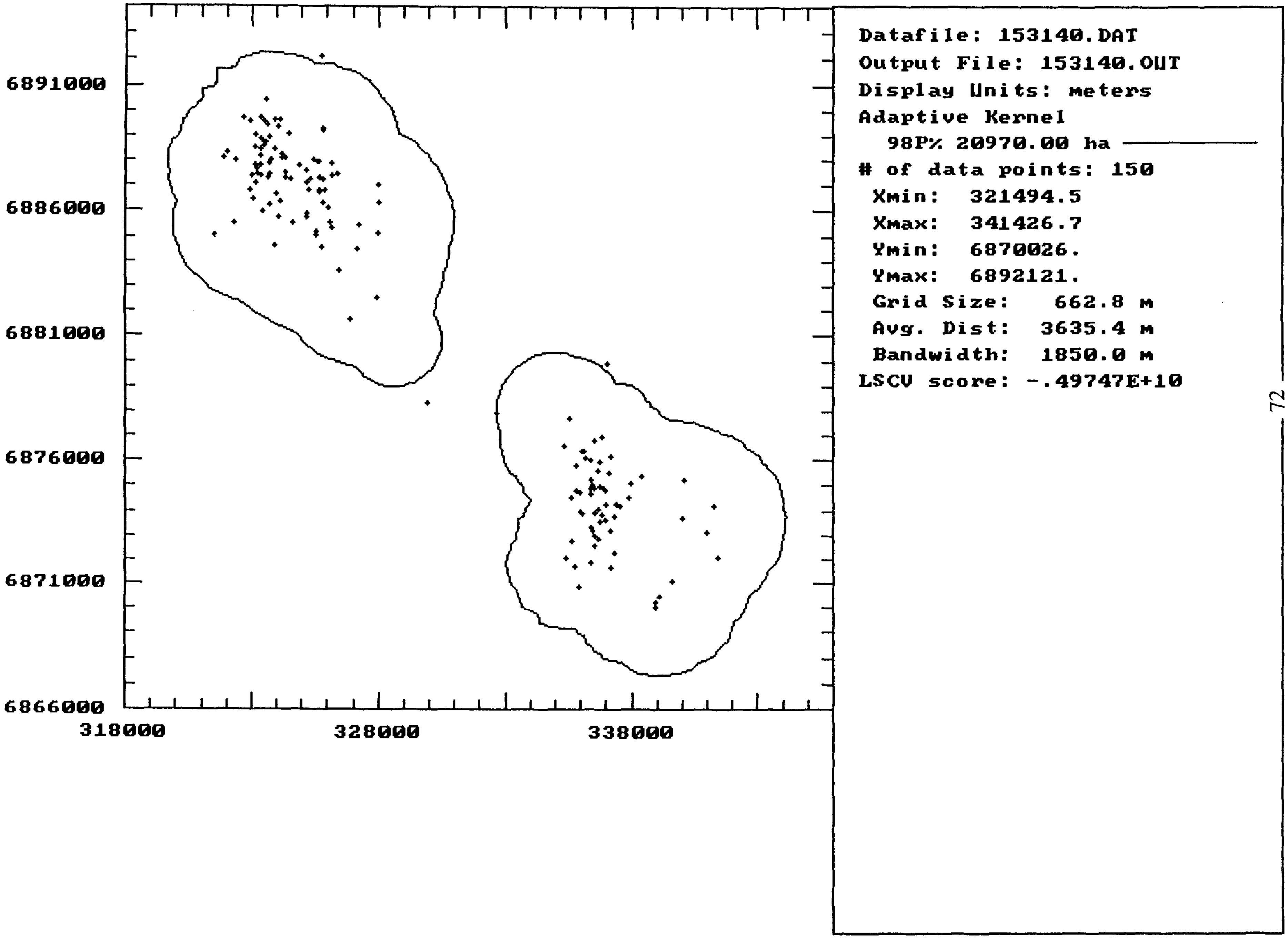
Datafile: 153102.DAT
Output File: 153102.OUT
Display Units: meters
Adaptive Kernel
98P% 8169.000 ha
# of data points: 70
Xmin: 339954.4
Xmax: 361006.1
Ymin: 6885846.
Ymax: 6896397.
Grid Size: 631.5 m
Avg. Dist: 4100.3 m
Bandwidth: 1200.0 m
LSCV score: -.46671E+10

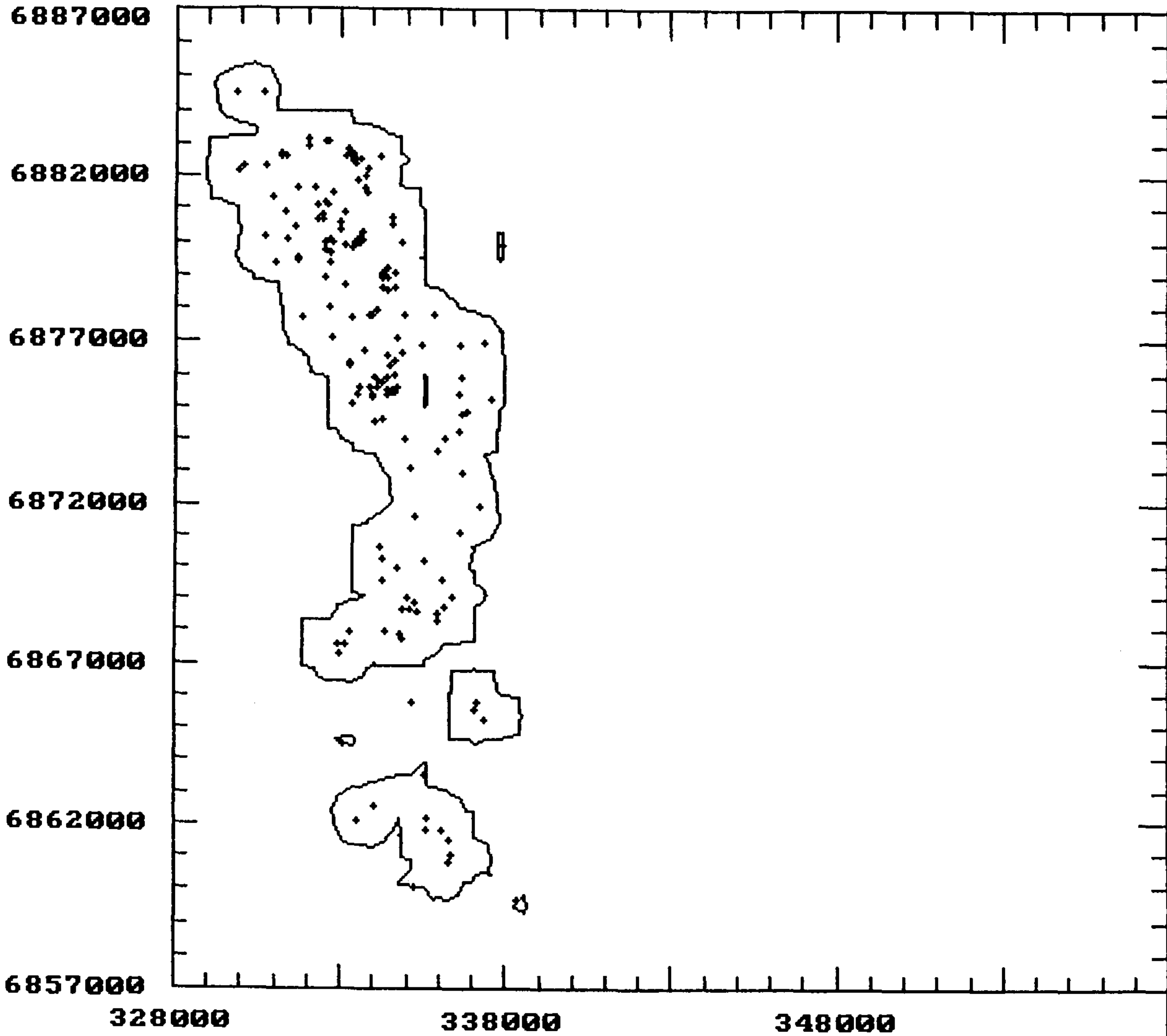

6893000
6888000
6883000
6878000
6873000
6868000
326000
336000
346000
Datafile: 153110.DAT
Output File: 153110.OUT
Display Units: meters
Adaptive Kernel
98P% 20520.00 ha
# of data points: 102
Xmin: 328920.2
Xmax: 345285.0
Ymin: 6871386.
Ymax: 6895094.
Grid Size: 711.2 m
Avg. Dist: 3902.5 m
Bandwidth: 1600.0 m
LSCV score: -.25636E+10


6870000
6860000
6850000
6840000
6830000
6820000
6810000
6800000
250000
270000
290000
310000
Datafile: 153122.DAT
Output File: 153122.OUT
Display Units: meters
Adaptive Kernel
98P% 17280.00 ha
# of data points: 35
Xmin: 262291.2
Xmax: 307743.5
Ymin: 6804434.
Ymax: 6831388.
Grid Size: 1363.5 m
Avg. Dist: 5582.0 m
Bandwidth: 2250.0 m
LSCV score: -.59943E+11

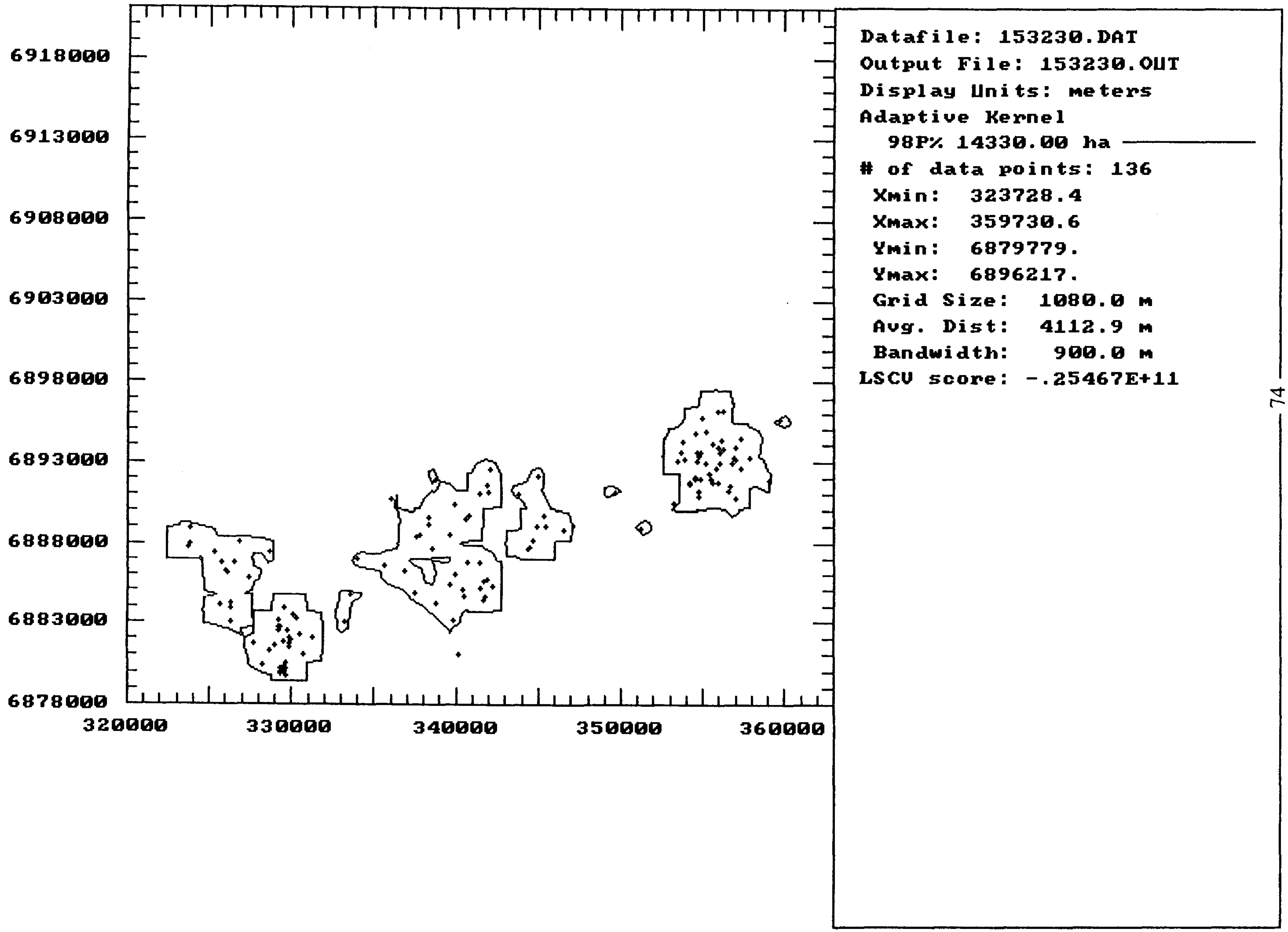


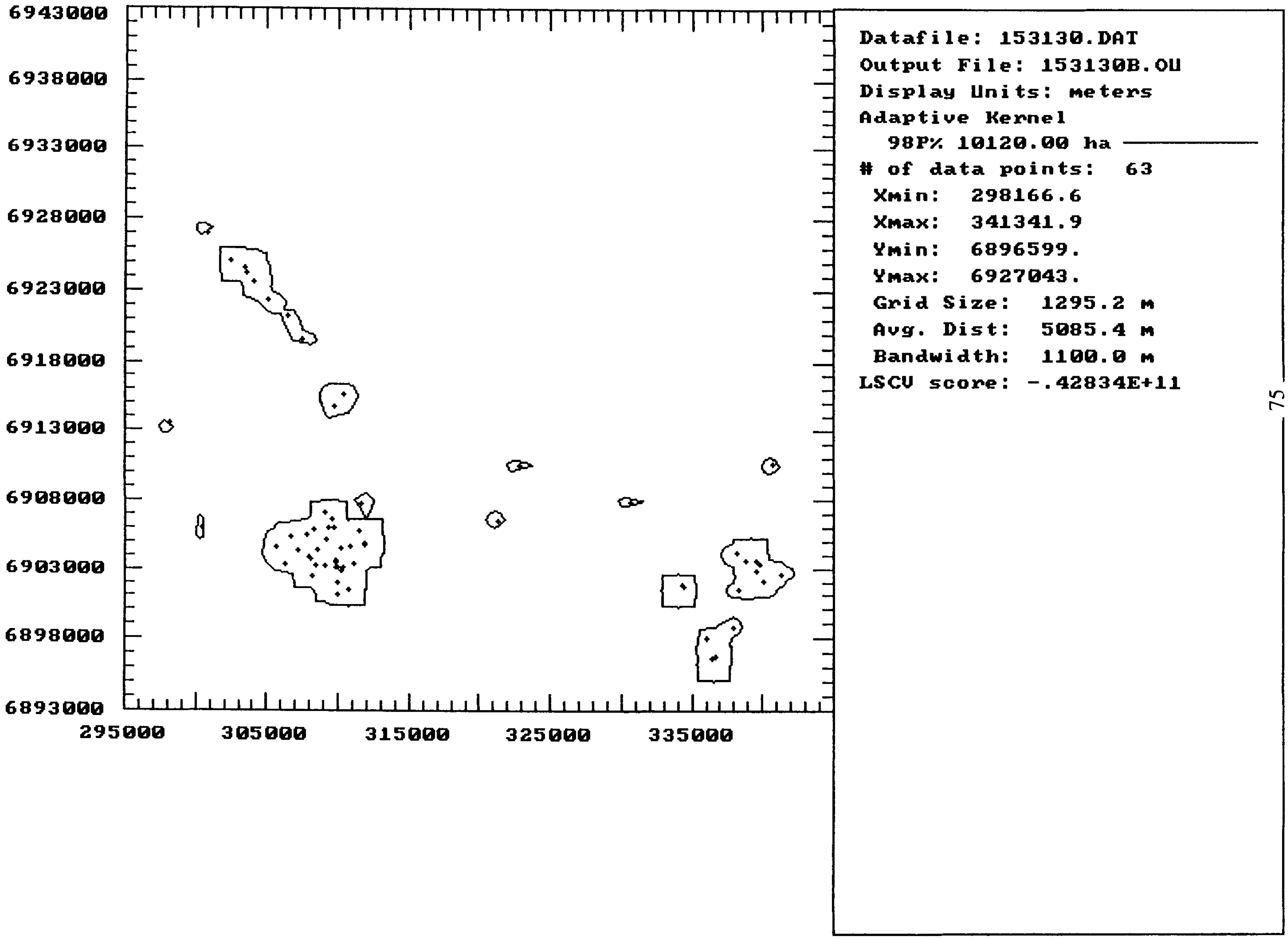
Datafile: 153123.DAT
Output File: 15123B.OUT
Display Units: meters
Adaptive Kernel
98P% 15330.00 ha
# of data points: 92
Xmin: 325104.5
Xmax: 350795.1
Ymin: 6870891.
Ymax: 6890016.
Grid Size: 770.7 m
Avg. Dist: 4110.4 m
Bandwidth: 1250.0 m
LSCV score: -.33348E+10

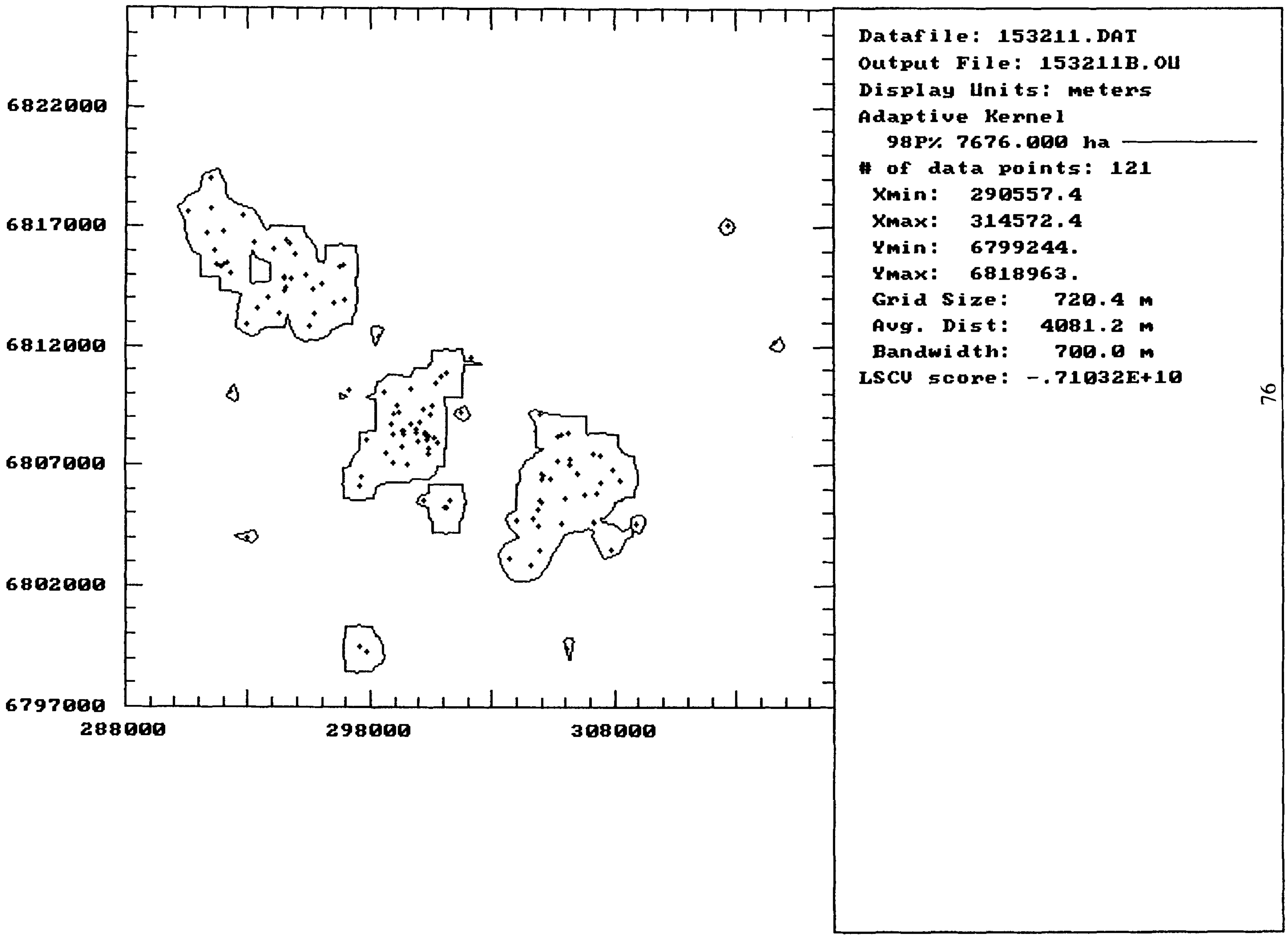

6891000
6886000
6881000
6876000
6871000
6866000
318000
328000
338000
Datafile: 153140.DAT
Output File: 153140.OUT
Display Units: meters
Adaptive Kernel
98P% 20970.00 ha
# of data points: 150
Xmin: 321494.5
Xmax: 341426.7
Ymin: 6870026.
Ymax: 6892121.
Grid Size: 662.8 m
Avg. Dist: 3635.4 m
Bandwidth: 1850.0 m
LSCV score: -.49747E+10



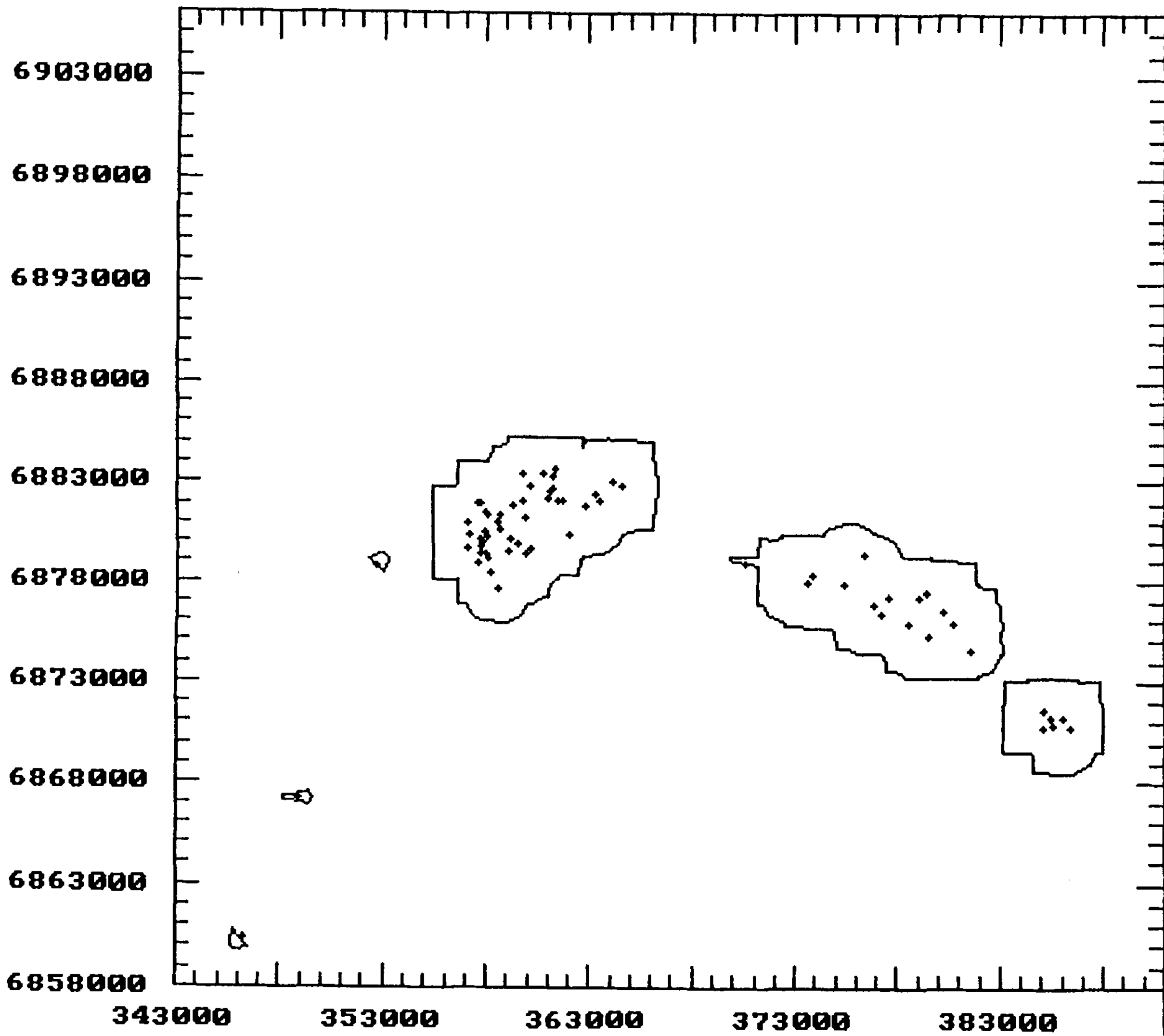
Datafile: 153170.DAT
Output File: 153170.OUT
Display Units: meters
Adaptive Kernel
98P% 10120.00 ha
# of data points: 171
Xmin: 329790.1
Xmax: 338363.8
Ymin: 6859641.
Ymax: 6884505.
Grid Size: 745.9 m
Avg. Dist: 3076.4 m
Bandwidth: 750.0 m
LSCV score: -.11447E+11


6918000
6913000
6908000
6903000
6898000
6893000
6888000
6883000
6878000
320000
330000
340000
350000
360000
Datafile: 153230.DAT
Output File: 153230.OUT
Display Units: meters
Adaptive Kernel
98P% 14330.00 ha
# of data points: 136
Xmin: 323728.4
Xmax: 359730.6
Ymin: 6879779.
Ymax: 6896217.
Grid Size: 1080.0 m
Avg. Dist: 4112.9 m
Bandwidth: 900.0 m
LSCV score: -.25467E+11

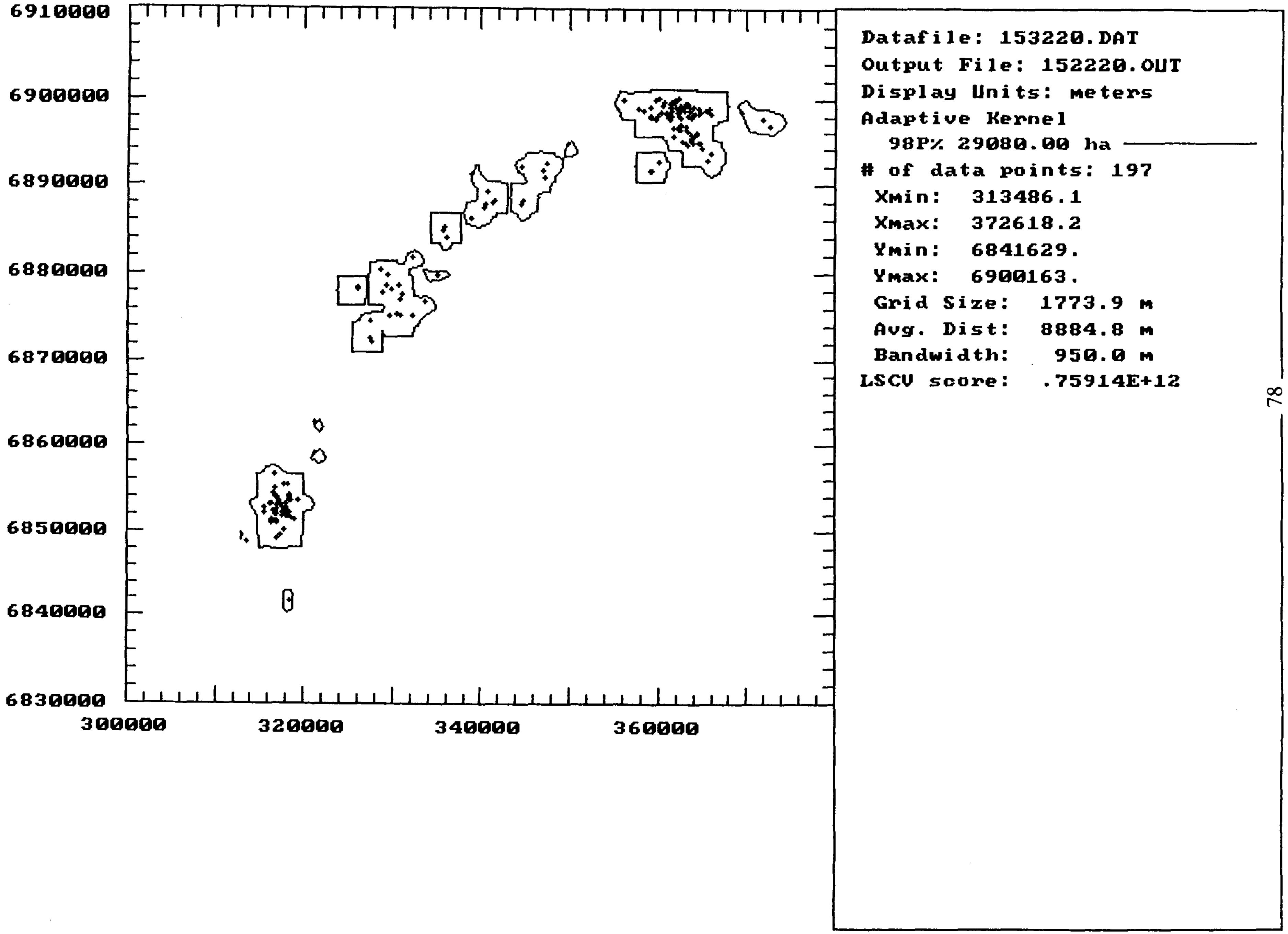

6943000
6938000
6933000
6928000
6923000
6918000
6913000
6908000
6903000
6898000
6893000
295000
305000
315000
325000
335000
Datafile: 153130.DAT
Output File: 153130B.OU
Display Units: meters
Adaptive Kernel
98P% 10120.00 ha
# of data points: 63
Xmin: 298166.6
Xmax: 341341.9
Ymin: 6896599.
Ymax: 6927043.
Grid Size: 1295.2 m
Avg. Dist: 5085.4 m
Bandwidth: 1100.0 m
LSCV score: -.42834E+11

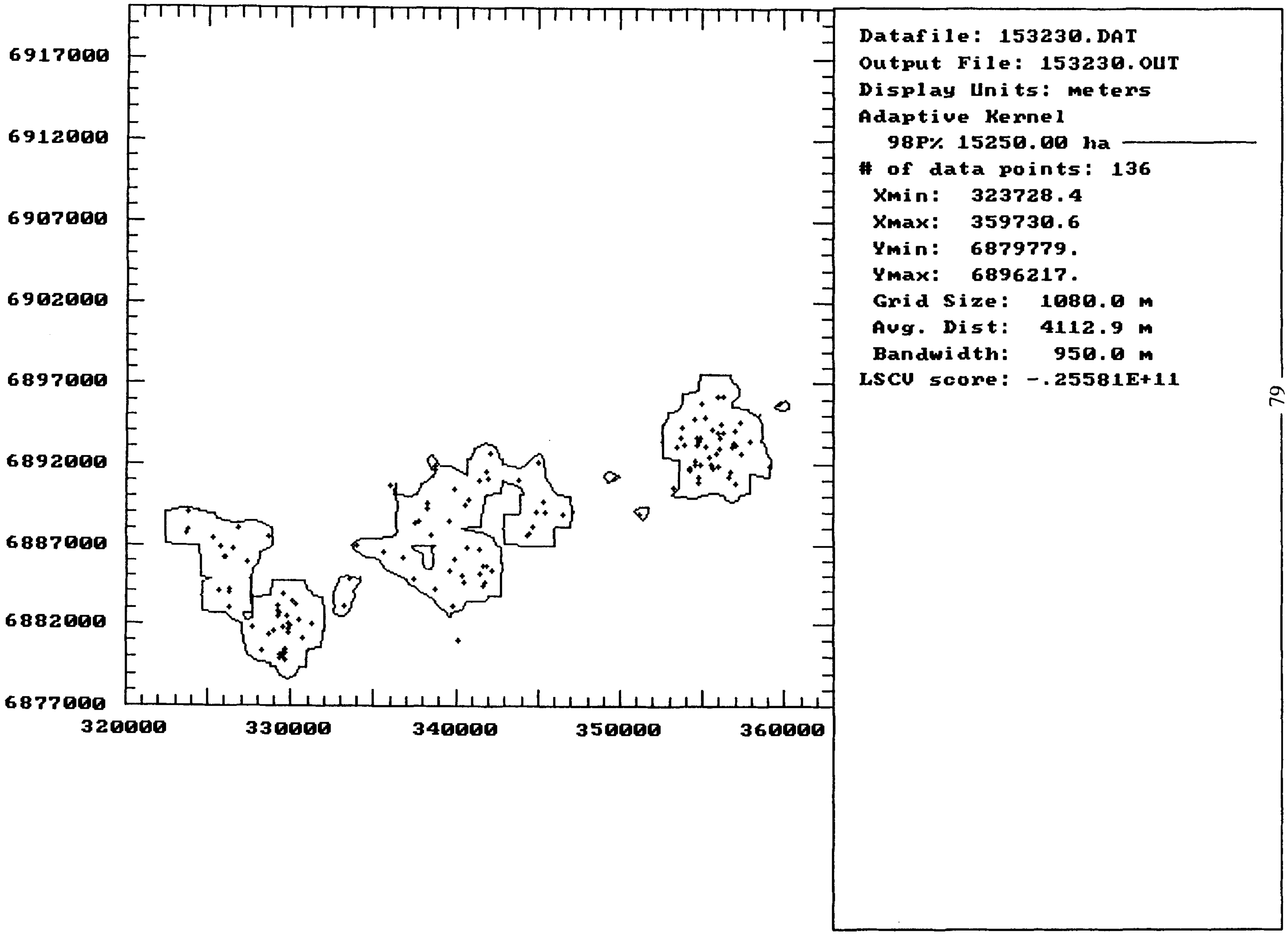


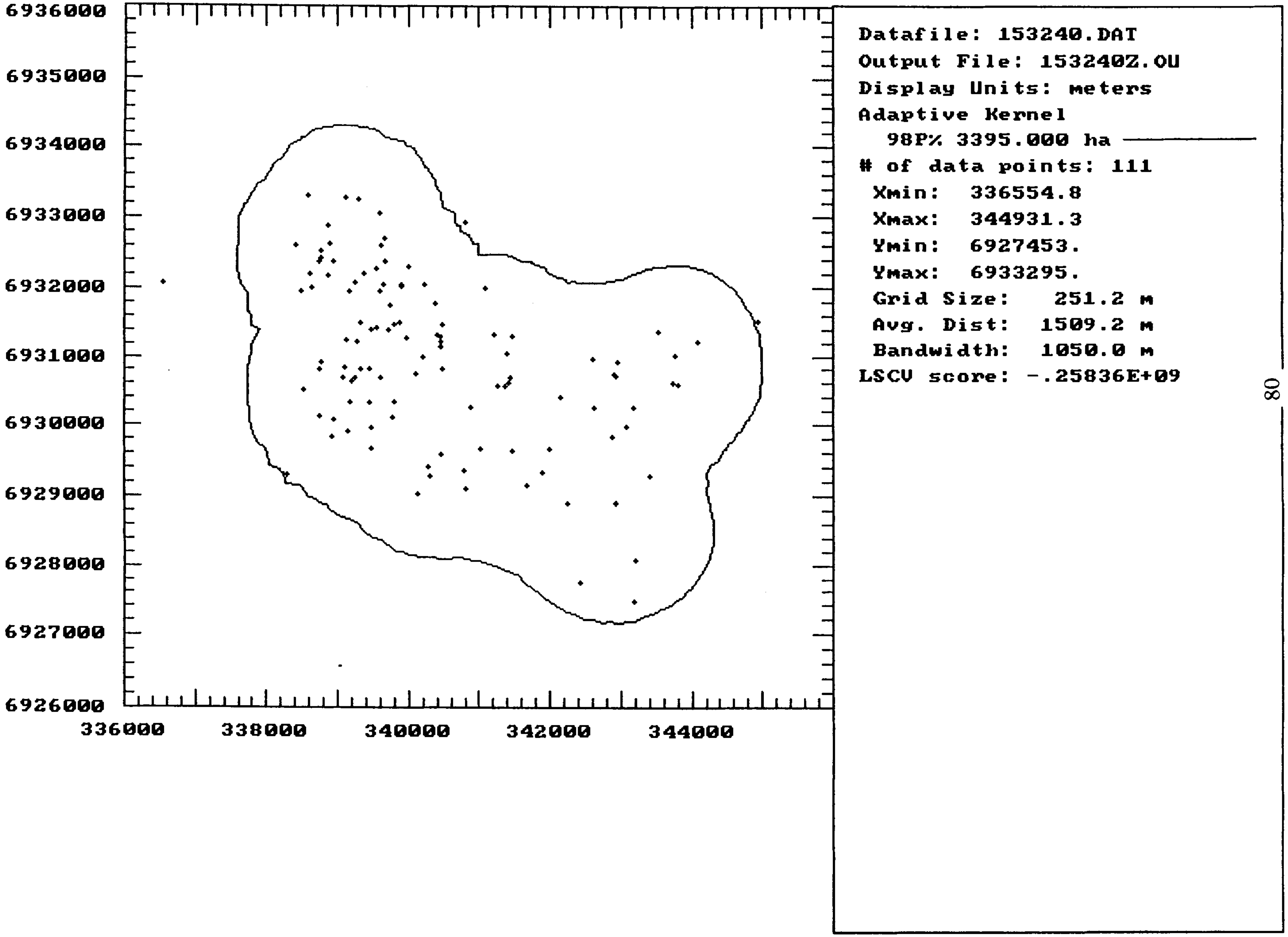
6822000
6817000
6812000
6807000
6802000
6797000
288000
298000
308000
Datafile: 153211.DAT
Output File: 153211B.OU
Display Units: meters
Adaptive Kernel
98P% 7676.000 ha
# of data points: 121
Xmin: 290557.4
Xmax: 314572.4
Ymin: 6799244.
Ymax: 6818963.
Grid Size: 720.4 m
Avg. Dist: 4081.2 m
Bandwidth: 700.0 m
LSCV score: -.71032E+10



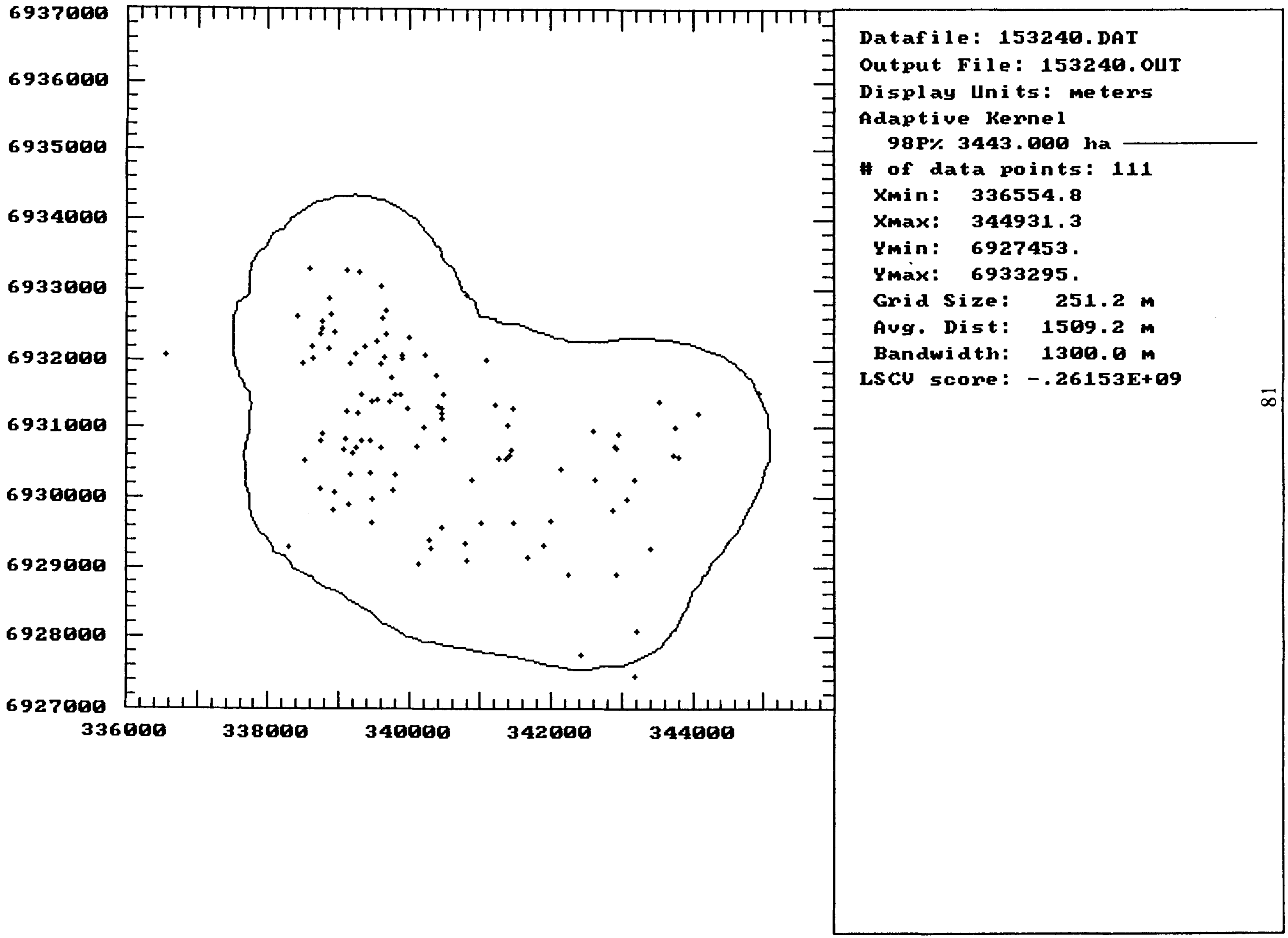
Datafile: 153215.DAT
Output File: 153215.OUT
Display Units: meters
Adaptive Kernel
98P% 15610.00 ha
# of data points: 70
Xmin: 346216.7
Xmax: 386384.3
Ymin: 6860376.
Ymax: 6883592.
Grid Size: 1205.0 m
Avg. Dist: 5178.4 m
Bandwidth: 1600.0 m
LSCV score: -.53523E+11

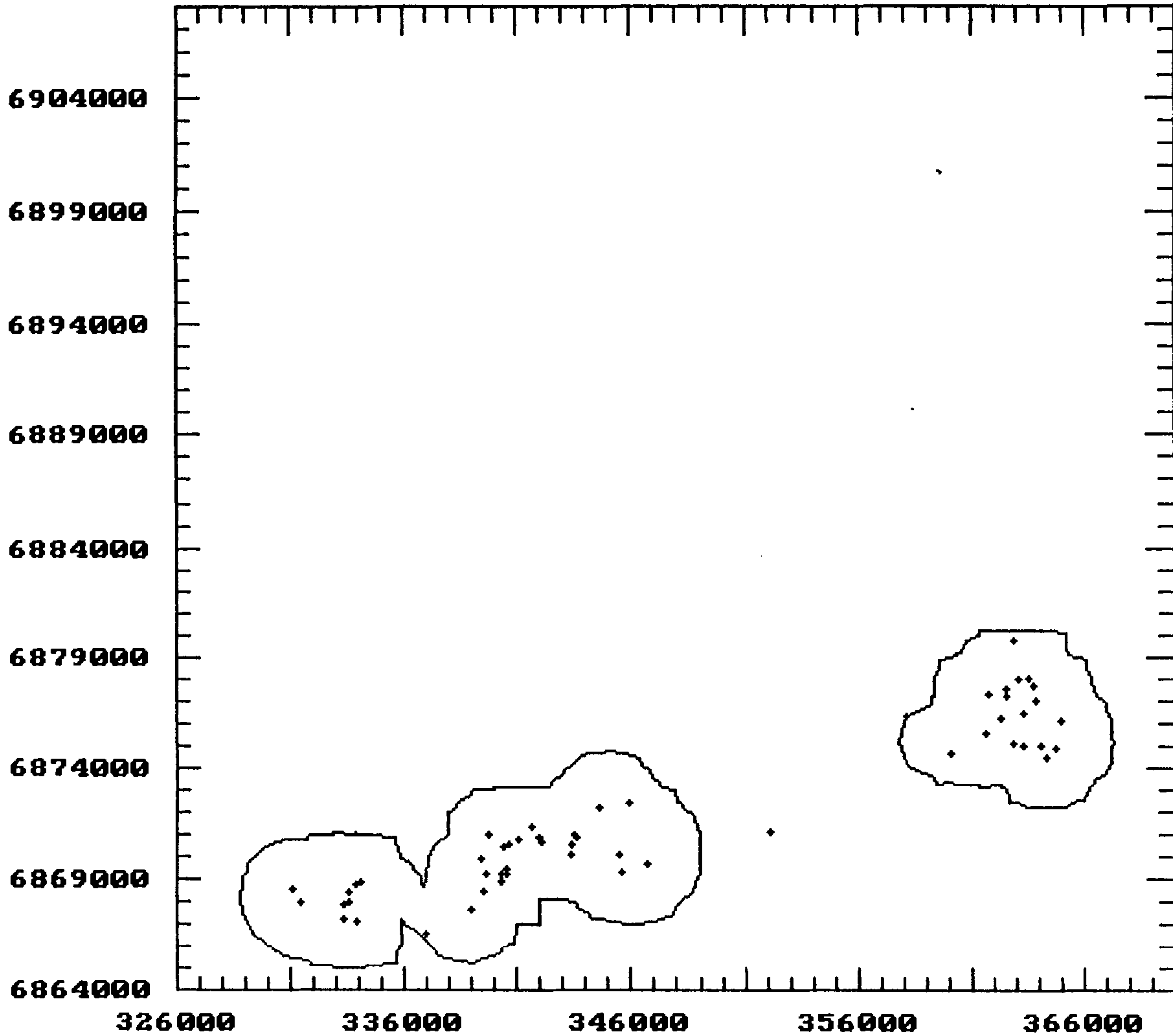

6910000
6900000
6890000
6880000
6870000
6860000
6850000
6840000
6830000
300000
320000
340000
360000
Datafile: 153220.DAT
Output File: 152220.OUT
Display Units: meters
Adaptive Kernel
98P% 29080.00 ha
# of data points: 197
Xmin: 313486.1
Xmax: 372618.2
Ymin: 6841629.
Ymax: 6900163.
Grid Size: 1773.9 m
Avg. Dist: 8884.8 m
Bandwidth: 950.0 m
LSCV score: .75914E+12


6917000
6912000
6907000
6902000
6897000
6892000
6887000
6882000
6877000
320000
330000
340000
350000
360000
Datafile: 153230.DAT
Output File: 153230.OUT
Display Units: meters
Adaptive Kernel
98P% 15250.00 ha
# of data points: 136
Xmin: 323728.4
Xmax: 359730.6
Ymin: 6879779.
Ymax: 6896217.
Grid Size: 1080.0 m
Avg. Dist: 4112.9 m
Bandwidth: 950.0 m
LSCV score: -.25581E+11

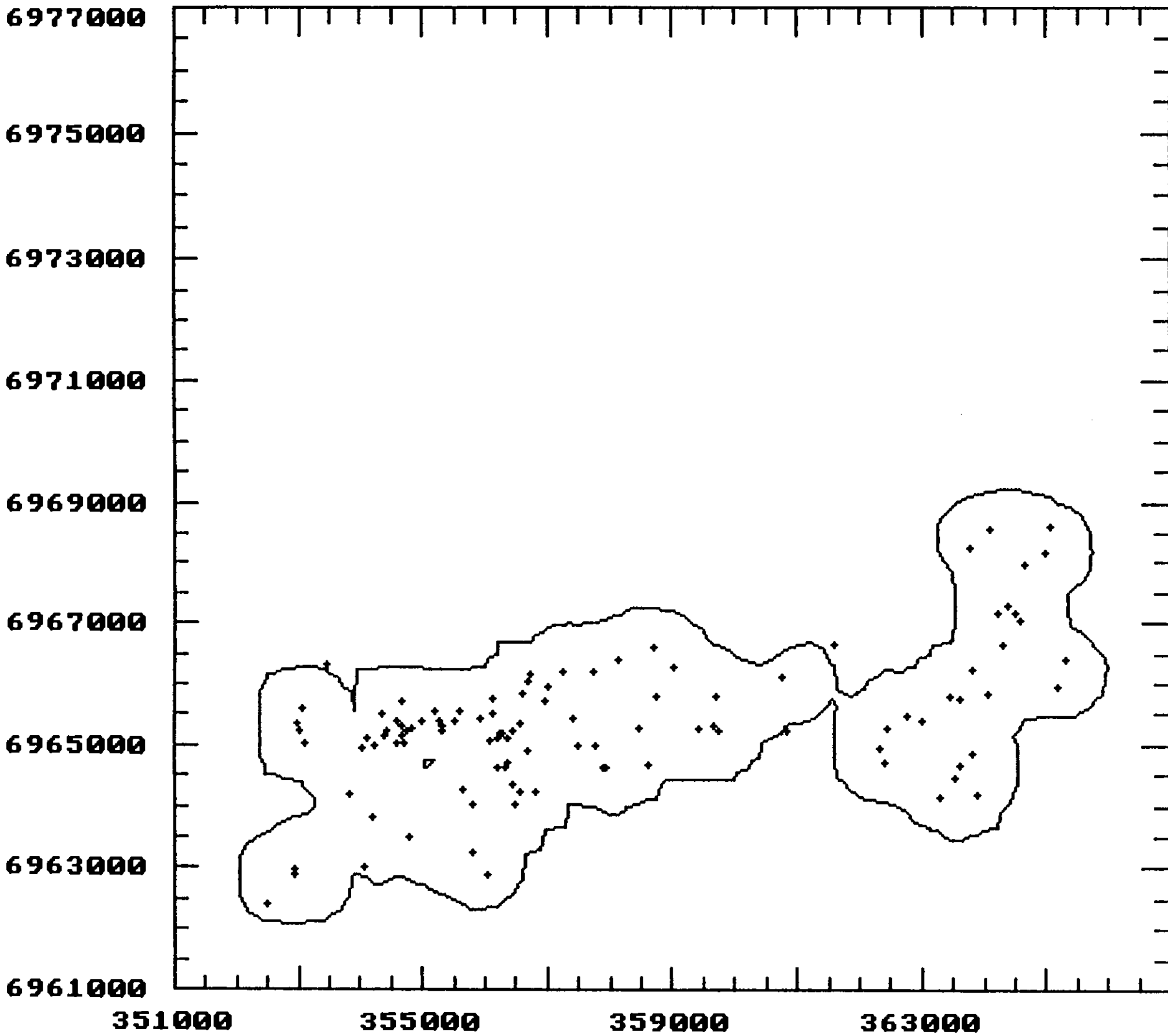


6936000
6935000
6934000
6933000
6932000
6931000
6930000
6929000
6928000
6927000
6926000
336000
338000
340000
342000
344000
Datafile: 153240.DAT
Output File: 153240Z.OU
Display Units: meters
Adaptive Kernel
98P% 3395.000 ha
# of data points: 111
Xmin: 336554.8
Xmax: 344931.3
Ymin: 6927453.
Ymax: 6933295.
Grid Size: 251.2 m
Avg. Dist: 1509.2 m
Bandwidth: 1050.0 m
LSCV score: -.25836E+09

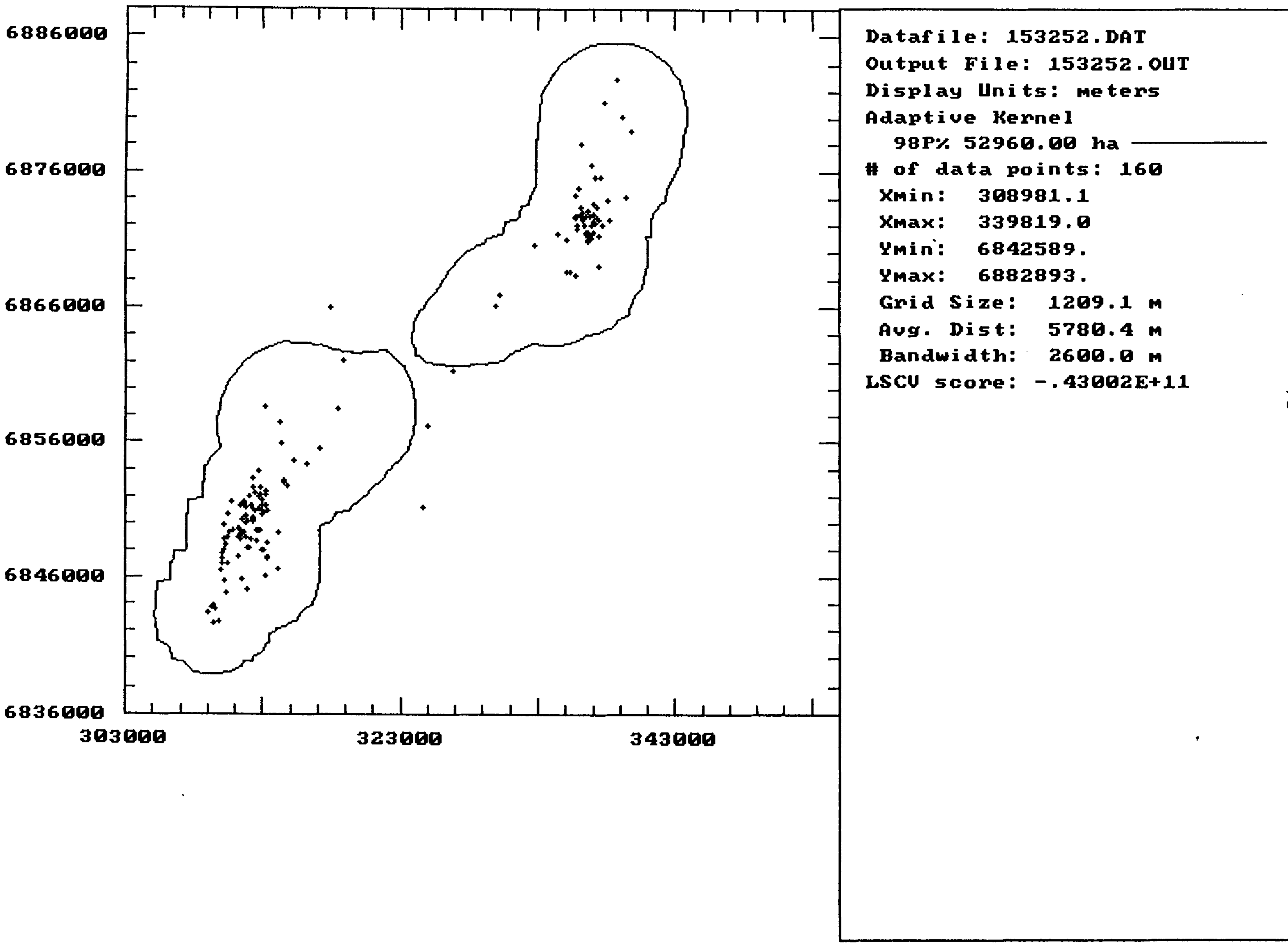

6937000
6936000
6935000
6934000
6933000
6932000
6931000
6930000
6929000
6928000
6927000
336000
338000
340000
342000
344000
Datafile: 153240.DAT
Output File: 153240.OUT
Display Units: meters
Adaptive Kernel
98P% 3443.000 ha
# of data points: 111
Xmin: 336554.8
Xmax: 344931.3
Ymin: 6927453.
Ymax: 6933295.
Grid Size: 251.2 m
Avg. Dist: 1509.2 m
Bandwidth: 1300.0 m
LSCV score: -.26153E+09

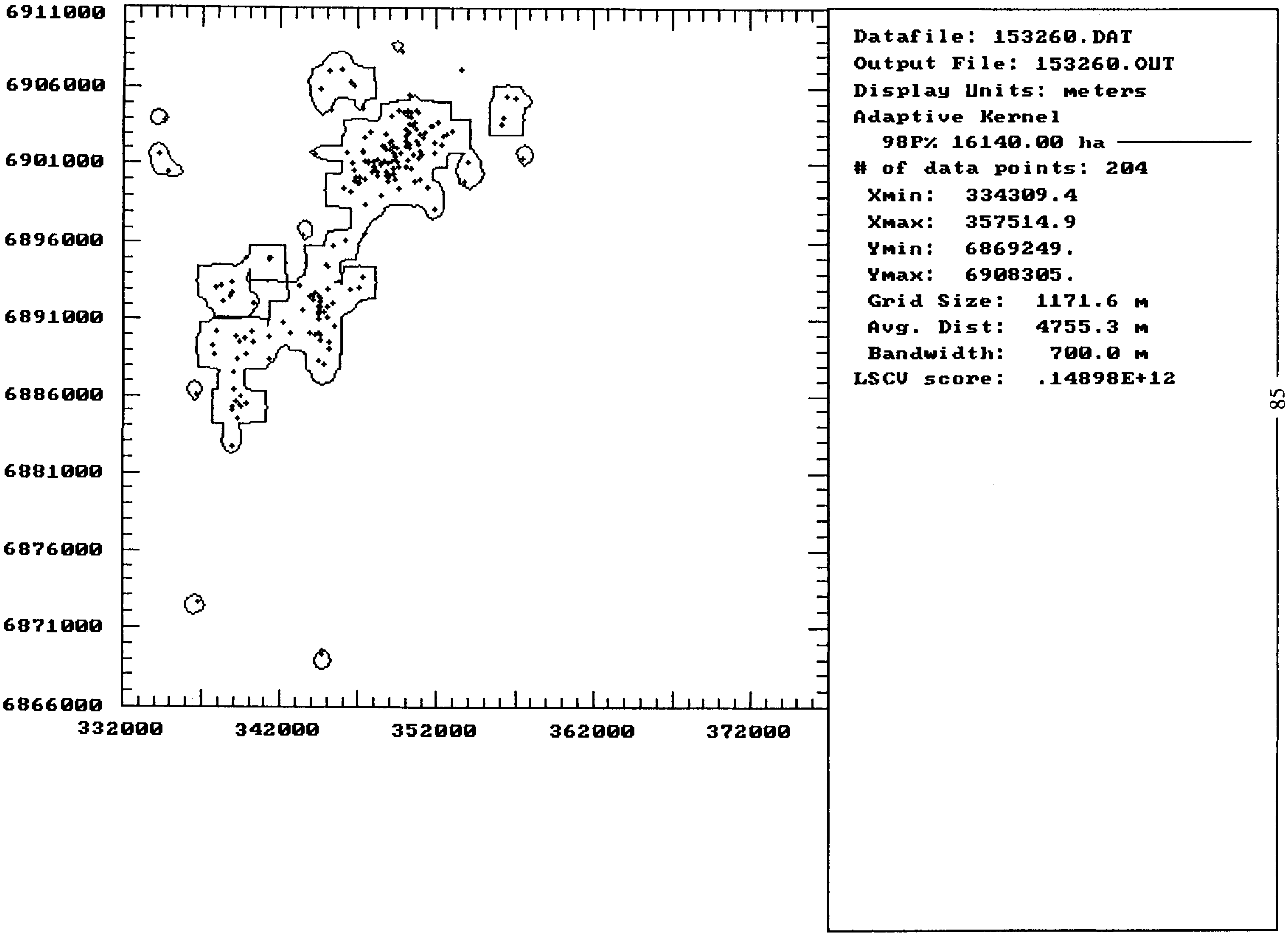


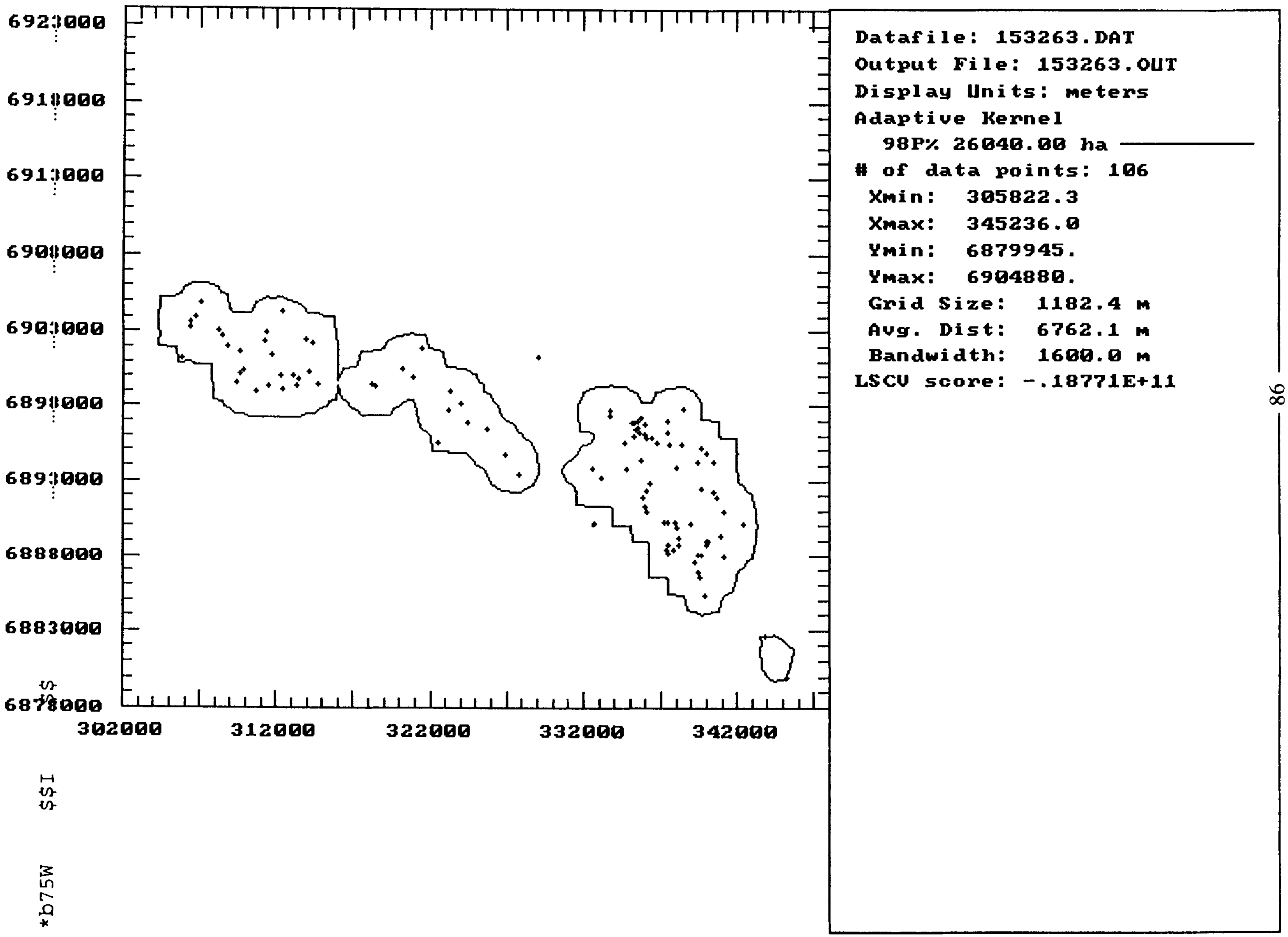
Datafile: 153242.DAT
Output File: 153242.OUT
Display Units: meters
Adaptive Kernel
98P% 17080.00 ha
# of data points: 54
Xmin: 331140.1
Xmax: 365053.3
Ymin: 6866505.
Ymax: 6879732.
Grid Size: 1017.4 m
Avg. Dist: 5877.7 m
Bandwidth: 2300.0 m
LSCV score: -.16265E+11

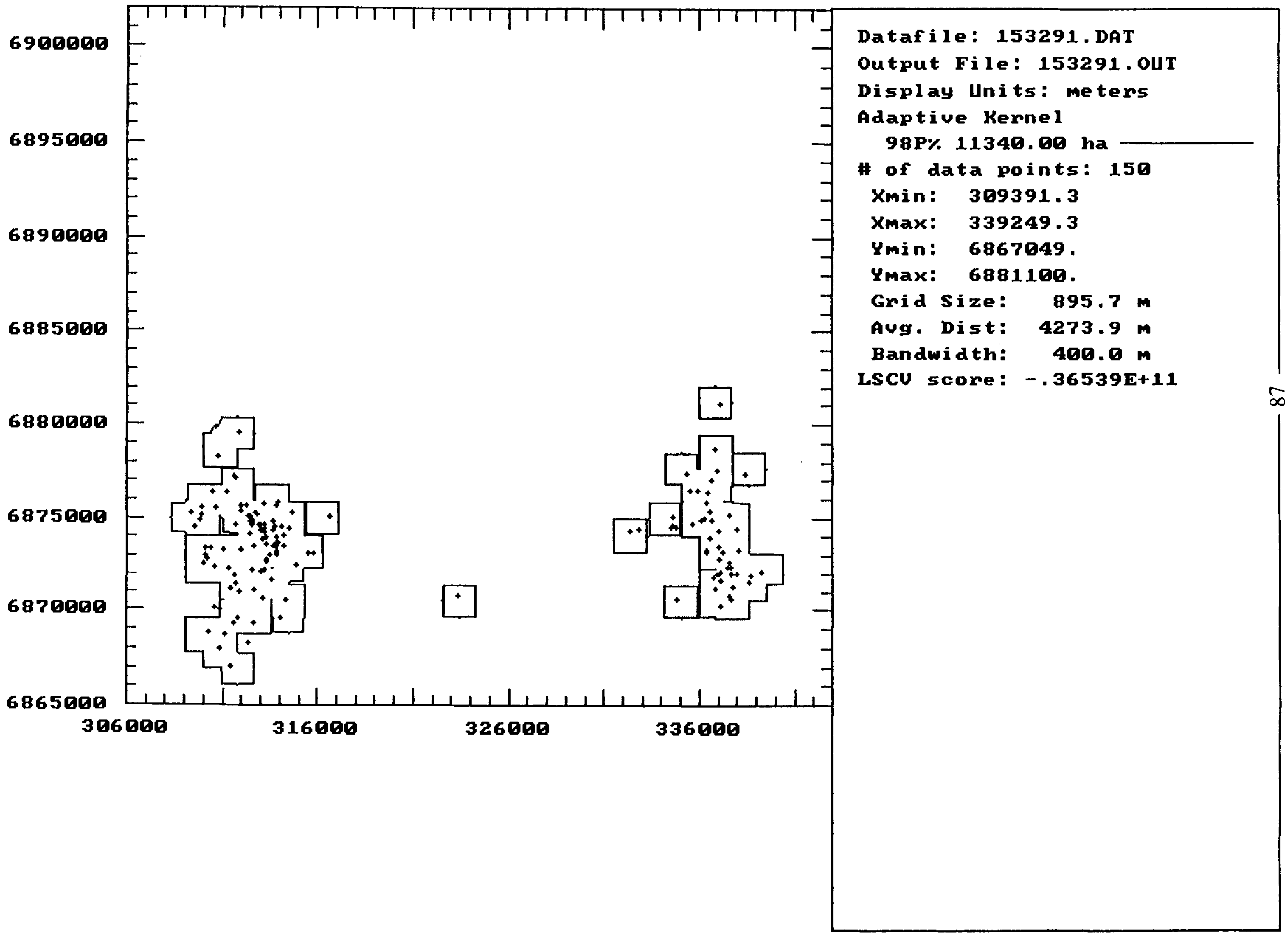


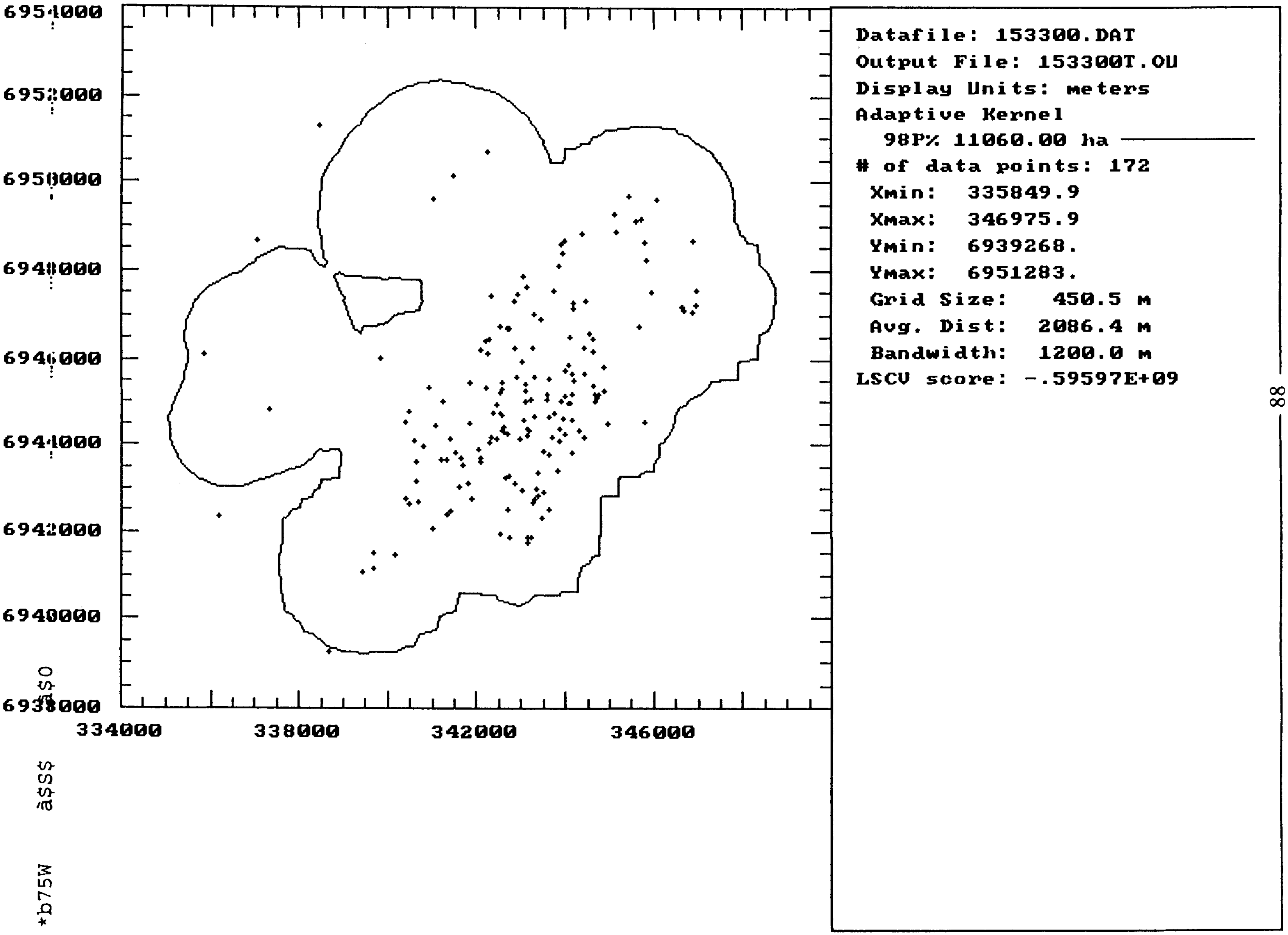
Datafile: 152243.DAT
Output File: 152243.OUT
Display Units: meters
Adaptive Kernel
98P% 4220.000 ha
# of data points: 107
Xmin: 352474.1
Xmax: 365293.8
Ymin: 6962428.
Ymax: 6968628.
Grid Size: 384.5 m
Avg. Dist: 2344.6 m
Bandwidth: 700.0 m
LSCV score: -.16877E+10


Datafile: 153252.DAT
Output File: 153252.OUT
Display Units: meters
Adaptive Kernel
98P% 52960.00 ha
# of data points: 160
Xmin: 308981.1
Xmax: 339819.0
Ymin: 6842589.
Ymax: 6882893.
Grid Size: 1209.1 m
Avg. Dist: 5780.4 m
Bandwidth: 2600.0 m
LSCV score: -.43002E+11
6886000
6876000
6866000
6856000
6846000
6836000
303000
323000
343000

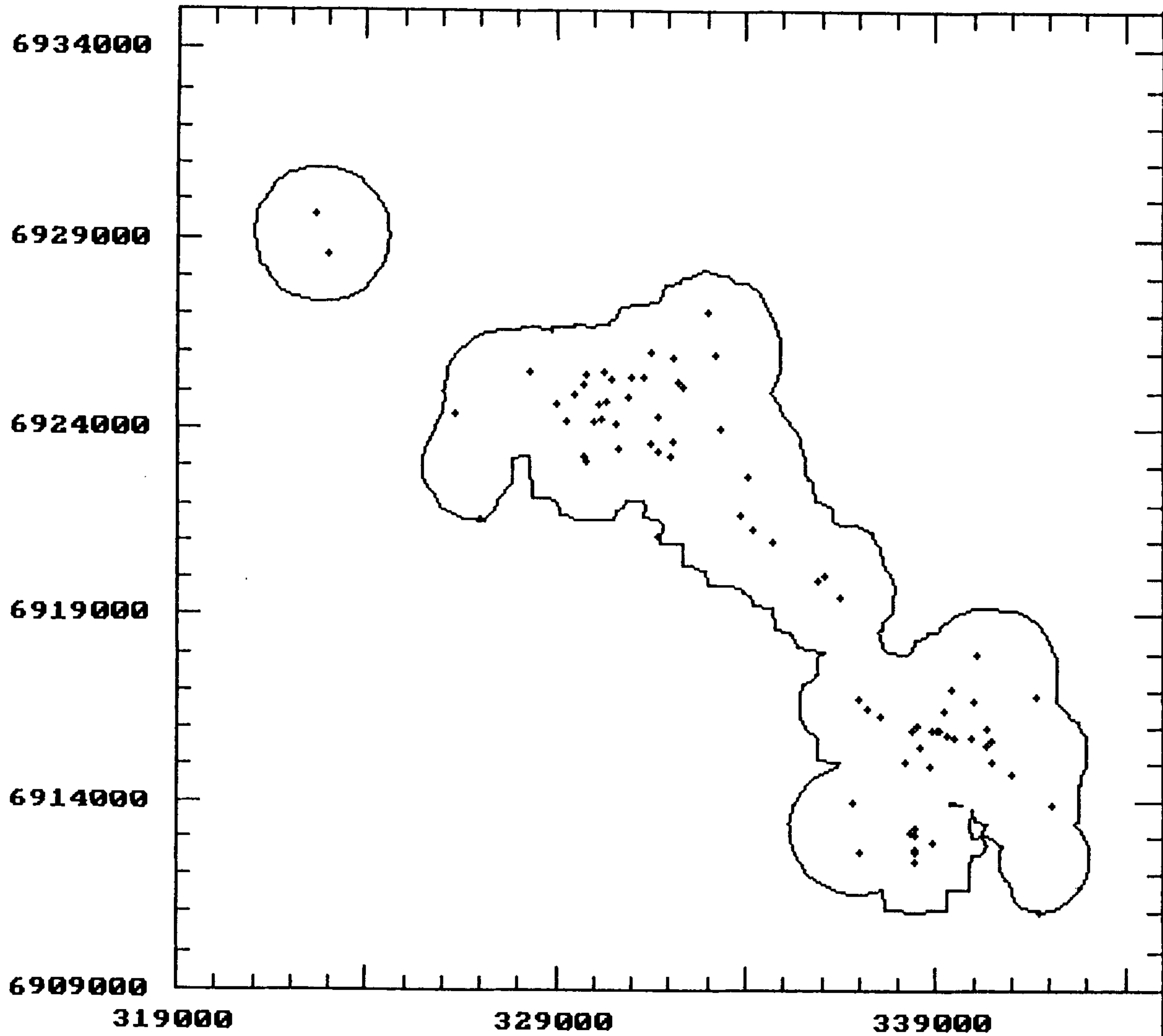

6911000
6906000
6901000
6896000
6891000
6886000
6881000
6876000
6871000
6866000
332000
342000
352000
362000
372000
Datafile: 153260.DAT
Output File: 153260.OUT
Display Units: meters
Adaptive Kernel
98P% 16140.00 ha
# of data points: 204
Xmin: 334309.4
Xmax: 357514.9
Ymin: 6869249.
Ymax: 6908305.
Grid Size: 1171.6 m
Avg. Dist: 4755.3 m
Bandwidth: 700.0 m
LSCV score: .14898E+12


6923000
6918000
6913000
6908000
6903000
6898000
6893000
6888000
6883000
6878000
302000
312000
322000
332000
342000
Datafile: 153263.DAT
Output File: 153263.OUT
Display Units: meters
Adaptive Kernel
98P% 26040.00 ha
# of data points: 106
Xmin: 305822.3
Xmax: 345236.0
Ymin: 6879945.
Ymax: 6904880.
Grid Size: 1182.4 m
Avg. Dist: 6762.1 m
Bandwidth: 1600.0 m
LSCV score: -.18771E+11

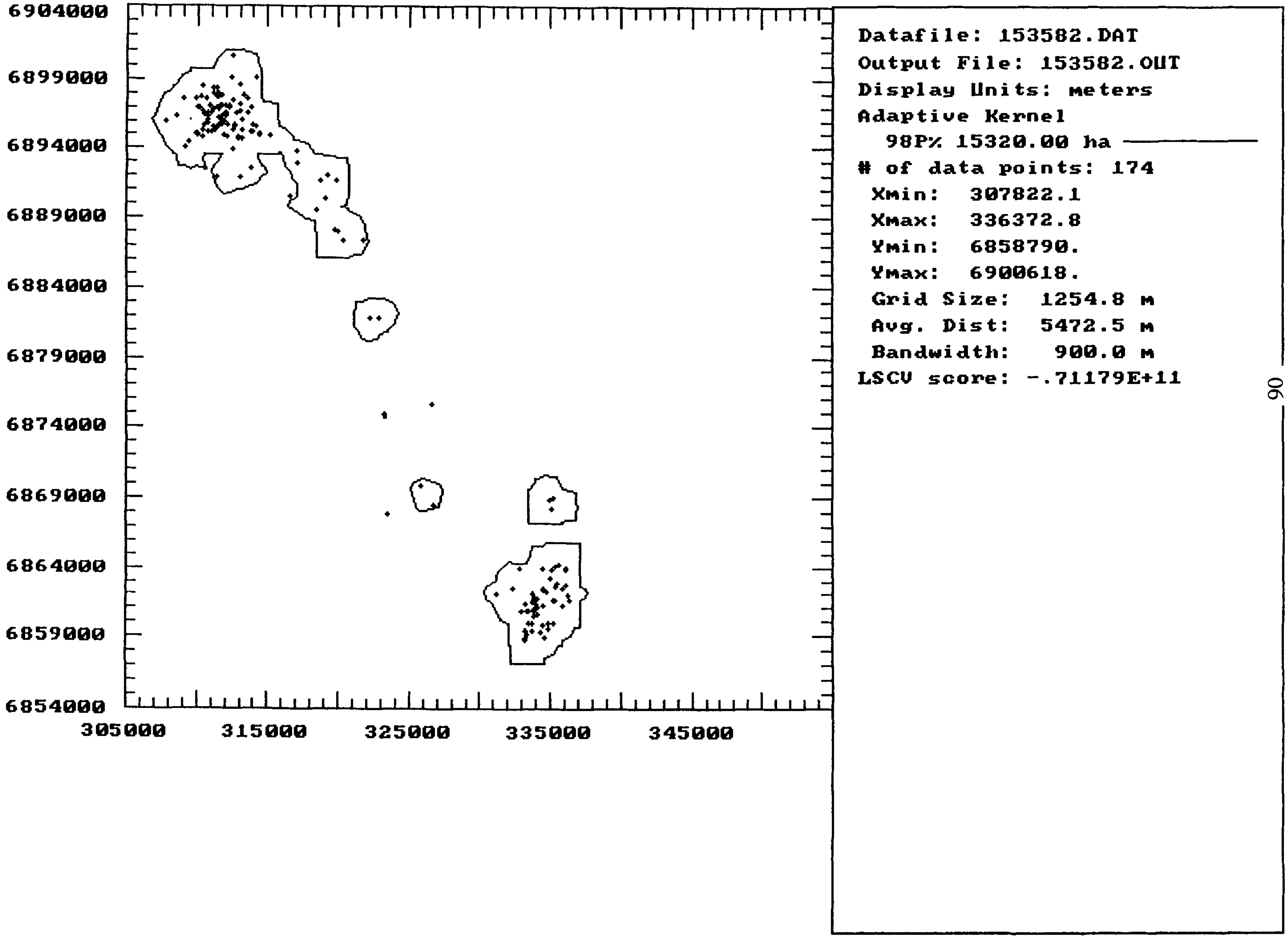

6900000
6895000
6890000
6885000
6880000
6875000
6870000
6865000
306000
316000
326000
336000
Datafile: 153291.DAT
Output File: 153291.OUT
Display Units: meters
Adaptive Kernel
98P% 11340.00 ha
# of data points: 150
Xmin: 309391.3
Xmax: 339249.3
Ymin: 6867049.
Ymax: 6881100.
Grid Size: 895.7 m
Avg. Dist: 4273.9 m
Bandwidth: 400.0 m
LSCV score: -.36539E+11

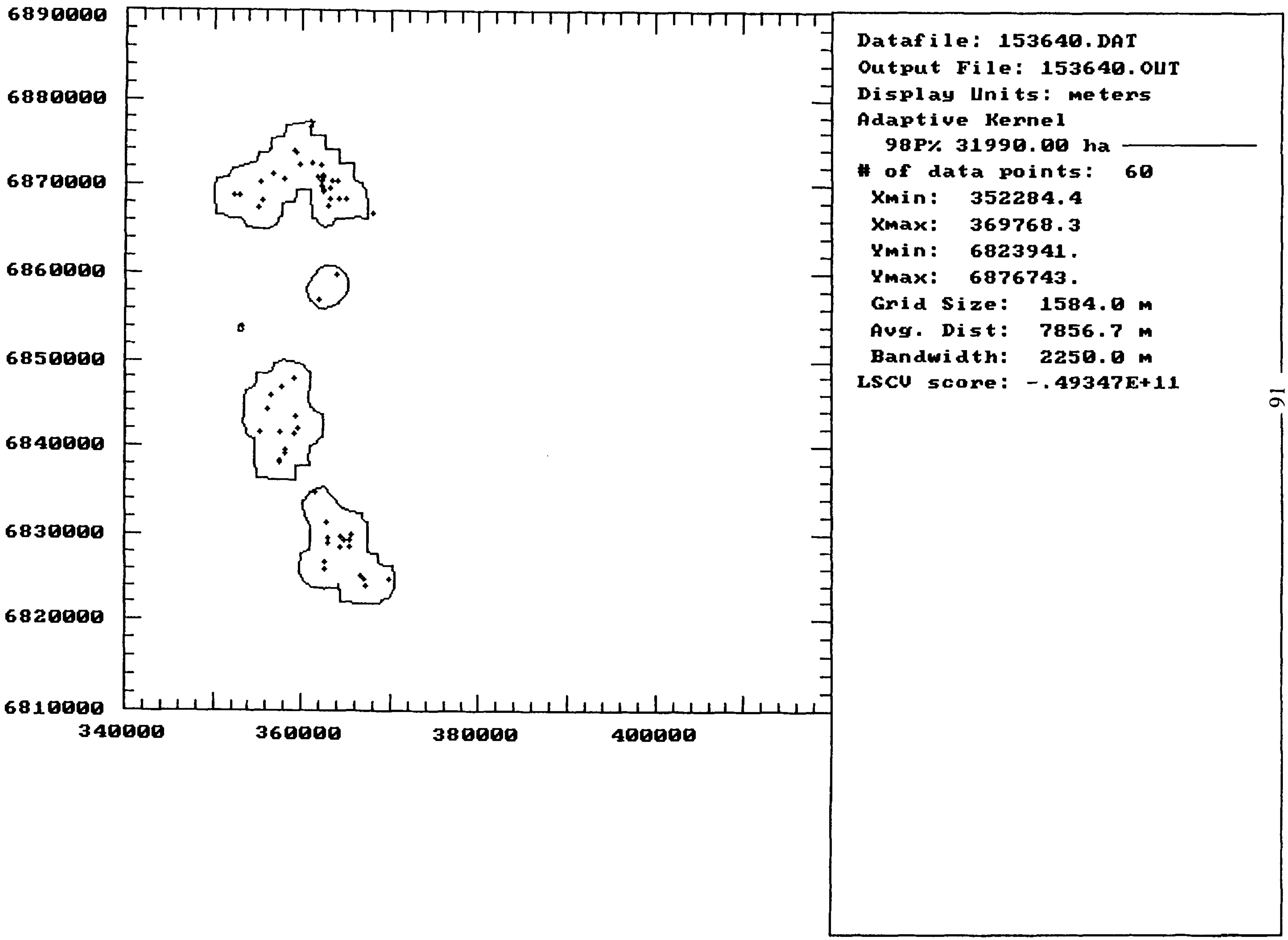


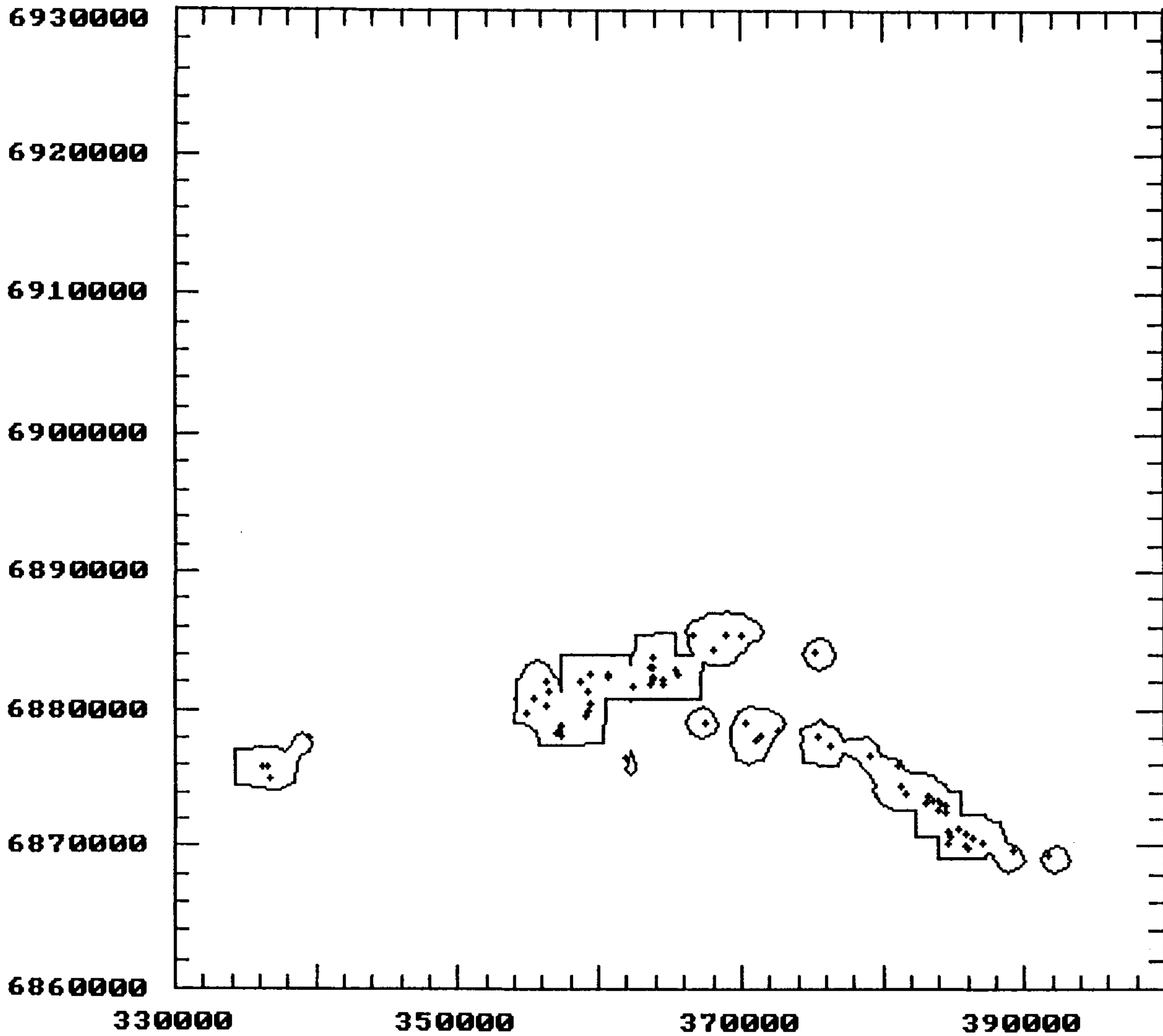
6954000
6952000
6950000
6948000
6946000
6944000
6942000
6940000
6938000
334000
338000
342000
346000
Datafile: 153300.DAT
Output File: 153300T.OU
Display Units: meters
Adaptive Kernel
98P% 11060.00 ha
# of data points: 172
Xmin: 335849.9
Xmax: 346975.9
Ymin: 6939268.
Ymax: 6951283.
Grid Size: 450.5 m
Avg. Dist: 2086.4 m
Bandwidth: 1200.0 m
LSCV score: -.59597E+09



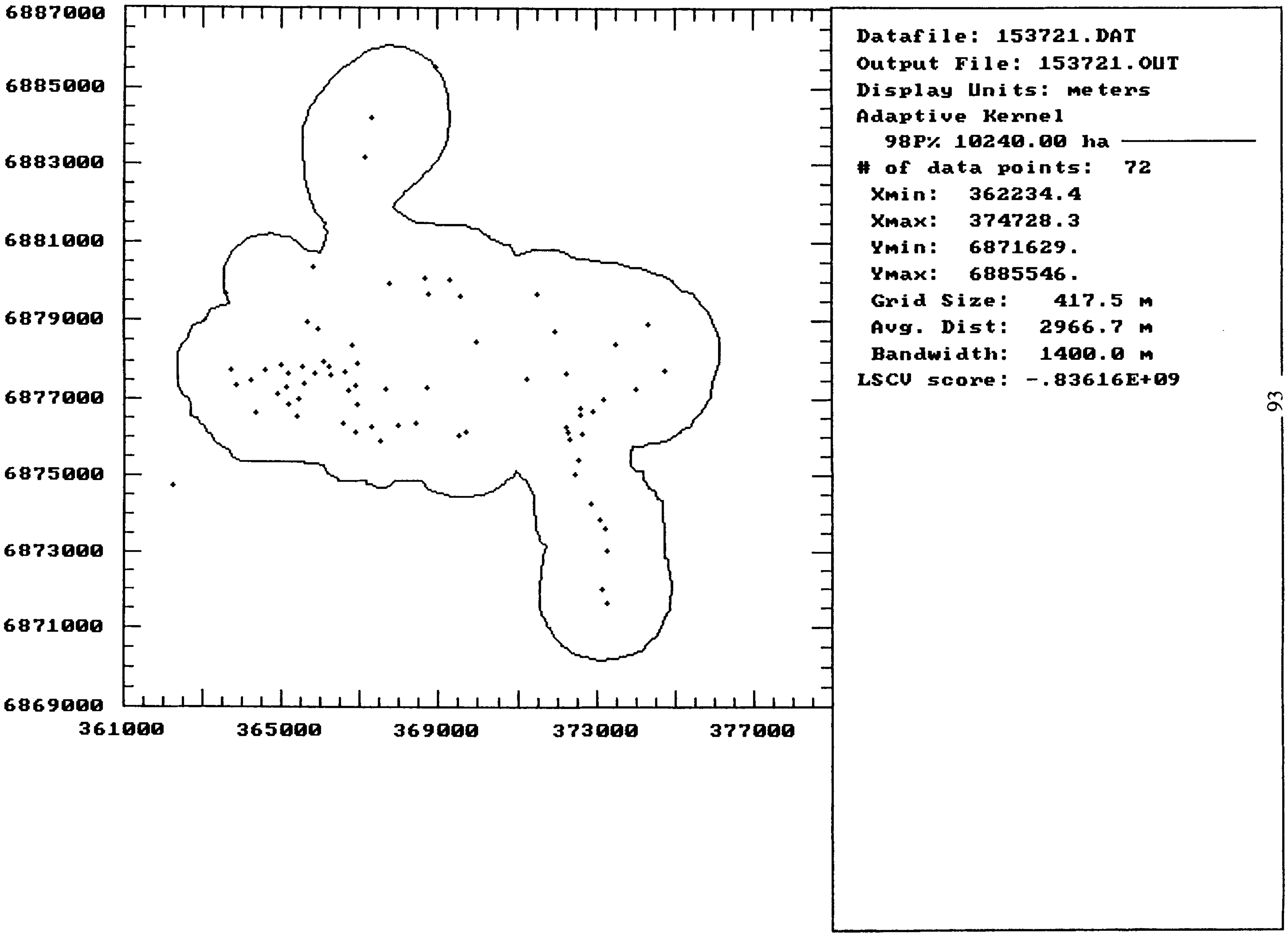
Datafile: 153311.DAT
Output File: 153311.OUT
Display Units: meters
Adaptive Kernel
98P% 12350.00 ha
# of data points: 78
Xmin: 322672.6
Xmax: 342057.4
Ymin: 6911013.
Ymax: 6929655.
Grid Size: 581.5 m
Avg. Dist: 3639.1 m
Bandwidth: 1350.0 m
LSCV score: -.26173E+10


Datafile: 153582.DAT
Output File: 153582.OUT
Display Units: meters
Adaptive Kernel
98P% 15320.00 ha
# of data points: 174
Xmin: 307822.1
Xmax: 336372.8
Ymin: 6858790.
Ymax: 6900618.
Grid Size: 1254.8 m
Avg. Dist: 5472.5 m
Bandwidth: 900.0 m
LSCV score: -.71179E+11
6904000
6899000
6894000
6889000
6884000
6879000
6874000
6869000
6864000
6859000
6854000
305000
315000
325000
335000
345000

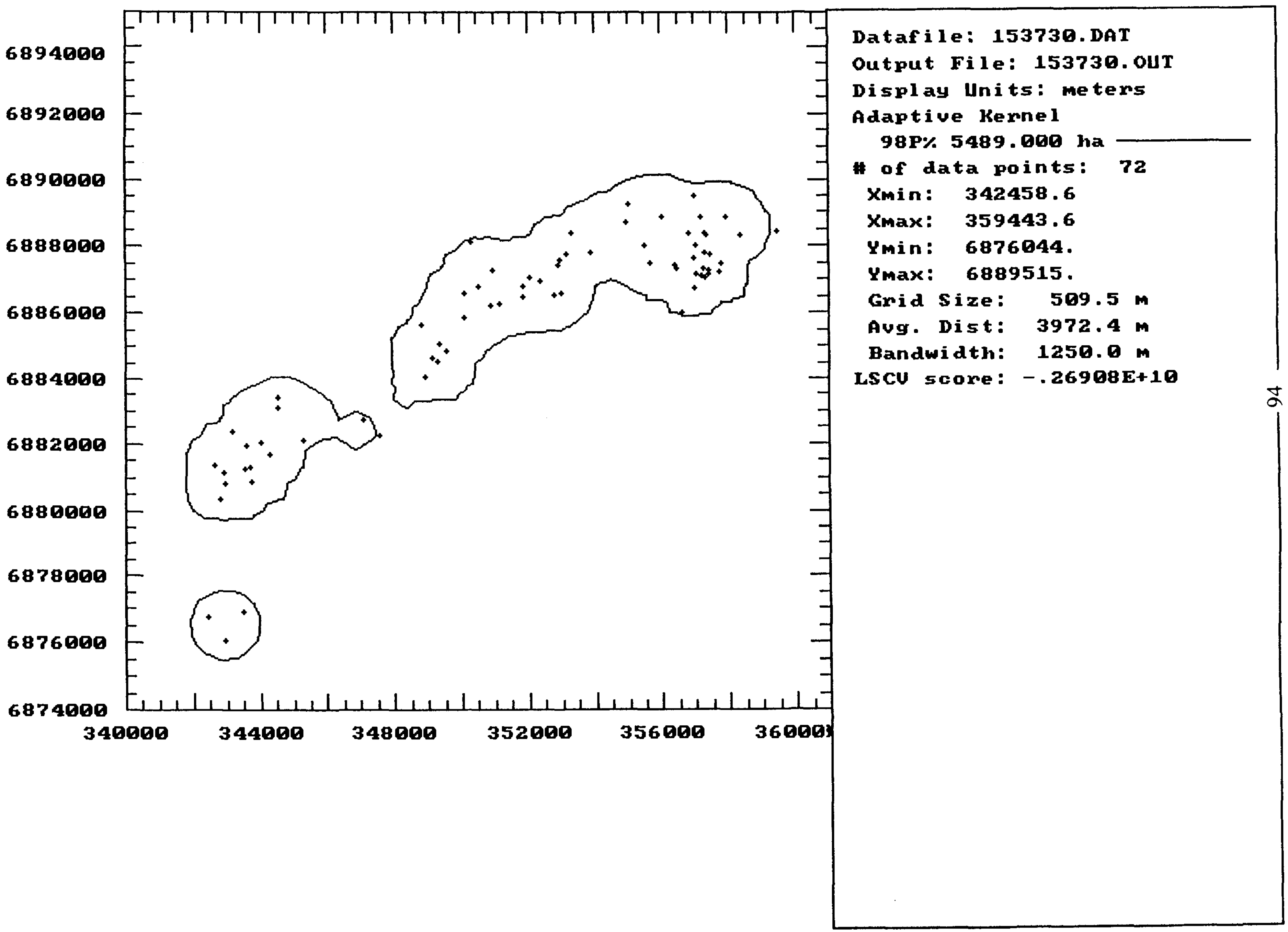

6890000
6880000
6870000
6860000
6850000
6840000
6830000
6820000
6810000
340000
360000
380000
400000
Datafile: 153640.DAT
Output File: 153640.OUT
Display Units: meters
Adaptive Kernel
98P% 31990.00 ha
# of data points: 60
Xmin: 352284.4
Xmax: 369768.3
Ymin: 6823941.
Ymax: 6876743.
Grid Size: 1584.0 m
Avg. Dist: 7856.7 m
Bandwidth: 2250.0 m
LSCV score: -.49347E+11

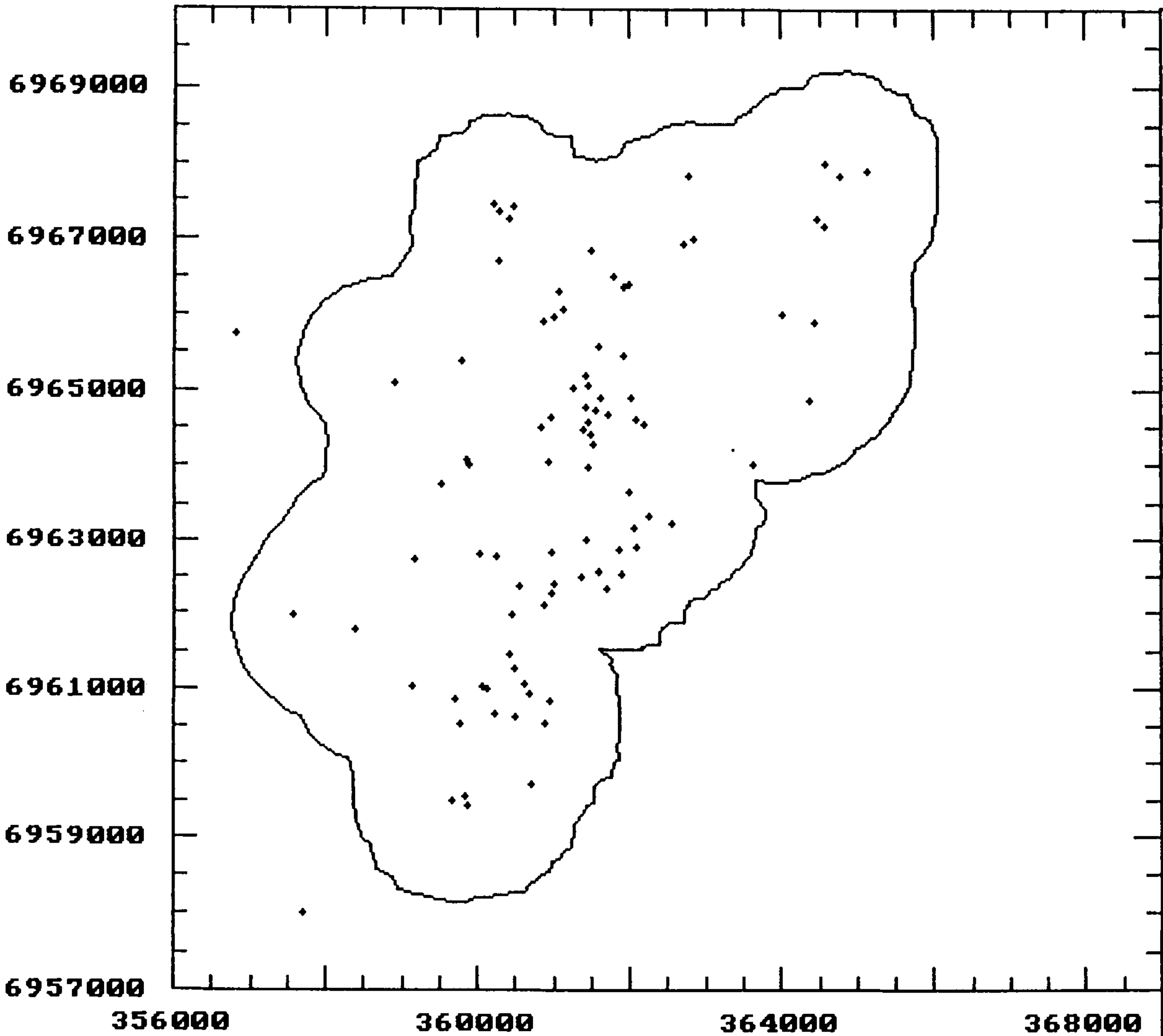


Datafile: 153761.DAT
Output File: 153761.OUT
Display Units: meters
Adaptive Kernel
98P% 16110.00 ha
# of data points: 68
Xmin: 336213.4
Xmax: 391725.2
Ymin: 6869390.
Ymax: 6885410.
Grid Size: 1665.3 m
Avg. Dist: 9768.1 m
Bandwidth: 1050.0 m
LSCV score: -.78090E+11



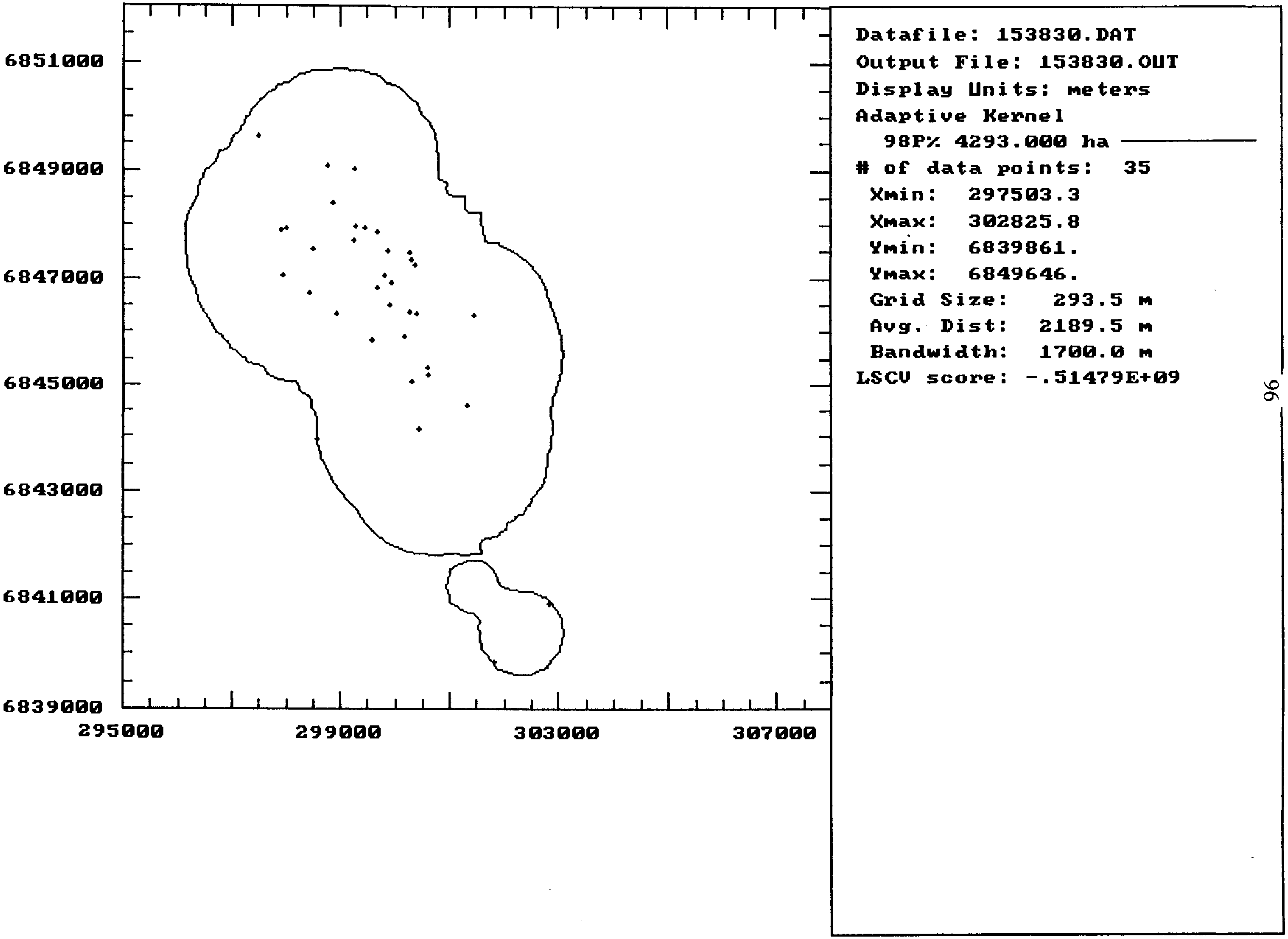
Datafile: 153721.DAT
Output File: 153721.OUT
Display Units: meters
Adaptive Kernel
98P% 10240.00 ha
# of data points: 72
Xmin: 362234.4
Xmax: 374728.3
Ymin: 6871629.
Ymax: 6885546.
Grid Size: 417.5 m
Avg. Dist: 2966.7 m
Bandwidth: 1400.0 m
LSCV score: -.83616E+09
6887000
6885000
6883000
6881000
6879000
6877000
6875000
6873000
6871000
6869000
361000
365000
369000
373000
377000

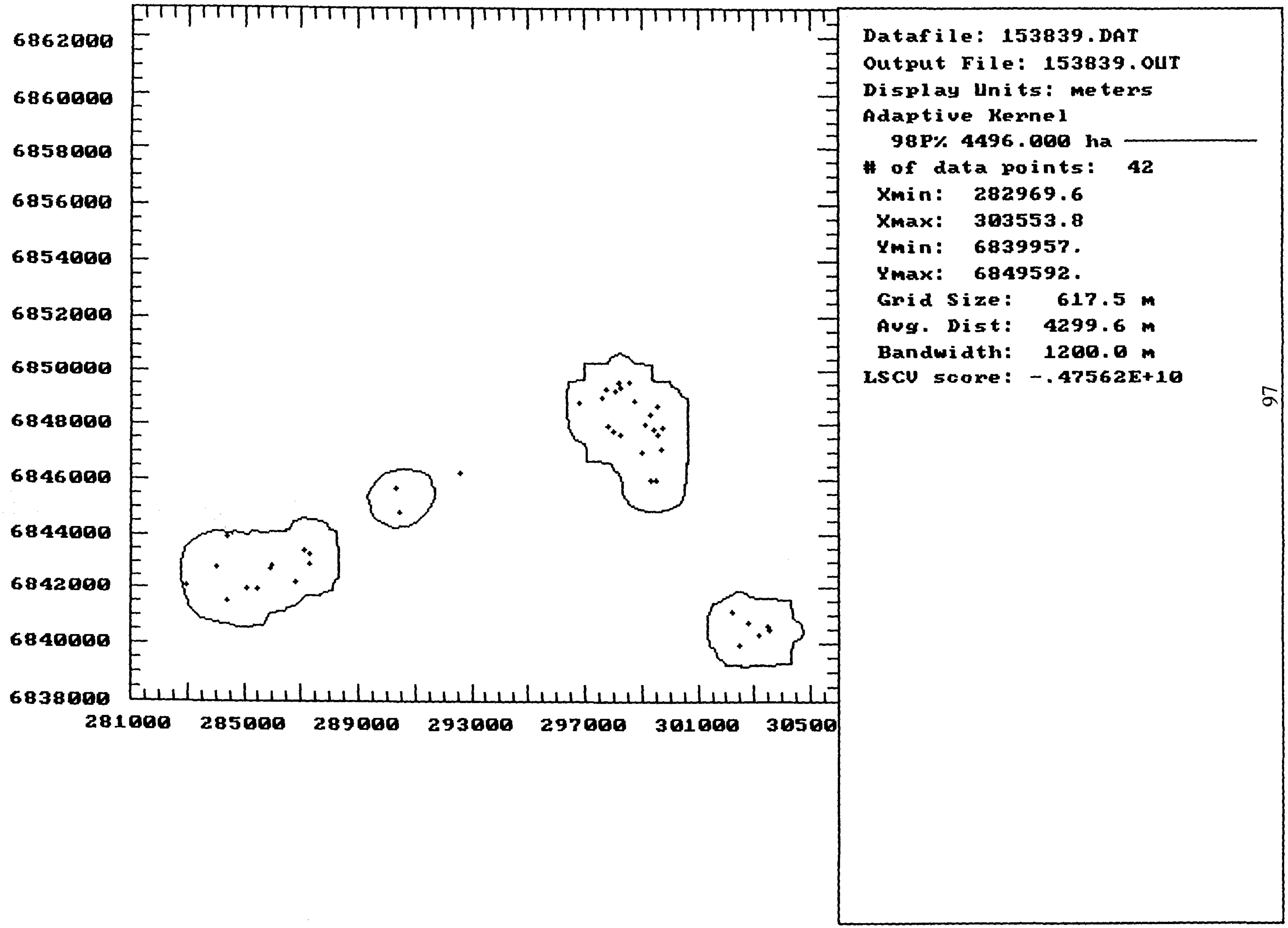

Datafile: 153730.DAT
Output File: 153730.OUT
Display Units: meters
Adaptive Kernel
98P% 5489.000 ha
# of data points: 72
Xmin: 342458.6
Xmax: 359443.6
Ymin: 6876044.
Ymax: 6889515.
Grid Size: 509.5 m
Avg. Dist: 3972.4 m
Bandwidth: 1250.0 m
LSCV score: -.26908E+10
6894000
6892000
6890000
6888000
6886000
6884000
6882000
6880000
6878000
6876000
6874000
340000
344000
348000
352000
356000



Datafile: 153813.DAT
Output File: 153813L.OU
Display Units: meters
Adaptive Kernel
98P% 6045.000 ha
# of data points: 91
Xmin: 356816.7
Xmax: 365127.6
Ymin: 6958015.
Ymax: 6967999.
Grid Size: 299.5 m
Avg. Dist: 1788.0 m
Bandwidth: 1100.0 m
LSCV score: -.38974E+09

95


Datafile: 153830.DAT
Output File: 153830.OUT
Display Units: meters
Adaptive Kernel
98P% 4293.000 ha
# of data points: 35
Xmin: 297503.3
Xmax: 302825.8
Ymin: 6839861.
Ymax: 6849646.
Grid Size: 293.5 m
Avg. Dist: 2189.5 m
Bandwidth: 1700.0 m
LSCV score: -.51479E+09
6851000
6849000
6847000
6845000
6843000
6841000
6839000
295000
299000
303000
307000


6862000
6860000
6858000
6856000
6854000
6852000
6850000
6848000
6846000
6844000
6842000
6840000
6838000
281000
285000
289000
293000
297000
301000
30500
Datafile: 153839.DAT
Output File: 153839.OUT
Display Units: meters
Adaptive Kernel
98P% 4496.000 ha
# of data points: 42
Xmin: 282969.6
Xmax: 303553.8
Ymin: 6839957.
Ymax: 6849592.
Grid Size: 617.5 m
Avg. Dist: 4299.6 m
Bandwidth: 1200.0 m
LSCV score: -.47562E+10

APPENDIX D. Summary of results of trial and error process used in selecting bandwidth for use in CALHOME adaptive kernel home range analysis of moose point-location data.

D:\CALHOME\BANDSUMM.WK1

MOOSE ID	BAND WIDTH	P%	CELL SIZE	LSCV SCORE	RANGE SIZE (HA)	(SQ MI)	NO. POLYS/	>2 PTS	MINIMUM LVSC
153240	1300	98	-50	-0.26153 E+09	3443	13.29	1	0	***
153300	1200	98	-50	-0.59597 E+09	11060	42.70	1	0	***
153311	1350	98	-50	-0.26173 E+09	12350	47.68	1	0	***
153102	1200	97	-50	-0.46671 E+10	8022	30.97	1	0	***
153813	1150	98	-50	-0.38974 E+09	6170	23.82	1	0	***
153021	2300	98	-44	-0.21148 E+09	13300	51.35	1	0	***
150200	1800	98	-50	-0.43466 E+11	15000	57.91	1	0	***
152750	2200	98	-50	-0.22665 E+10	16190	62.50	1	0	***
152045	1350	98	-50	-0.88652 E+09	9085	35.07	1	0	***
152243	700	98	-50	-0.16877 E+10	4220	16.29	1	0	***
153620	1300	98	-50	-0.11941 E+10	11440	44.16	1	0	***
153100	2450	98	-50	-0.13055 E+12	39630	153.0	1	0	***
153721	1400	98	-50	-0.83616 E+09	10240	39.53	1	0	***
153240	1300	98	-50	-0.26153 E+09	3379	13.04	1	0	***
152980	1250	98	-50	-0.20538 E+10	5106	19.71	1	0	***
153110	1600	98	-50	-0.25636 E+10	20520	79.22	1	0	***
153830	1700	98	-50	-0.51479 E+09	4293	16.57	1	0	***
153140	1850	98	-50	-0.49747 E+10	20970	80.96	2	0	***
152175	1200	98	-50	-0.10162 E+11	14160	54.67	2	0	***
153123	1250	98	-50	-0.33348 E+10	15330	59.18	2	0	***
153291	400	98	-50	-0.36539 E+11	11340	43.78	2	0	***
153122	2250	98	-50	-0.59943 E+11	17280	66.71	2	0	***
5281079	2200	98	-50	-0.48313 E+11	15560	60.07	2	0	***
152156	1650	98	-50	-0.66471 E+11	28630	110.5	2	0	***
153252	2600	98	-50	-0.43002 E+11	52960	204.4	2	0	***
152243	1050	98	-50	-0.13272 E+10	4630	17.87	2	0	
152950	1800	98	-50	-0.30578 E+11	19920	76.91	2	0	***
153242	2300	97	-50	-0.16265 E+11	16560	63.93	2	0	***
5281018	3850	98	-50	-0.19971 E+11	26550	102.5	2	0	***
152145	850	98	-50	-0.76503 E+09	3554	13.72	2	0	***
153730	1250	98	-50	-0.26908 E+10	5489	21.19	3	0	***
153640	2250	98	-50	-0.49347 E+11	31990	123.5	3	0	***
153230	950	98	-50	-0.25581 E+11	15250	58.88	3	0	***
152145	450	98	600	-0.50037 E+09	2395	9.247	3	0	***
153215	1600	98	-50	-0.53523 E+11	15610	60.27	3	0	***
153582	900	98	-50	-0.71179 E+11	15320	59.15	3	0	***
153031	2500	98	-50	-0.94986 E+11	40970	158.1	3	0	***
153070	1450	98	-49	-0.13166 E+10	9761	37.68	3	0	***
153263	1600	98	-50	-0.18771 E+11	26040	100.5	3	0	***
153070	1700	98	-46	-0.14593 E+10	14070	54.32	3	0	***
153170	750	98	-50	-0.11447 E+11	10120	39.07	3	0	***
153211	700	98	-50	-0.71032 E+10	7676	29.63	4	0	***

153130	1100	98	-50	-0.42834	E+11	10120	39.07	4	0	***
153761	1050	98	-50	-0.7809	E+11	16110	62.20	4	0	***
1522105	1200	98	-50	-0.70279	E+11	9019	34.82	4	0	***
152191	1100	98	-50	-0.26905	E+10	8319	32.11	4	0	***
152330	1500	98	-45	-0.22612	E+10	14460	55.83	4	0	***
153081	1000	98	-46	-0.25026	E+10	5479	21.15	4	0	***
153260	700	98	-50	-0.14898	E+12	16140	62.31	4	0	***
153230	900	98	-50	-0.25467	E+11	14330	55.32	5	0	***
152075	1200	98	-50	-0.3648	E+10	6420	24.78	5	0	***
152036	750	98	-50	-0.11198	E+12	11320	43.70	5	0	***
152076	1000	98	-50	-0.23252	E+11	13450	51.93	7	0	***
153220	950	98	-50	-0.75914	E+12	29080	112.2	8	0	***

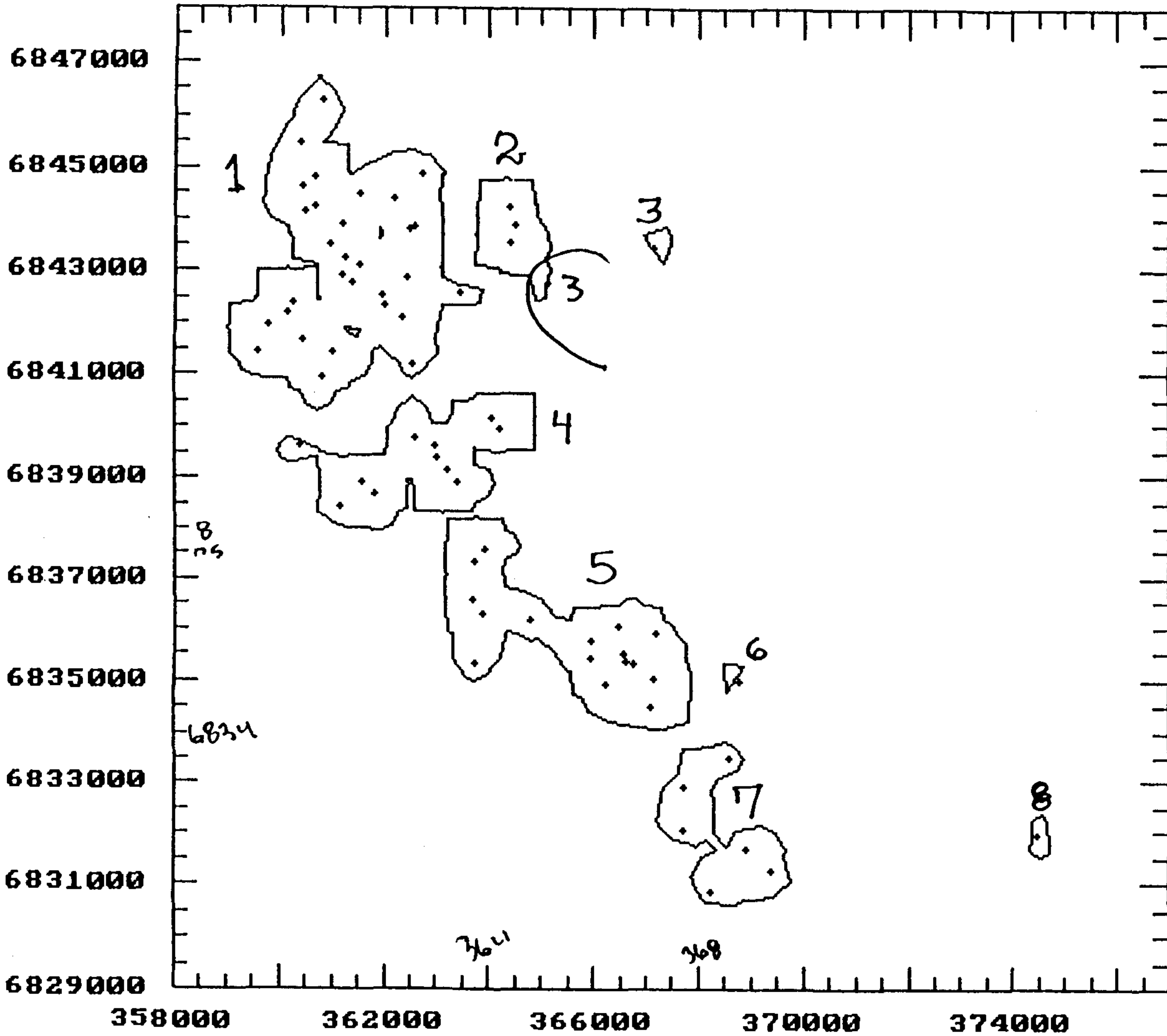
APPENDIX E. Sample of database file used in indentifying Julian day of point locations in numbered utilization distribution polygons of moose home ranges.

D:\CALHOME\5214539 COL 39 MOOSE NO. 152145 COL NO. 39

X_COORD	Y_COORD	OBS	CENTROID	DATE	SEASON	PERIOD	CYEAR	CJDAY	CENTROID	SY
314312.700000	6797319.000000	0	6	26-Feb-82		WINT	8182	296	6	2
310713.300000	6800037.000000	1	4	03-Mar-82	W		8182	301	4	2
311474.800000	6800416.000000	2	5	24-Mar-82			8182	322	5	2
311061.900000	6801417.000000	3	4	05-Apr-82			8182	334	4	2
313798.000000	6800214.000000	4	5	16-Apr-82			8182	345	5	2
313720.600000	6800317.000000	5	5	26-Apr-82			8182	355	5	2
313643.100000	6800788.000000	6	5	10-May-82	C		8283	4	5	3
313490.500000	6800723.000000	7	5	17-May-82	C	CALF	8283	11	5	3
313474.400000	6800123.000000	8	5	26-May-82	C	CALF	8283	20	5	3
311955.200000	6799226.000000	9	5	08-Jun-82	C		8283	33	5	3
311927.900000	6799481.000000	10	5	17-Jun-82			8283	42	5	3
314196.700000	6798226.000000	11	6	29-Jun-82			8283	54	6	3
311798.400000	6800713.000000	12	5	09-Jul-82	S		8283	64	5	3
311949.100000	6800968.000000	13	5	27-Jul-82	S	SUMM	8283	82	5	3
312230.900000	6800695.000000	14	5	06-Aug-82	S		8283	92	5	3
312529.400000	6799867.000000	15	5	16-Aug-82			8283	102	5	3
311353.400000	6800361.000000	16	5	31-Aug-82	H		8283	117	5	3
311060.400000	6799993.000000	17	4	23-Sep-82	H	RUT	8283	140	4	3
315037.700000	6798593.000000	18	6	05-Oct-82	R	RUT	8283	152	6	3
311036.900000	6799299.000000	19	4	20-Oct-82	P		8283	167	4	3
311276.300000	6799191.000000	20	4	10-Nov-82	V	PRUT	8283	188	4	3
310207.800000	6800615.000000	21	4	13-Dec-82	V		8283	221	4	3
311112.800000	6801323.000000	22	4	04-Jan-83			8283	243	4	3
310493.100000	6800876.000000	23	4	21-Jan-83	W		8283	260	4	3
310009.100000	6801366.000000	24	4	04-Feb-83			8283	274	4	3
312028.300000	6798054.000000	25	5	16-Feb-83		WINT	8283	286	5	3
309890.800000	6800510.000000	26	4	04-Mar-83	W		8283	302	4	3
311427.700000	6800078.000000	27	5	18-Mar-83	W		8283	316	5	3
313708.900000	6800206.000000	28	5	01-Apr-83			8283	330	5	3
313655.300000	6800075.000000	29	5	20-Apr-83			8283	349	5	3
313442.600000	6800160.000000	30	5	04-May-83			8283	363	5	3
313500.100000	6800730.000000	31	5	11-May-83	C		8384	5	5	4
313338.600000	6800429.000000	32	5	17-May-83	C	CALF	8384	11	5	4
312655.700000	6798189.000000	33	5	24-May-83	C	CALF	8384	18	5	4
312527.600000	6799279.000000	34	5	31-May-83	C	CALF	8384	25	5	4
311718.600000	6799369.000000	35	5	07-Jun-83	C		8384	32	5	4
312651.500000	6799311.000000	36	5	14-Jun-83	C		8384	39	5	4
311667.300000	6800683.000000	37	5	21-Jun-83			8384	46	5	4
312381.600000	6797895.000000	38	5	28-Jun-83			8384	53	5	4
313693.400000	6799129.000000	39	6	02-Aug-83	S	SUMM	8384	88	6	4
311542.000000	6800037.000000	40	5	27-Aug-83	H		8384	113	5	4
313829.100000	6801536.000000	41	5	06-Sep-83	H		8384	123	5	4
313516.100000	6801816.000000	42	5	19-Sep-83	H	RUT	8384	136	5	4
310801.800000	6800052.000000	43	4	03-Oct-83	R	RUT	8384	150	4	4
310418.500000	6800652.000000	44	4	21-Oct-83	P		8384	168	4	4
309899.400000	6802606.000000	45	3	09-Nov-83	V	PRUT	8384	187	3	4

309976.900000	6801137.000000	46	4	25-Nov-83	V		8384	203	4	4
310214.300000	6801166.000000	47	4	15-Dec-83	V		8384	223	4	4
309827.900000	6801156.000000	48	4	28-Dec-83			8384	236	4	4
310108.600000	6800883.000000	49	4	11-Jan-84			8384	250	4	4
307843.600000	6800934.000000	50	2	02-Feb-84			8384	272	2	4
310038.400000	6800416.000000	51	4	16-Feb-84		WINT	8384	286	4	4
310291.100000	6800813.000000	52	4	02-Mar-84	W		8384	301	4	4
307562.100000	6802187.000000	53	2	14-Mar-84	W		8384	313	2	4
313790.600000	6800757.000000	54	5	27-Mar-84			8384	326	5	4
313796.000000	6800421.000000	55	5	10-Apr-84			8384	340	5	4
313643.100000	6800280.000000	56	5	24-Apr-84			8384	354	5	4
313415.500000	6801343.000000	57	5	15-May-84	C		8485	9	5	5
312300.800000	6798837.000000	58	5	21-May-84	C	CALF	8485	15	5	5
312436.000000	6799498.000000	59	5	29-May-84	C	CALF	8485	23	5	5
312054.800000	6799604.000000	60	5	04-Jun-84	C	CALF	8485	29	5	5
312507.500000	6800188.000000	61	5	18-Jun-84			8485	43	5	5
311814.800000	6801275.000000	62	5	11-Jul-84	S		8485	66	5	5
312309.300000	6799482.000000	63	5	30-Jul-84	S	SUMM	8485	85	5	5
312103.400000	6800076.000000	64	5	10-Aug-84	S		8485	96	5	5
311079.200000	6799891.000000	65	4	05-Sep-84	H		8485	122	4	5
310997.700000	6799159.000000	66	4	26-Sep-84	H	RUT	8485	143	4	5
311109.300000	6799653.000000	67	4	17-Oct-84			8485	164	4	5
310342.600000	6801074.000000	68	4	06-Nov-84	P	PRUT	8485	184	4	5
310744.100000	6800177.000000	69	4	19-Nov-84	V		8485	197	4	5
310804.100000	6799234.000000	70	4	06-Dec-84	V		8485	214	4	5
310574.400000	6801036.000000	71	4	20-Dec-84	V		8485	228	4	5
306726.500000	6801078.000000	72	2	09-Jan-85			8485	248	2	5
306545.900000	6802059.000000	73	2	21-Jan-85	W		8485	260	2	5
307953.100000	6802044.000000	74	2	06-Feb-85			8485	276	2	5
308061.300000	6801910.000000	75	2	18-Feb-85		WINT	8485	288	2	5
307847.400000	6801259.000000	76	2	07-Mar-85	W		8485	305	2	5
304932.300000	6801265.000000	77	1	19-Mar-85	W		8485	317	1	5
307764.400000	6802577.000000	78	2	02-Apr-85			8485	331	2	5
308014.500000	6802145.000000	79	2	15-Apr-85			8485	344	2	5
306644.000000	6802534.000000	80	2	25-Apr-85			8485	354	2	5
307644.300000	6802714.000000	81	2	02-May-85			8485	361	2	5
313664.800000	6800897.000000	82	5	10-May-85	C		8586	4	5	6
313679.800000	6801179.000000	83	5	20-May-85	C	CALF	8586	14	5	6
313616.800000	6801063.000000	84	5	05-Jun-85	C	CALF	8586	30	5	6
313769.600000	6800642.000000	85	5	12-Jun-85	C		8586	37	5	6
313664.600000	6800719.000000	86	5	19-Jun-85			8586	44	5	6
313481.300000	6800739.000000	87	5	17-Mar-86	W		8586	315	5	6
311960.800000	6799474.000000	88	5	02-Jun-86	C	CALF	8687	27	5	7
311258.500000	6801467.000000	89	4	26-Sep-86	H	RUT	8687	143	4	7
307509.600000	6802986.000000	90	2	21-Dec-86	V		8687	229	2	7
306976.600000	6801294.000000	91	2	17-Jan-87			8687	256	2	7
307692.700000	6802839.000000	92	2	05-Feb-87			8687	275	2	7
306275.100000	6801070.000000	93	2	12-Mar-87	W		8687	310	2	7
305579.000000	6800625.000000	94	2	23-Mar-87			8687	321	2	7

APPENDIX F. Plots of moose home ranges with multiple utilization distribution polygons.

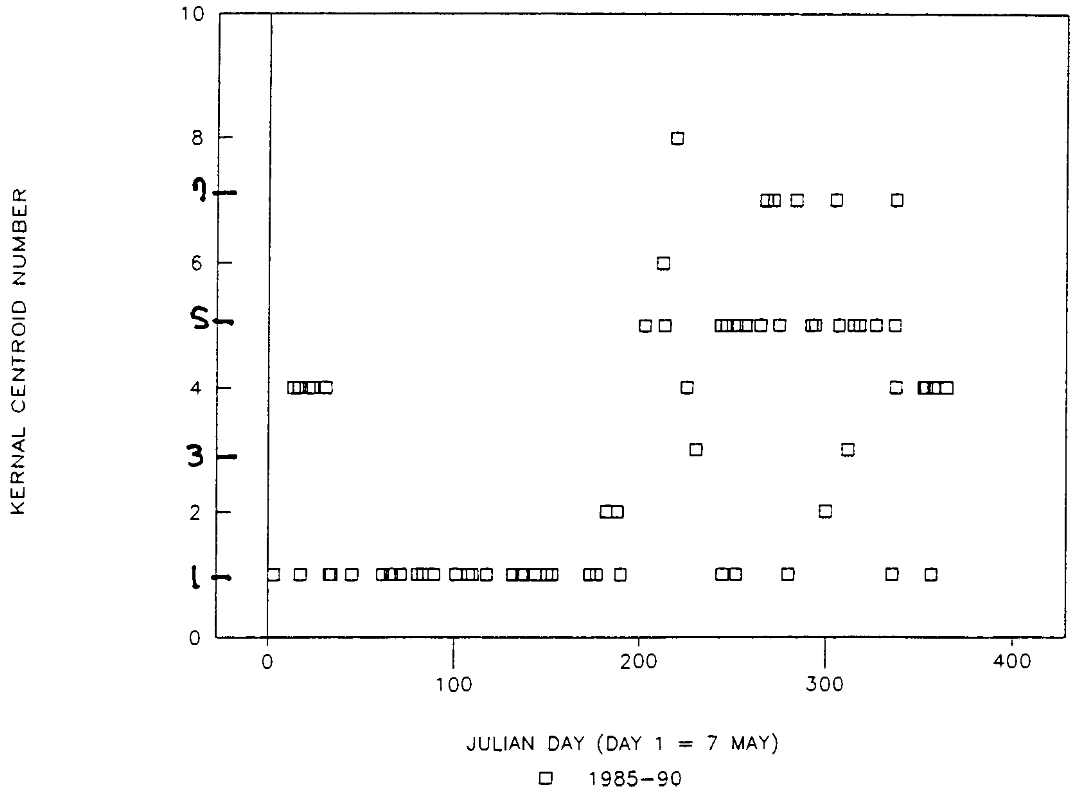


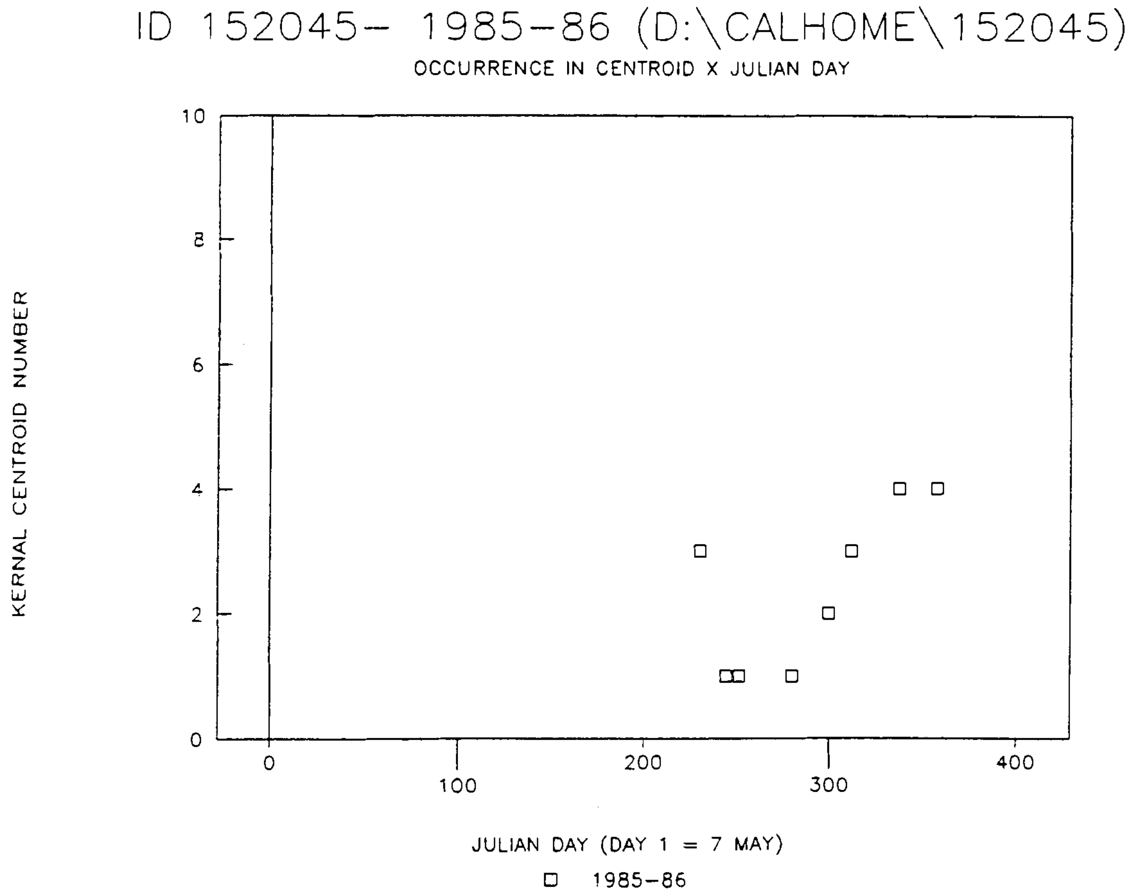
Datafile: 152045.DAT
Output File: 152045.OUT
Display Units: meters
Adaptive Kernel
98P% 3921.000 ha
# of data points: 70
Xmin: 359596.3
Xmax: 374480.6
Ymin: 6830853.
Ymax: 6846299.
Grid Size: 600.0 m
Avg. Dist: 3451.2 m
Bandwidth: 650.0 m
LSCV score: -.14464E+09

Out liers
3, 6, 8

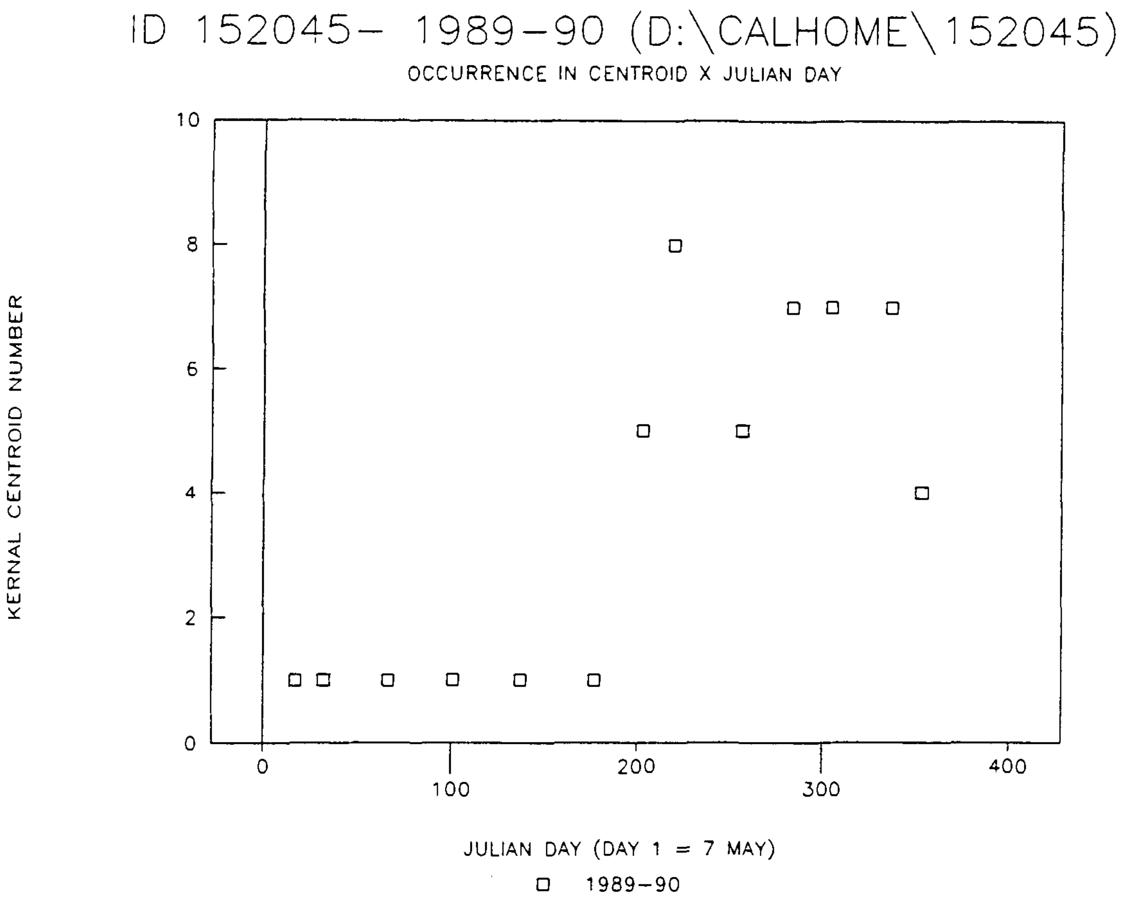
ID 152045- 1985-90 (D:\CALHOME\152045)

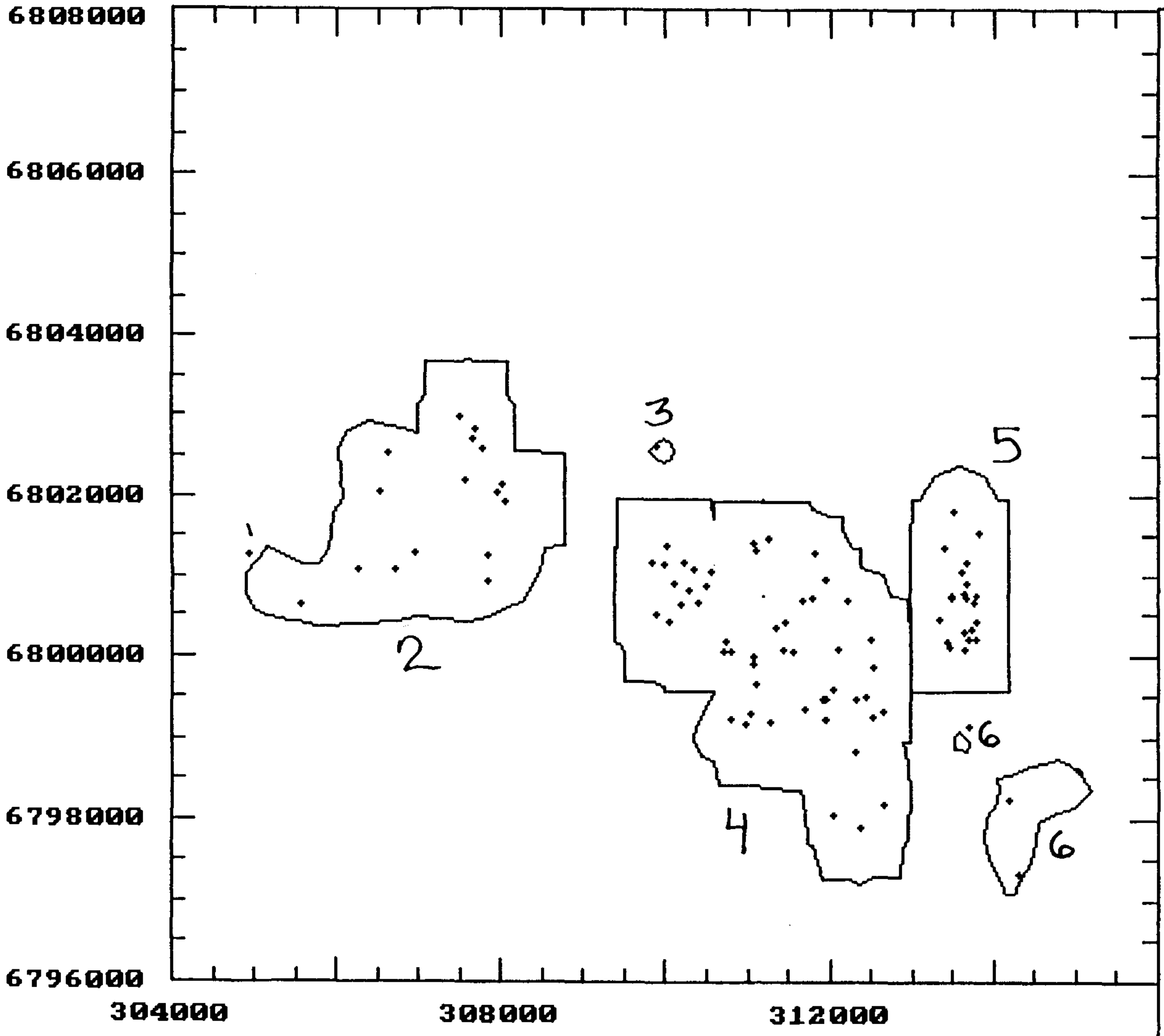
OCCURRENCE IN CENTROID X JULIAN DAY





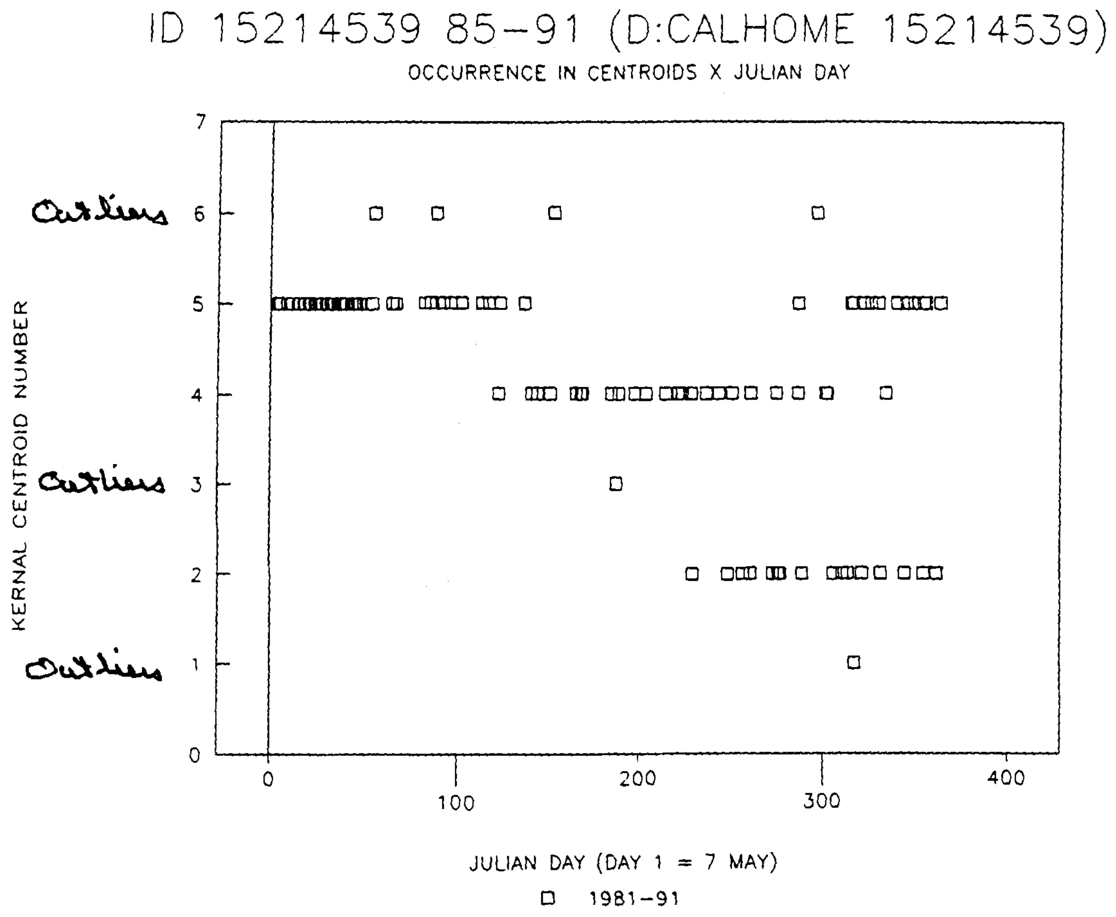
ID 152045– 1985–86 (D:\CALHOME\152045)
OCCURRENCE IN CENTROID X JULIAN DAY
KERNAL CENTROID NUMBER
10
8
6
4
2
0
0
100
200
300
400
JULIAN DAY (DAY 1 = 7 MAY)
1985–86

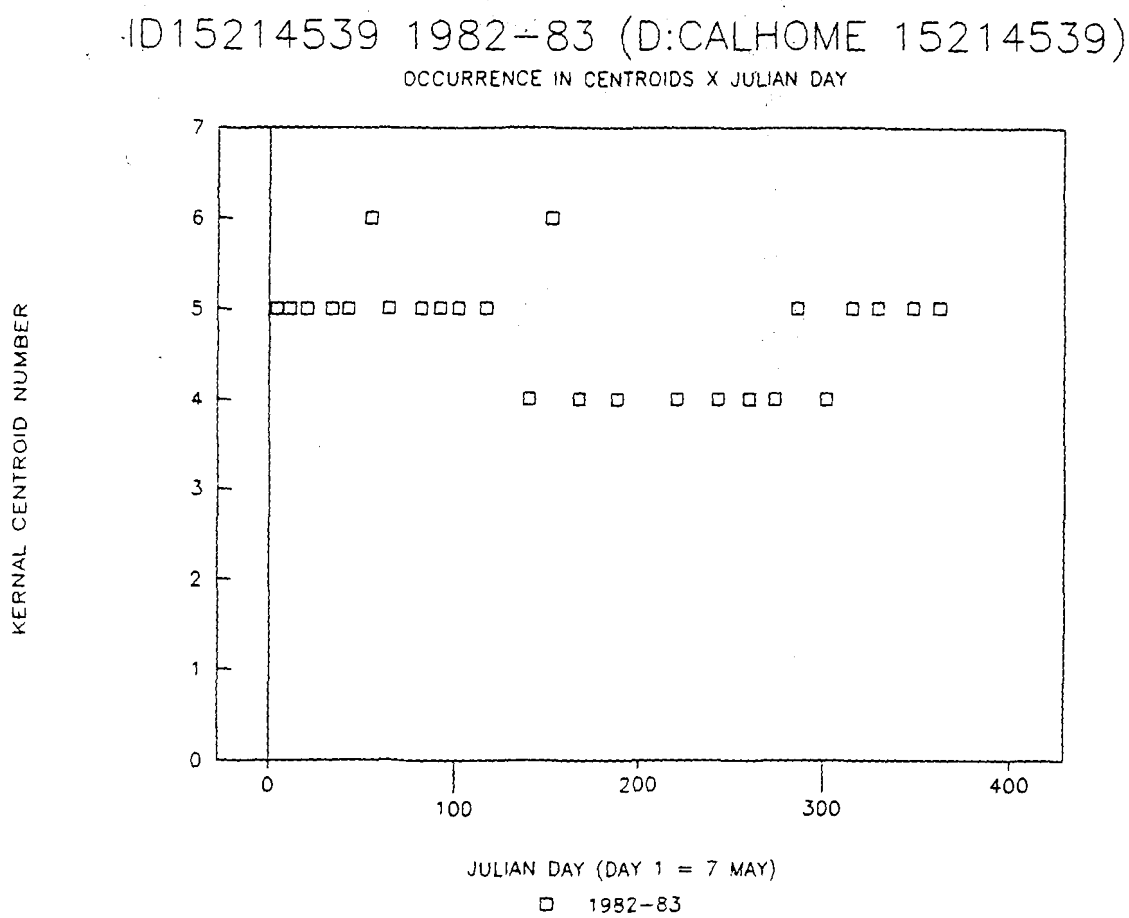

ID 152045- 1989-90 (D:\CALHOME\152045)
OCCURRENCE IN CENTROID X JULIAN DAY
KERNAL CENTROID NUMBER
10
8
6
4
2
0
0
100
200
300
400
JULIAN DAY (DAY 1 = 7 MAY)
1989-90

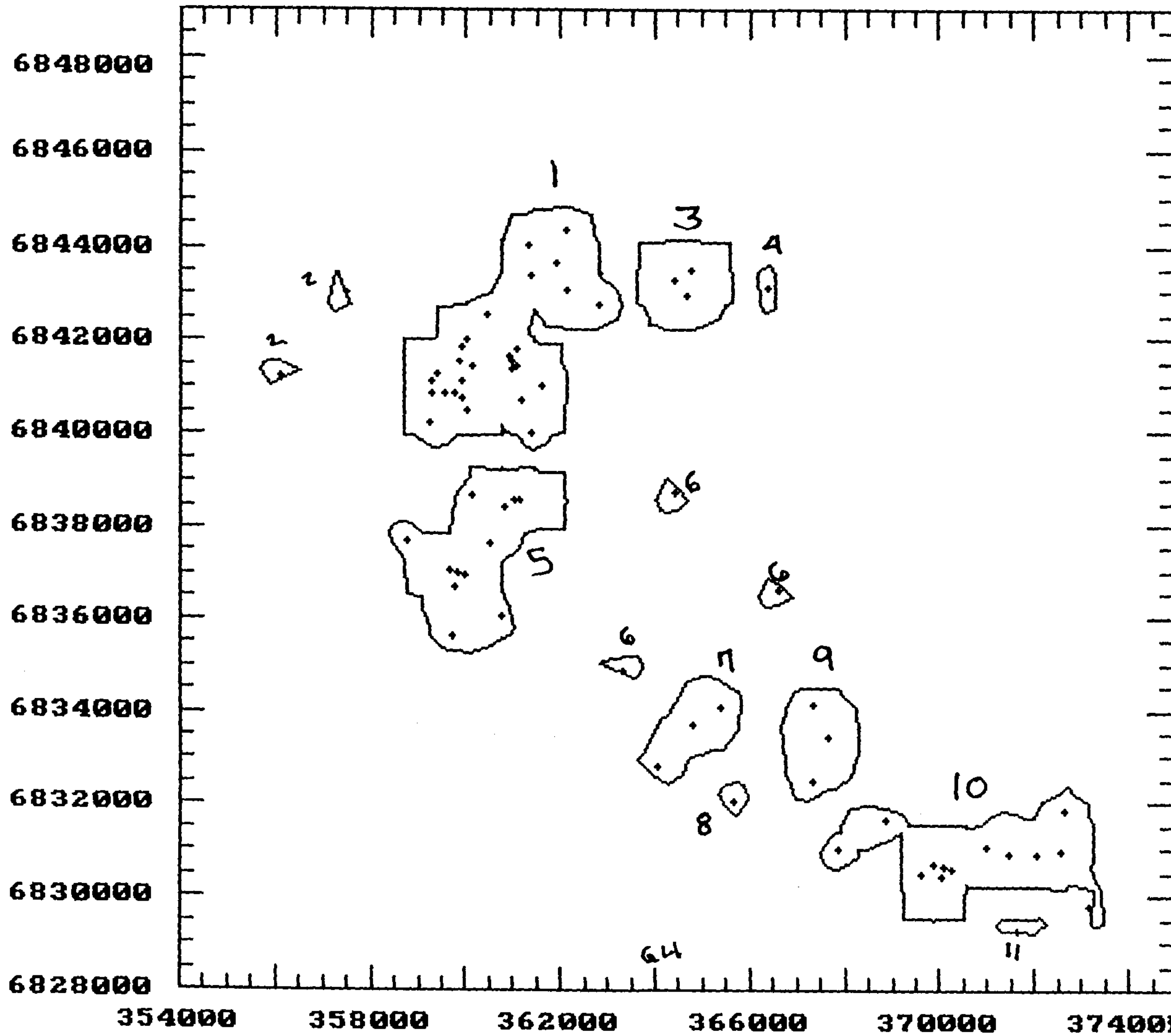


Datafile: 15214539.DAT
Output File: 5214539.OU
Display Units: meters
Adaptive Kernel
98P% 2395.000 ha
# of data points: 95
Xmin: 304932.3
Xmax: 315037.7
Ymin: 6797319.
Ymax: 6802986.
Grid Size: 600.0 m
Avg. Dist: 1523.6 m
Bandwidth: 450.0 m
LSCV score: .50037E+09

Outliers
1, 3, 6


ID 15214539 85-91 (D:CALHOME 15214539)
OCCURRENCE IN CENTROIDS X JULIAN DAY
KERNAL CENTROID NUMBER
Outliers
Outliers
Outliers
0
1
2
3
4
5
6
7
0
100
200
300
400
JULIAN DAY (DAY 1 = 7 MAY)
1981-91

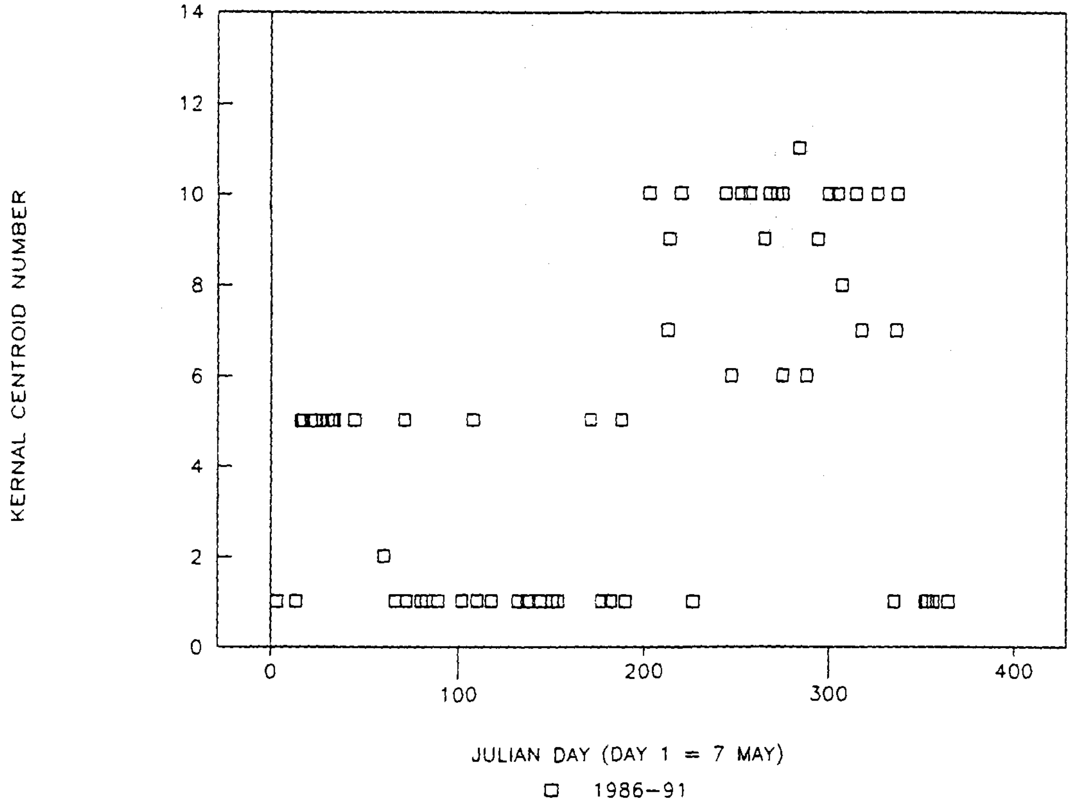

ID15214539 1982-83 (D:CALHOME 15214539)
OCCURRENCE IN CENTROIDS X JULIAN DAY
KERNAL CENTROID NUMBER
0
1
2
3
4
5
6
7
0
100
200
300
400
JULIAN DAY (DAY 1 = 7 MAY)
1982-83

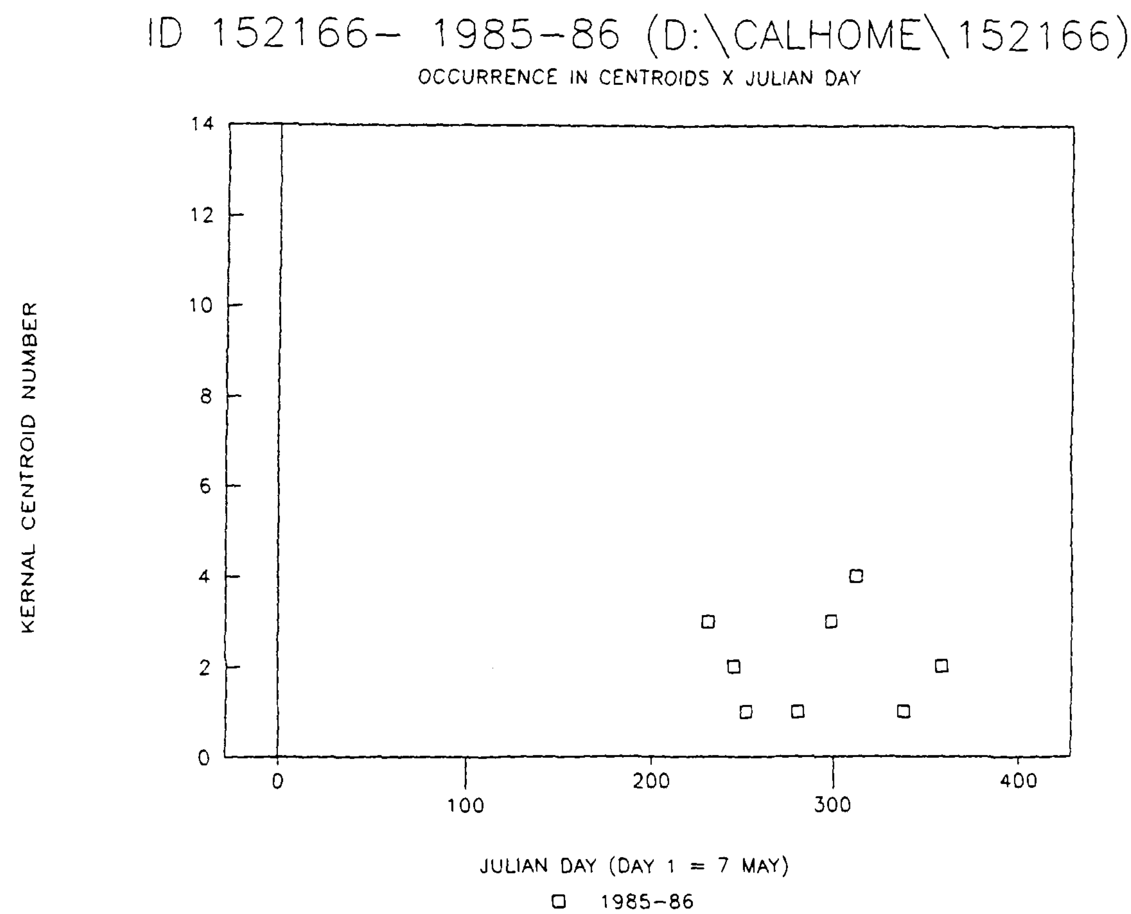


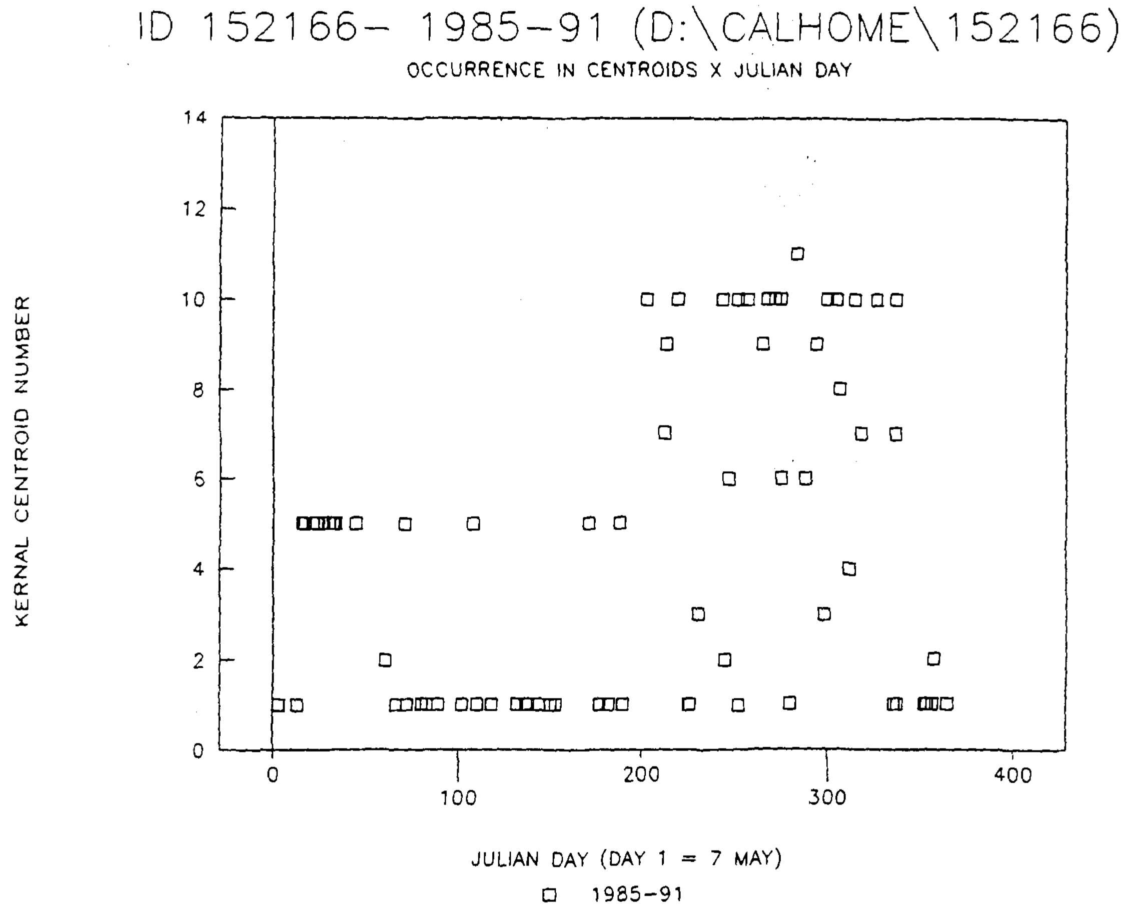
Datafile: 152166.DAT
Output File: 152166.OUT
Display Units: meters
Adaptive Kernel
98P% 4237.000 ha
# of data points: 70
Xmin: 356128.6
Xmax: 373133.1
Ymin: 6829252.
Ymax: 6844356.
Grid Size: 700.0 m
Avg. Dist: 3761.1 m
Bandwidth: 700.0 m
LSCV score: -.26889E+10

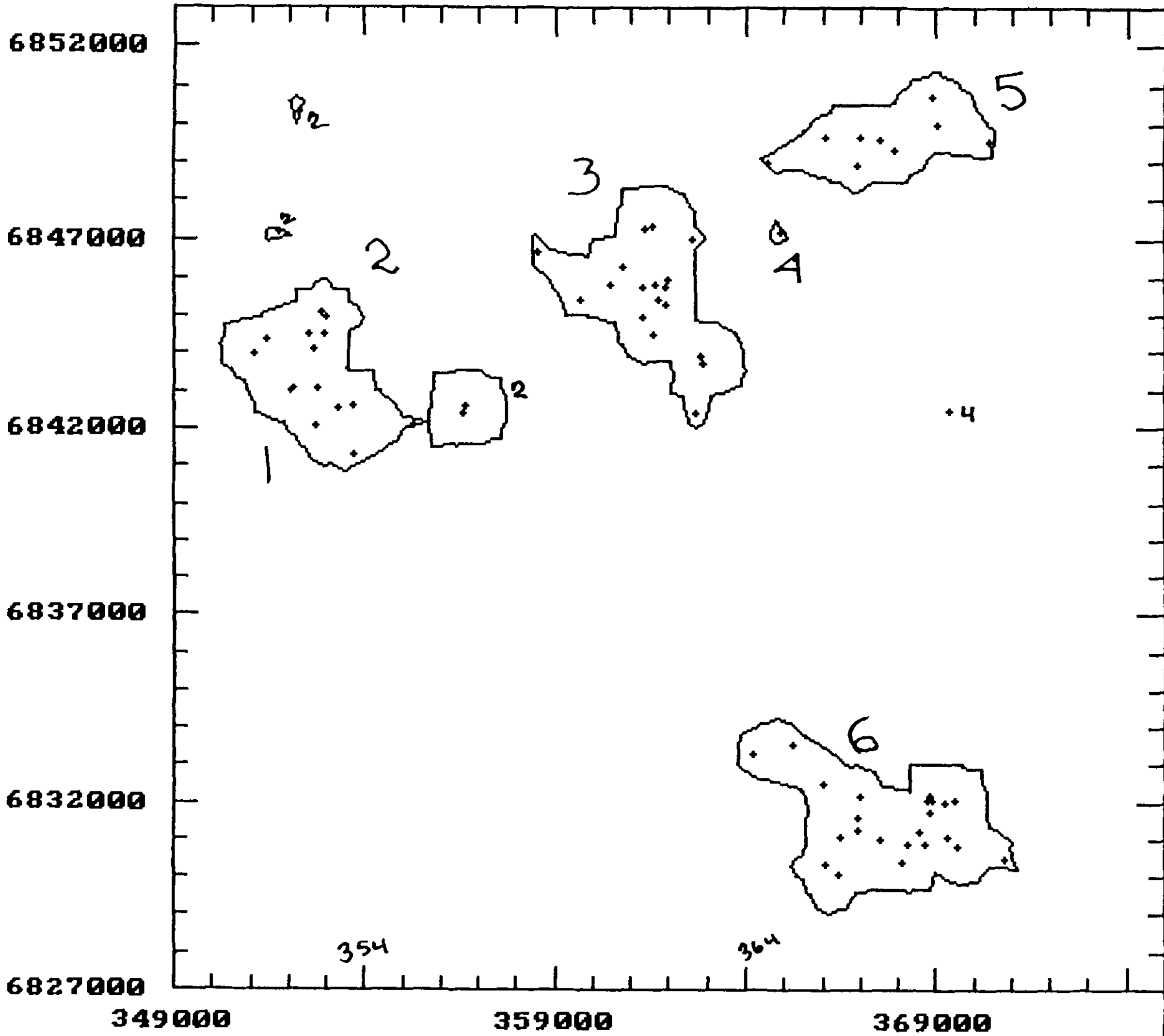
ID 152166– 1986–91 (D:\CALHOME\152166)

OCCURRENCE IN CENTROIDS X JULIAN DAY




ID 152166– 1985–86 (D:\CALHOME\152166)
OCCURRENCE IN CENTROIDS X JULIAN DAY
KERNAL CENTROID NUMBER
14
12
10
8
6
4
2
0
0
100
200
300
400
JULIAN DAY (DAY 1 = 7 MAY)
1985–86

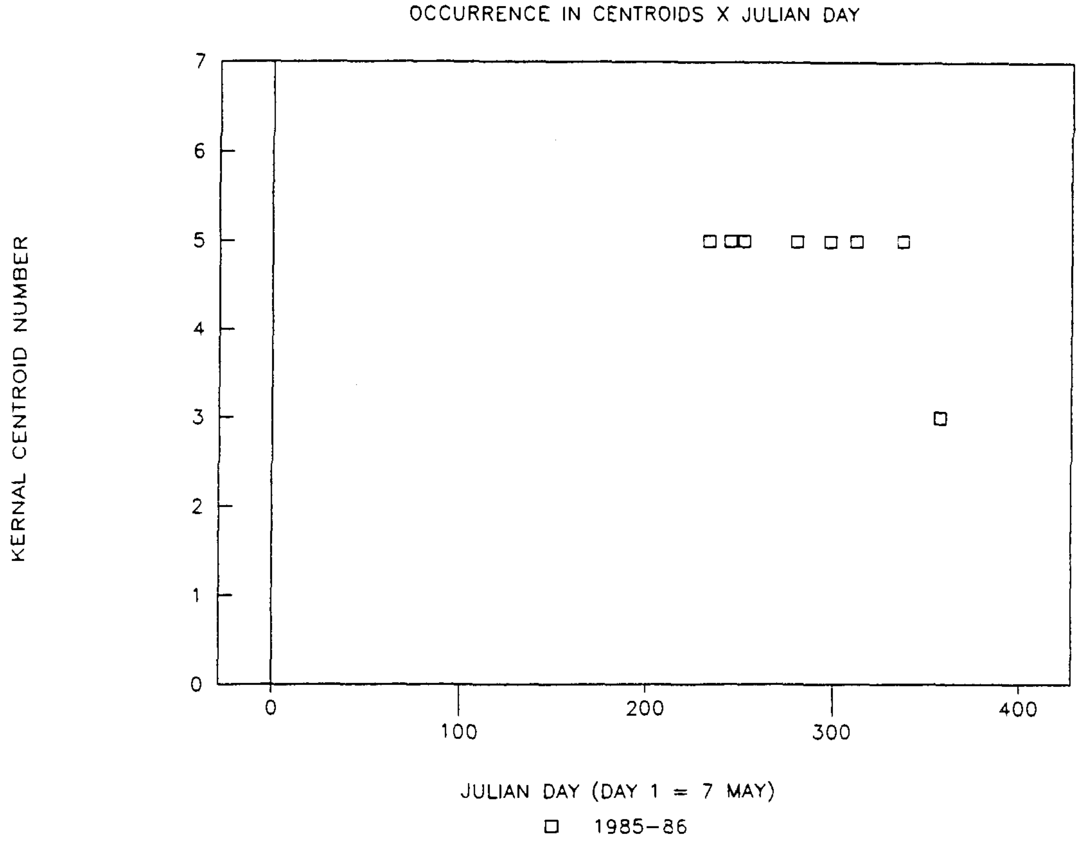

ID 152166– 1985–91 (D:\CALHOME\152166)
OCCURRENCE IN CENTROIDS X JULIAN DAY
KERNAL CENTROID NUMBER
14
12
10
8
6
4
2
0
0
100
200
300
400
JULIAN DAY (DAY 1 = 7 MAY)
1985–91



Datafile: 152191.DAT
Output File: 152191.OUT
Display Units: meters
Adaptive Kernel
98P% 6298.000 ha
# of data points: 71
Xmin: 351127.2
Xmax: 370777.9
Ymin: 6830078.
Ymax: 6850732.
Grid Size: 700.0 m
Avg. Dist: 5637.8 m
Bandwidth: 900.0 m
LSCV score: -.25763E+10

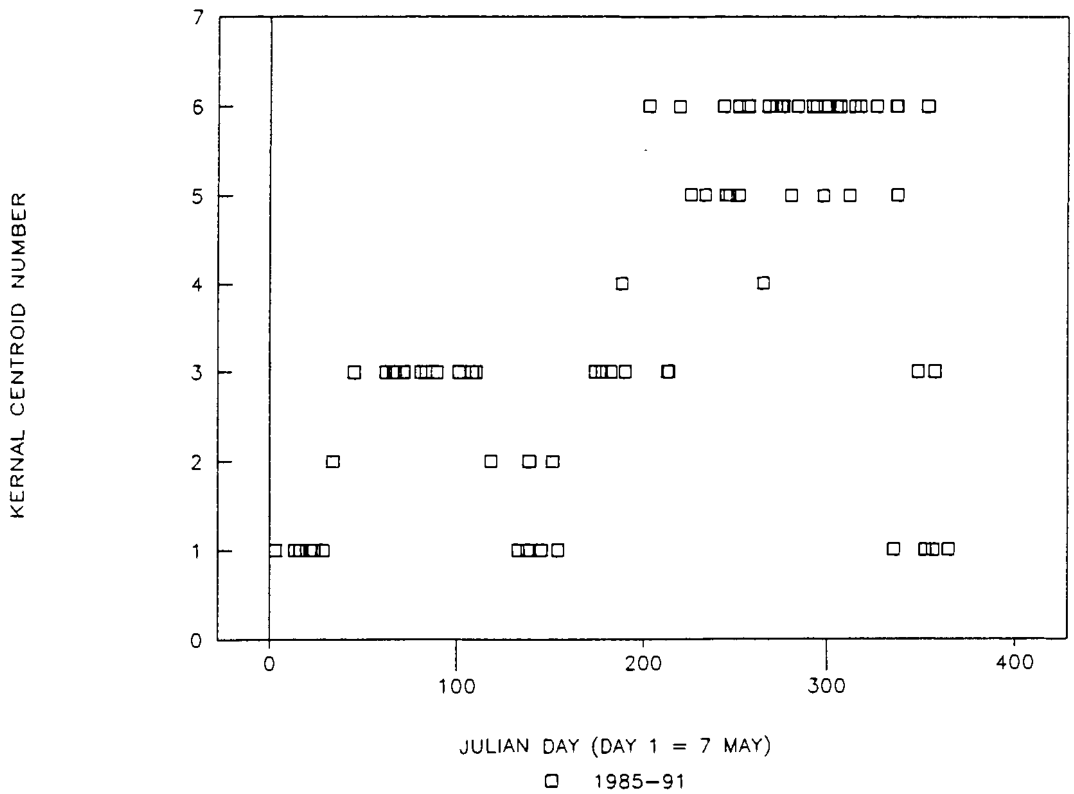
1 = Calf, Rut
2 = Rut
3 = Summer, Post Rut
5 = Winter 85-86
6 = Winter 86-87
87-88
88-89
89-90
90-91

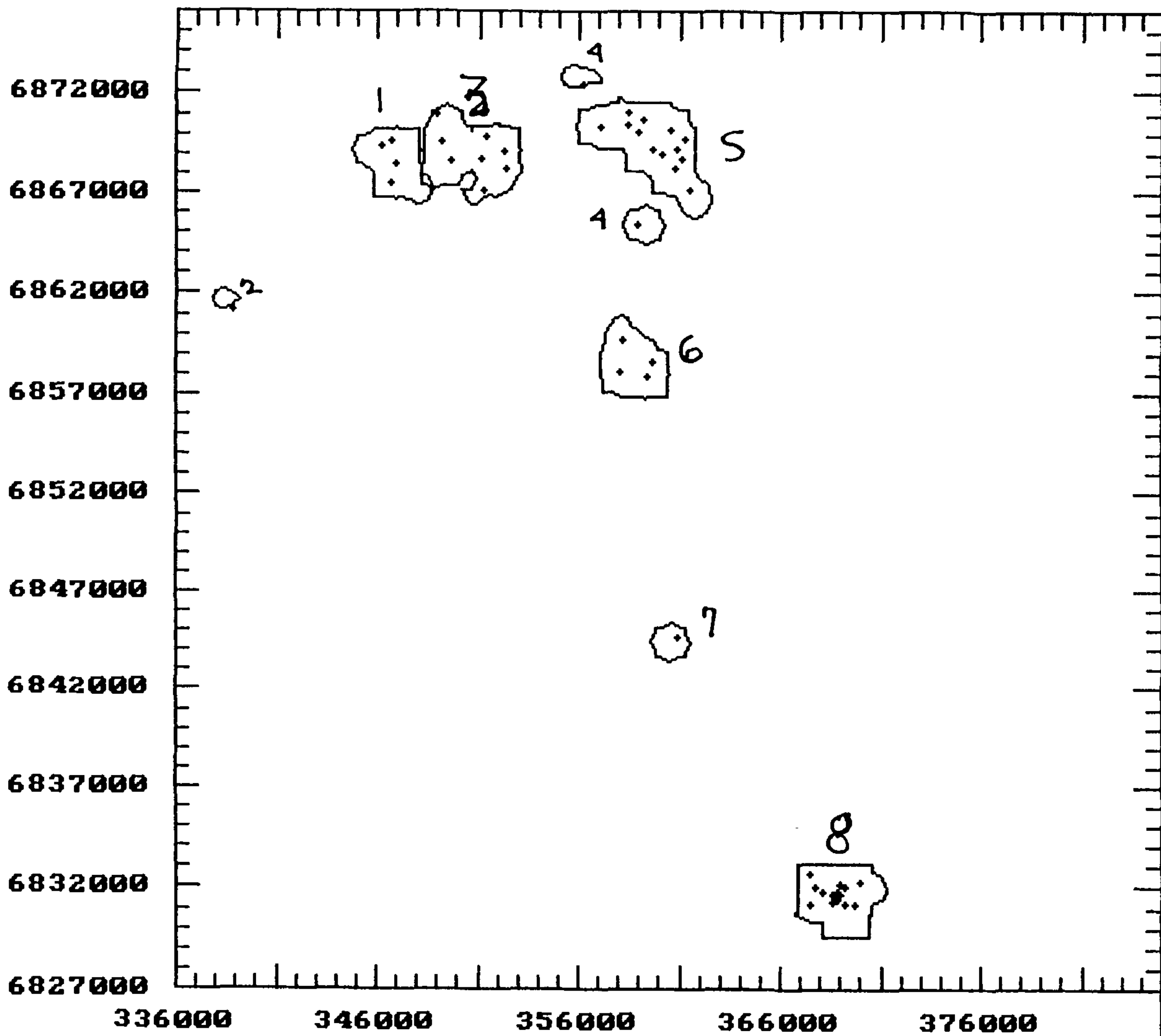
ID 152191– 1985–86 (D:\CALHOME\152191)



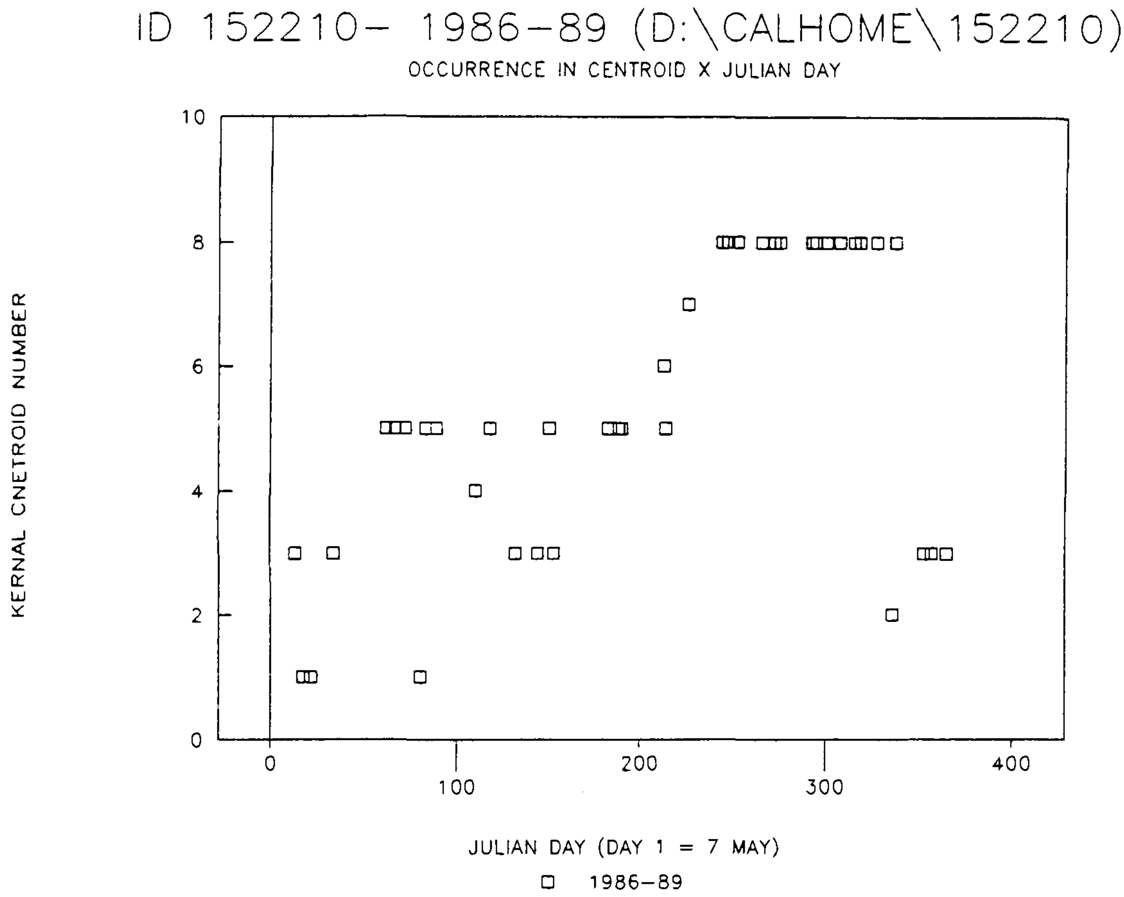
ID 152191– 1985–91 (D:\CALHOME\152191)

OCCURRENCE IN CENTROIDS X JULIAN DAY



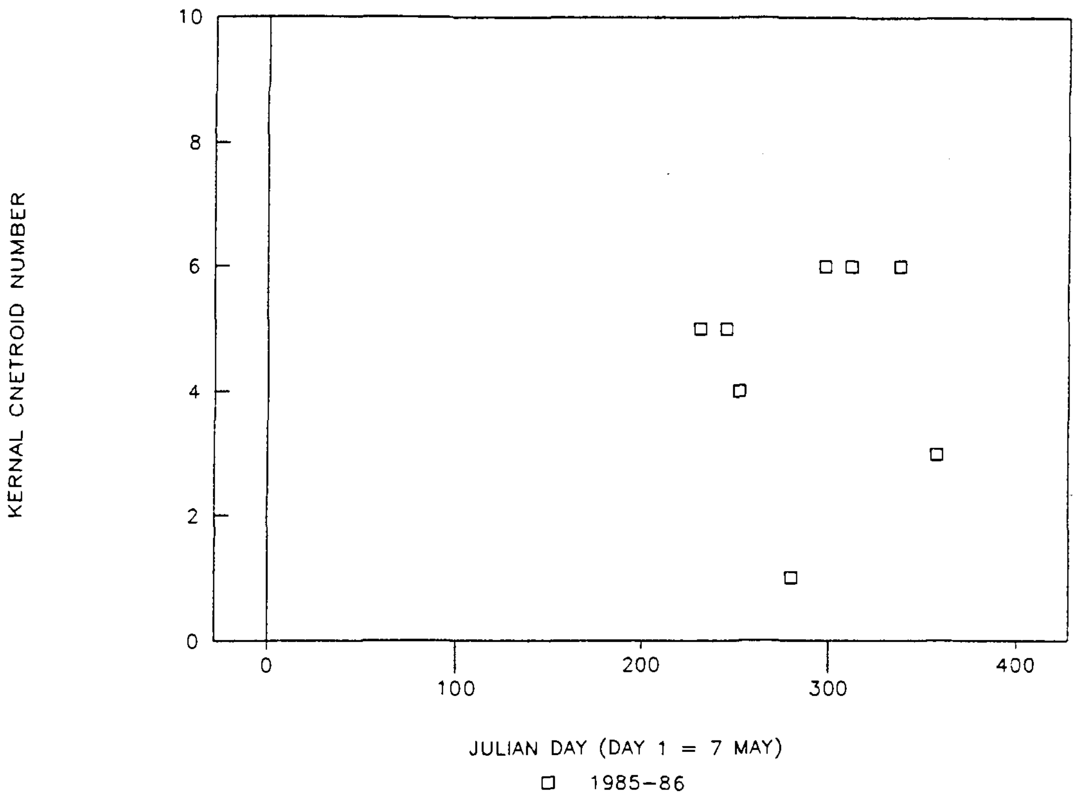


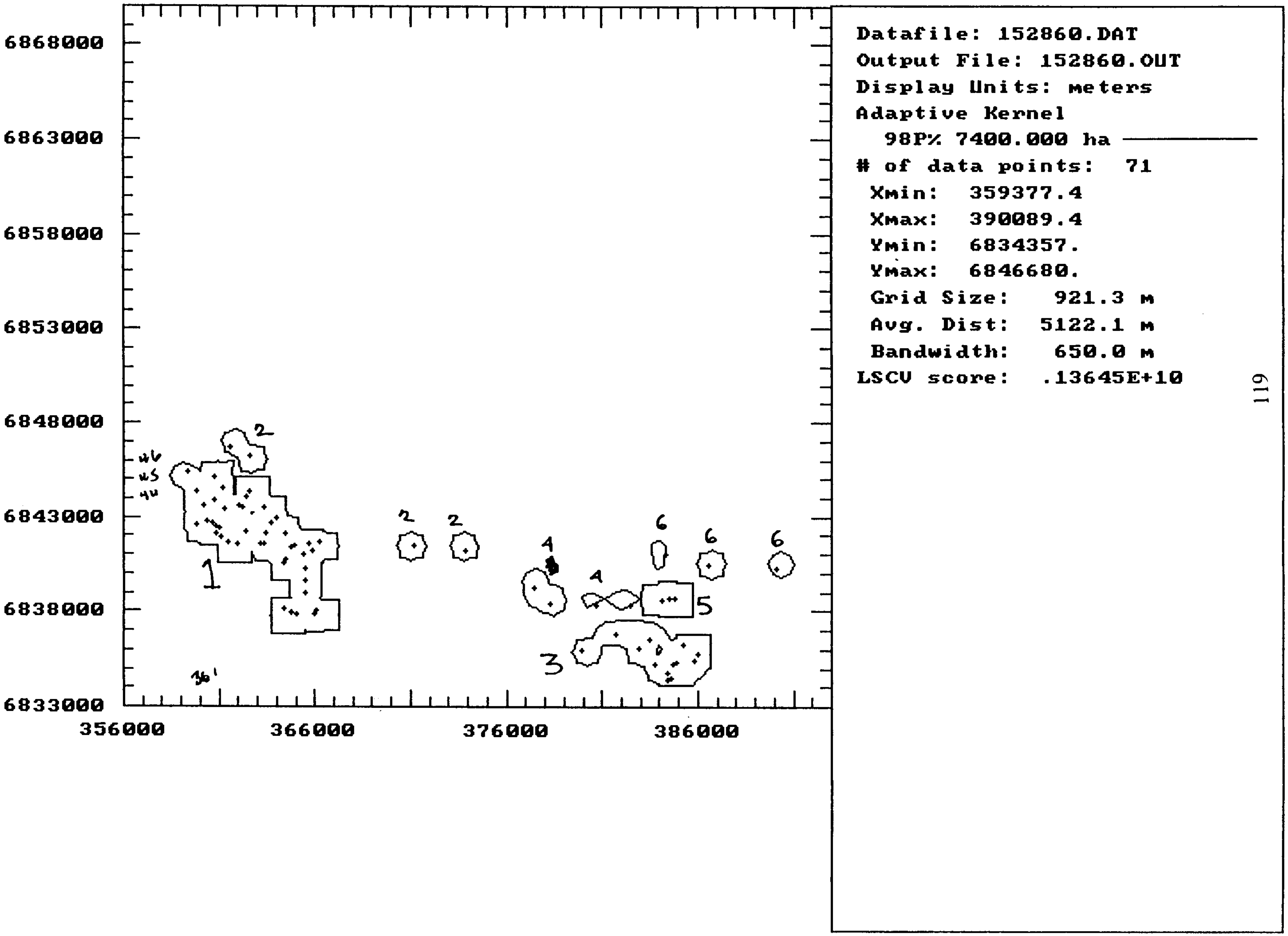
Datafile: 152210.DAT
Output File: 152210.OUT
Display Units: meters
Adaptive Kernel
98P% 7850.000 ha
# of data points: 49
Xmin: 338876.0
Xmax: 369961.9
Ymin: 6831152.
Ymax: 6872410.
Grid Size: 1237.7 m
Avg. Dist: 9284.7 m
Bandwidth: 800.0 m
LSCV score: -.80632E+11

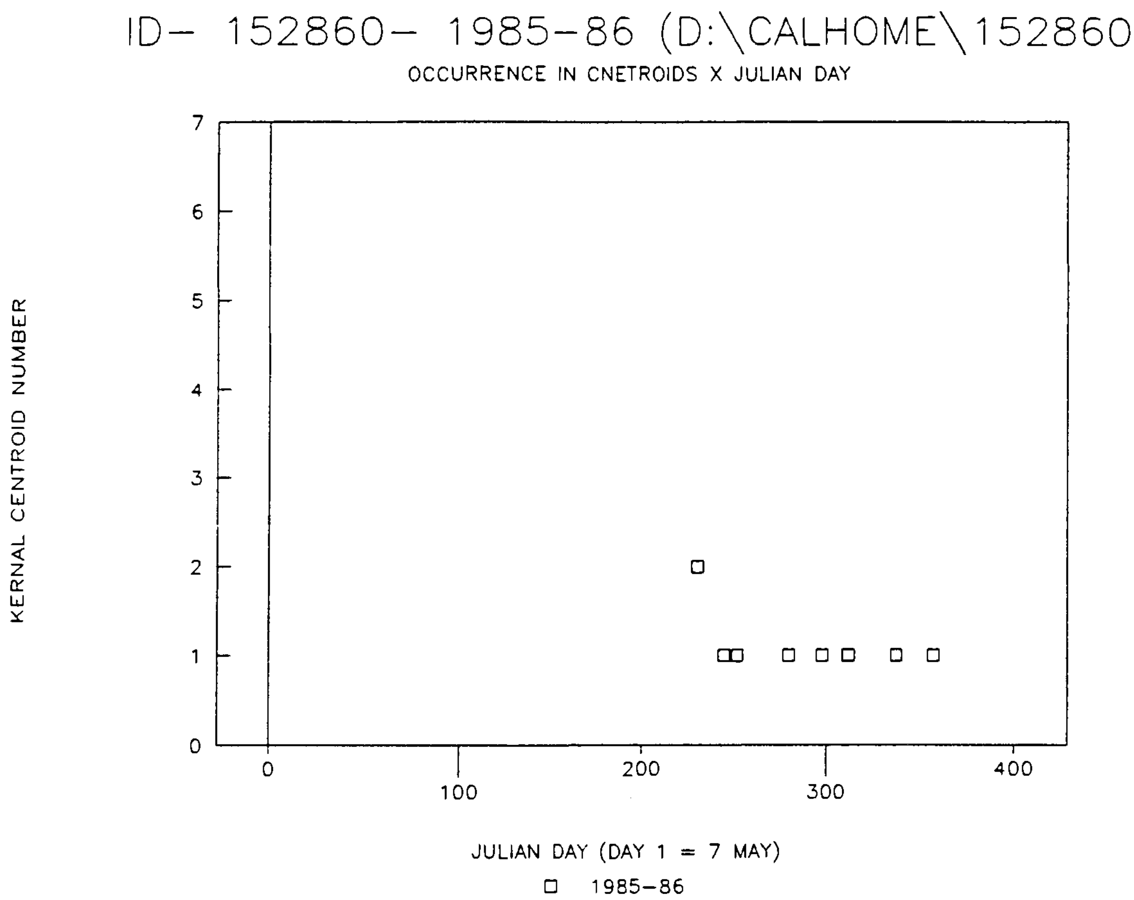

ID 152210- 1986-89 (D:\CALHOME\152210)
OCCURRENCE IN CENTROID X JULIAN DAY
KERNAL CNETROID NUMBER
0
2
4
6
8
10
0
100
200
300
400
JULIAN DAY (DAY 1 = 7 MAY)
1986-89

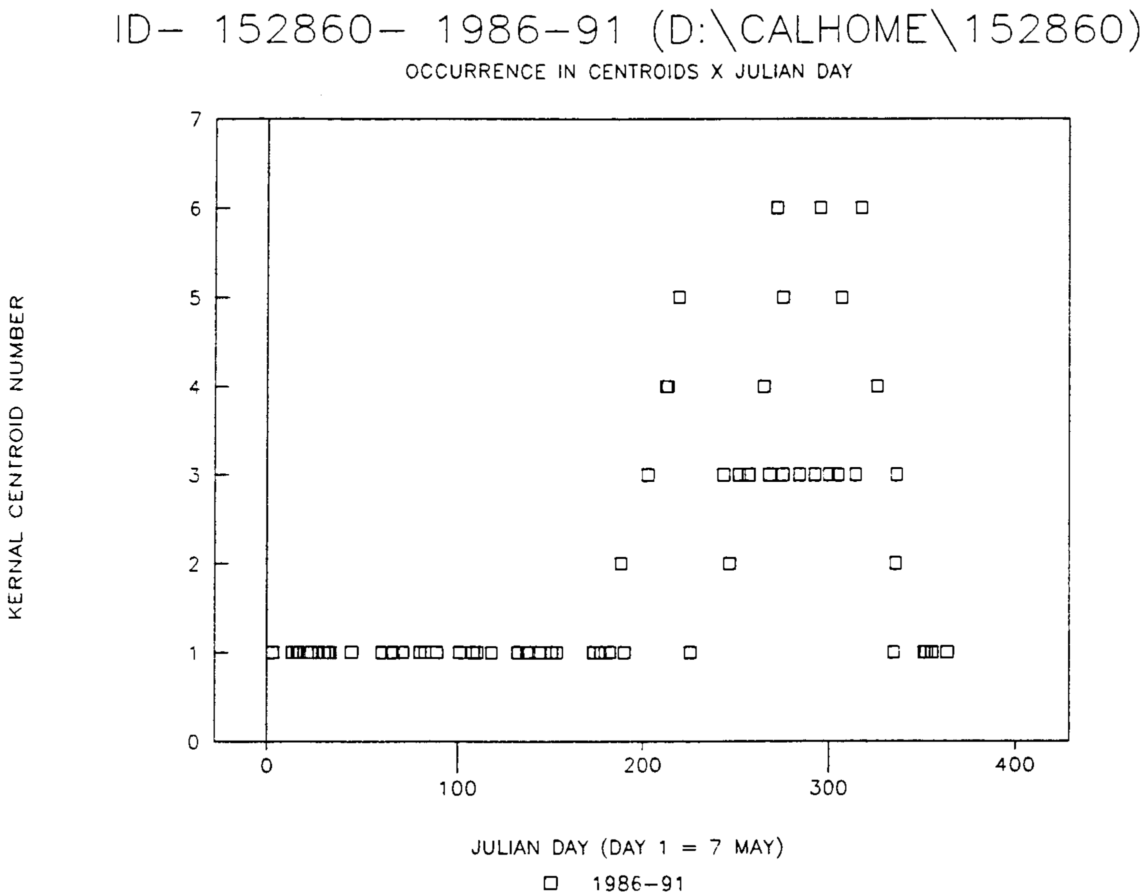
ID 152210– 1985–86 (D:\CALHOME\152210)

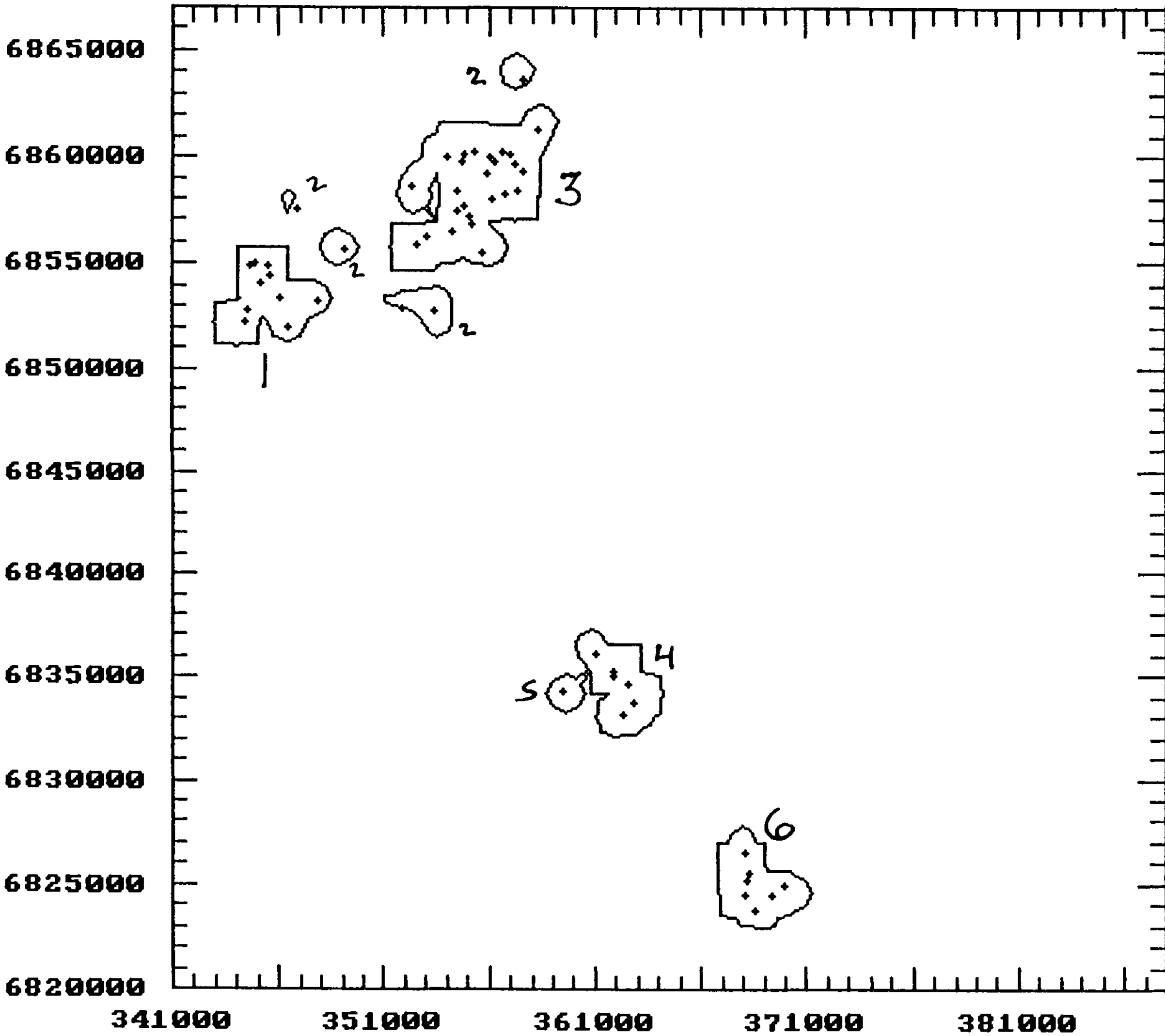
OCCURRENCE IN CENTROID X JULIAN DAY



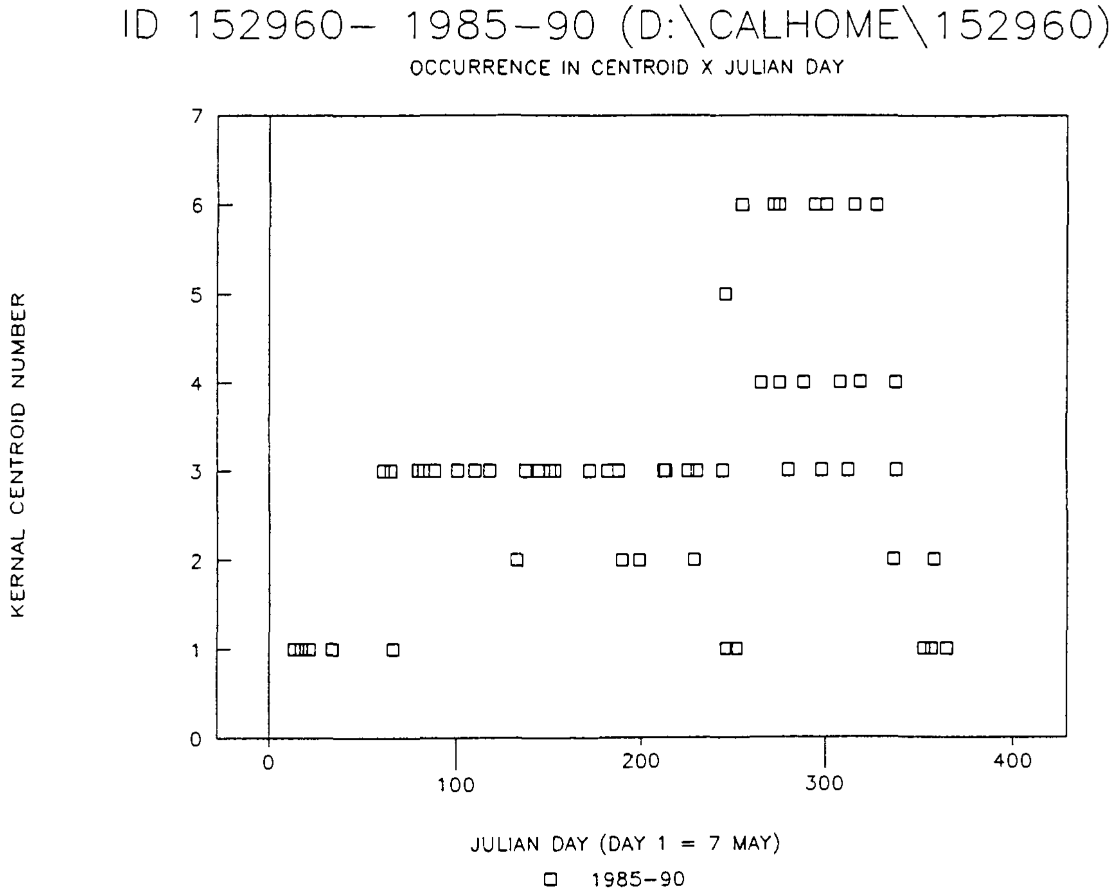

6868000
6863000
6858000
6853000
6848000
6843000
6838000
6833000
356000
366000
376000
386000
Datafile: 152860.DAT
Output File: 152860.OUT
Display Units: meters
Adaptive Kernel
98P% 7400.000 ha
# of data points: 71
Xmin: 359377.4
Xmax: 390089.4
Ymin: 6834357.
Ymax: 6846680.
Grid Size: 921.3 m
Avg. Dist: 5122.1 m
Bandwidth: 650.0 m
LSCV score: .13645E+10
1
2
2
2
3
4
4
5
6
6
6


ID- 152860- 1985-86 (D:\CALHOME\152860
OCCURRENCE IN CNETROIDS X JULIAN DAY
KERNAL CENTROID NUMBER
0
1
2
3
4
5
6
7
0
100
200
300
400
JULIAN DAY (DAY 1 = 7 MAY)
1985-86

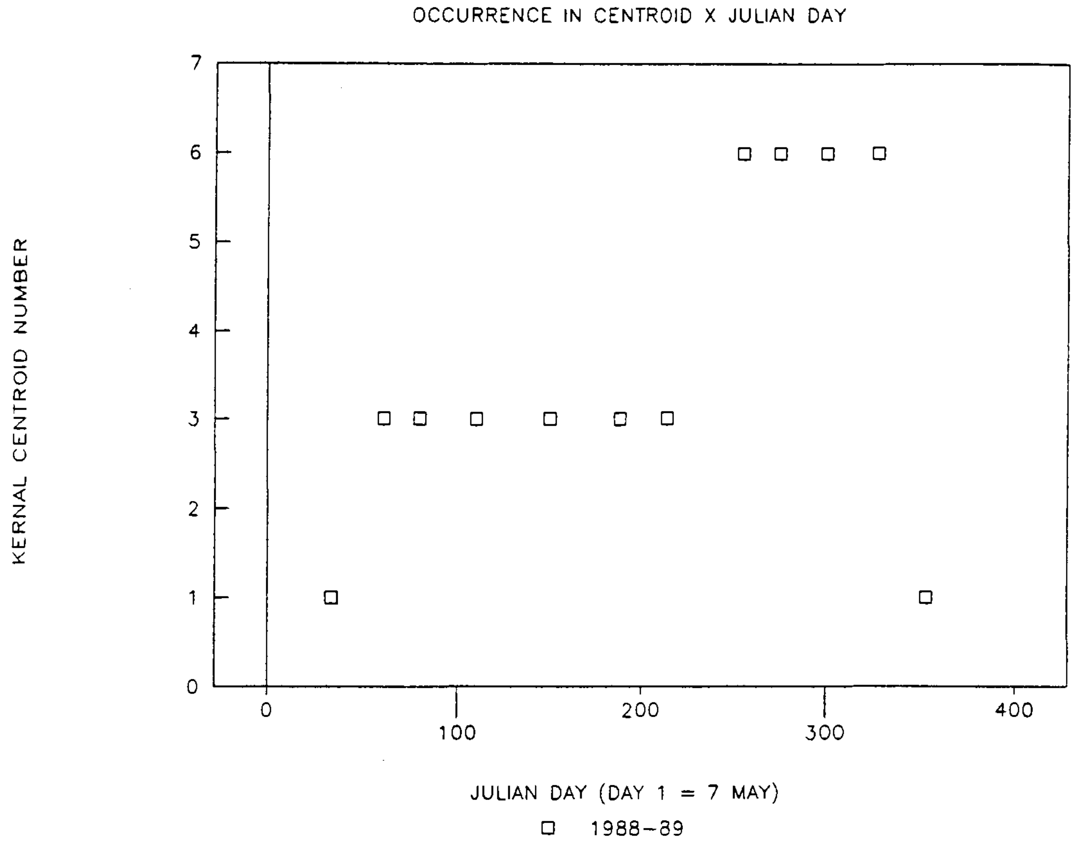

ID– 152860– 1986–91 (D:\CALHOME\152860)
OCCURRENCE IN CENTROIDS X JULIAN DAY
KERNAL CENTROID NUMBER
0
1
2
3
4
5
6
7
0
100
200
300
400
JULIAN DAY (DAY 1 = 7 MAY)
1986–91

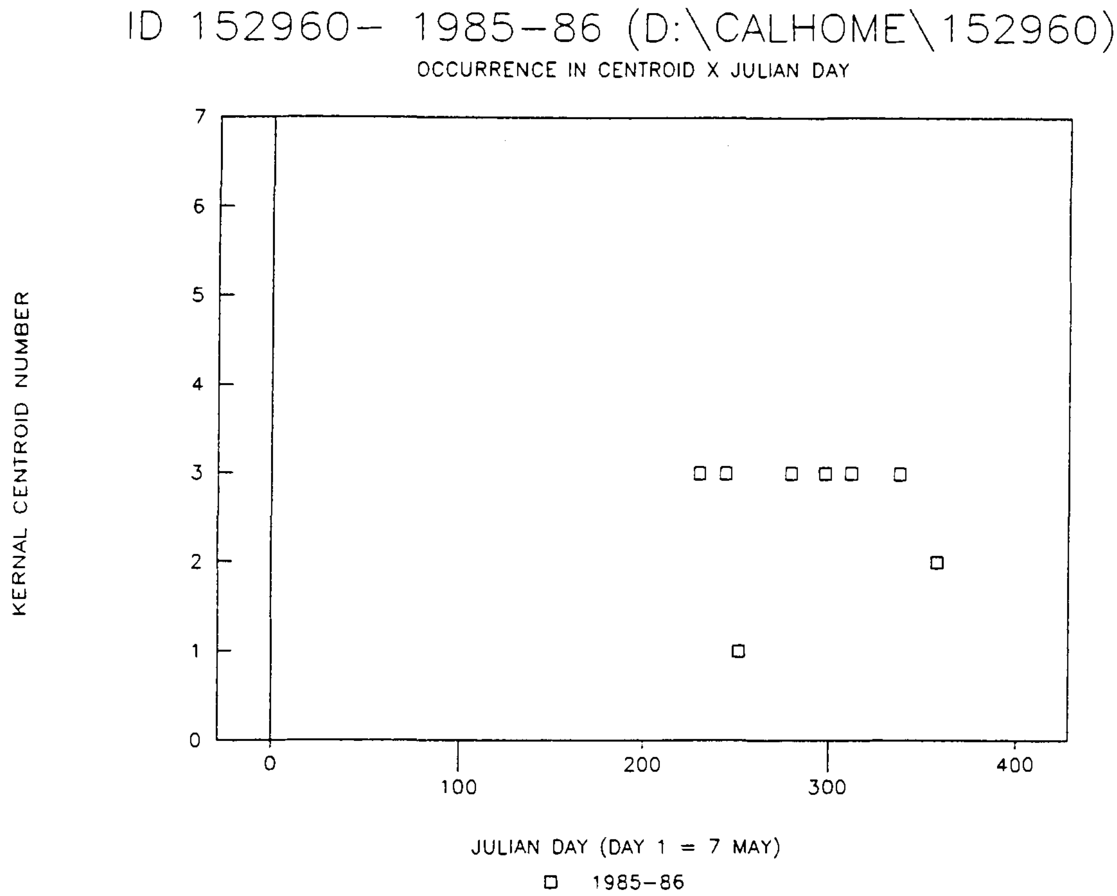


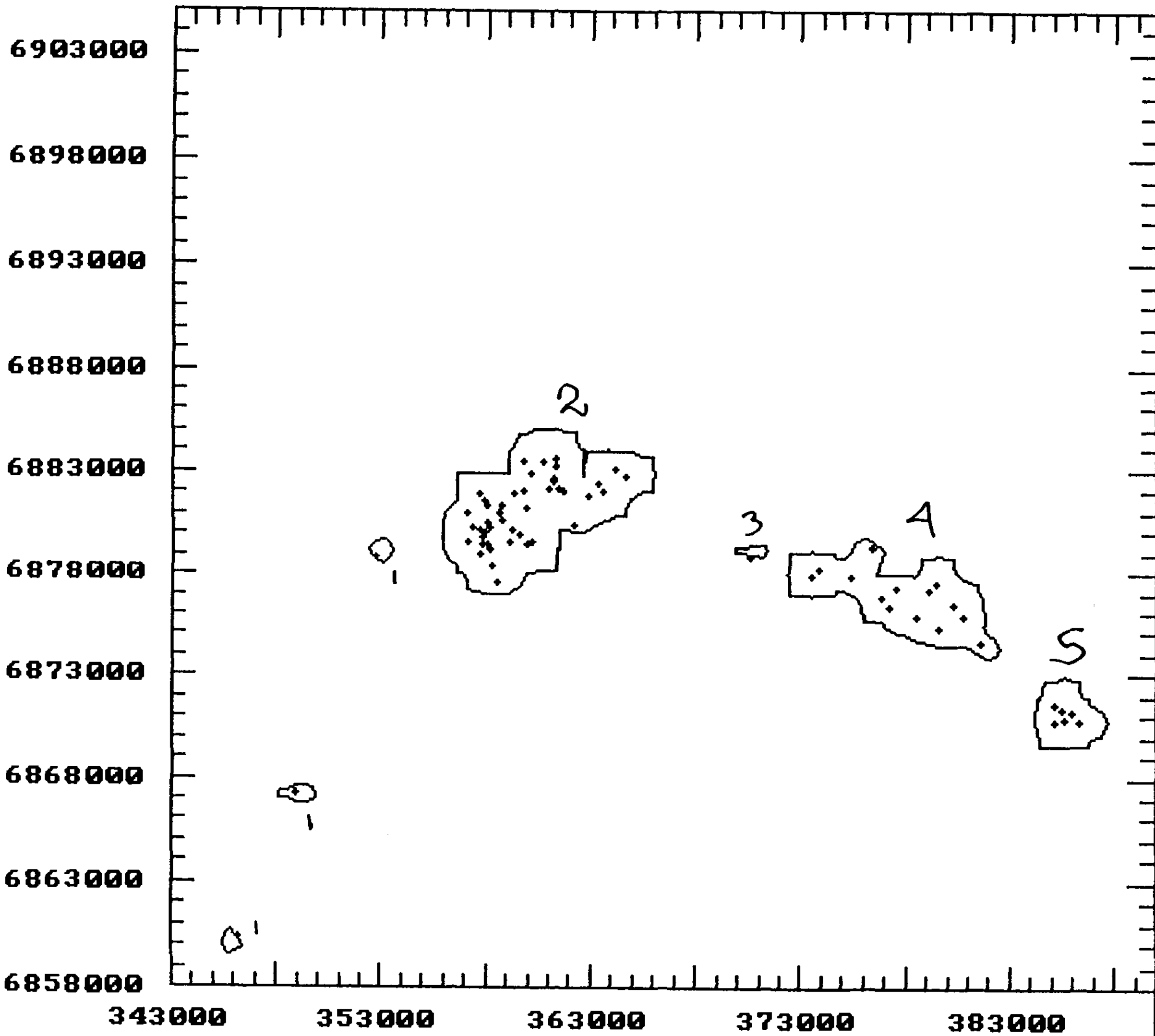
Datafile: 152960.DAT
Output File: 152960.OUT
Display Units: meters
Adaptive Kernel
98P% 9244.000 ha
# of data points: 54
Xmin: 344401.3
Xmax: 369997.6
Ymin: 6823832.
Ymax: 6863731.
Grid Size: 1196.9 m
Avg. Dist: 6984.9 m
Bandwidth: 900.0 m
LSCV score: -.73181E+10


ID 152960– 1985–90 (D:\CALHOME\152960)
OCCURRENCE IN CENTROID X JULIAN DAY
KERNAL CENTROID NUMBER
0
1
2
3
4
5
6
7
0
100
200
300
400
JULIAN DAY (DAY 1 = 7 MAY)
1985–90

ID 152960- 1988-89 (D:\CALHOME\152960)

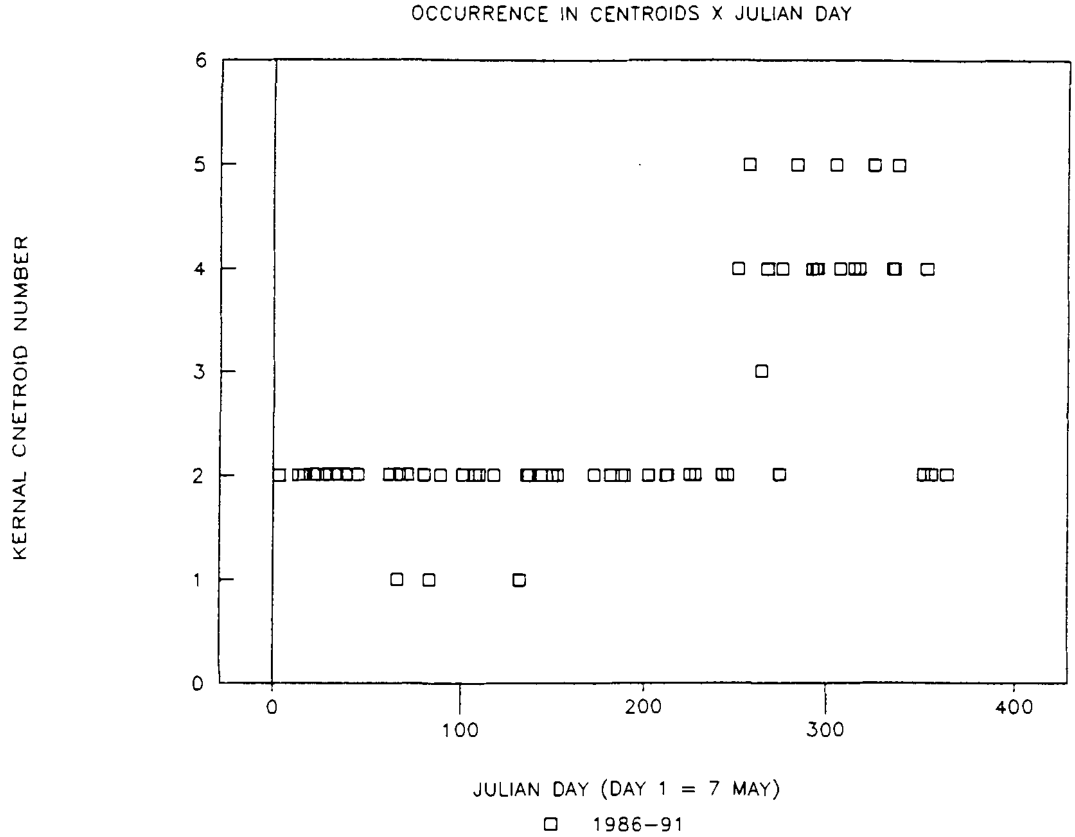


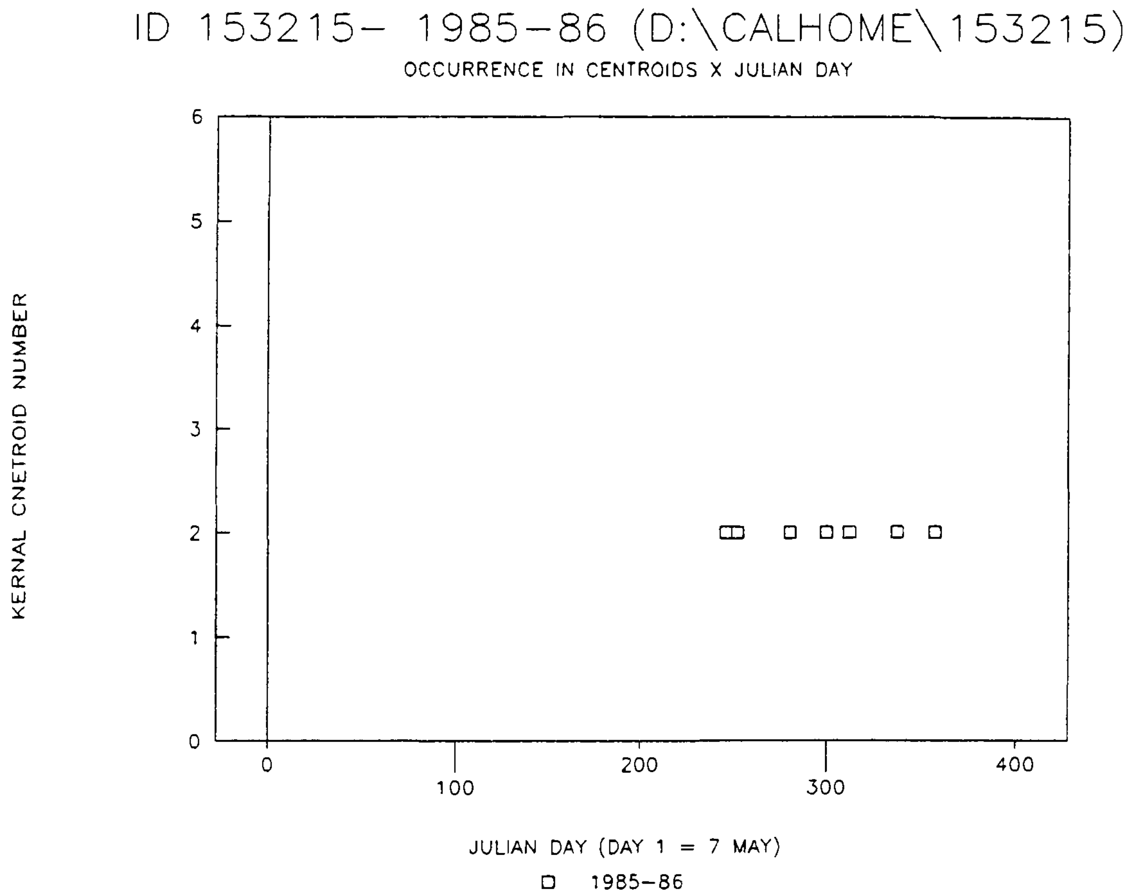

ID 152960- 1985-86 (D:\CALHOME\152960)
OCCURRENCE IN CENTROID X JULIAN DAY
KERNAL CENTROID NUMBER
7
6
5
4
3
2
1
0
0
100
200
300
400
JULIAN DAY (DAY 1 = 7 MAY)
1985-86

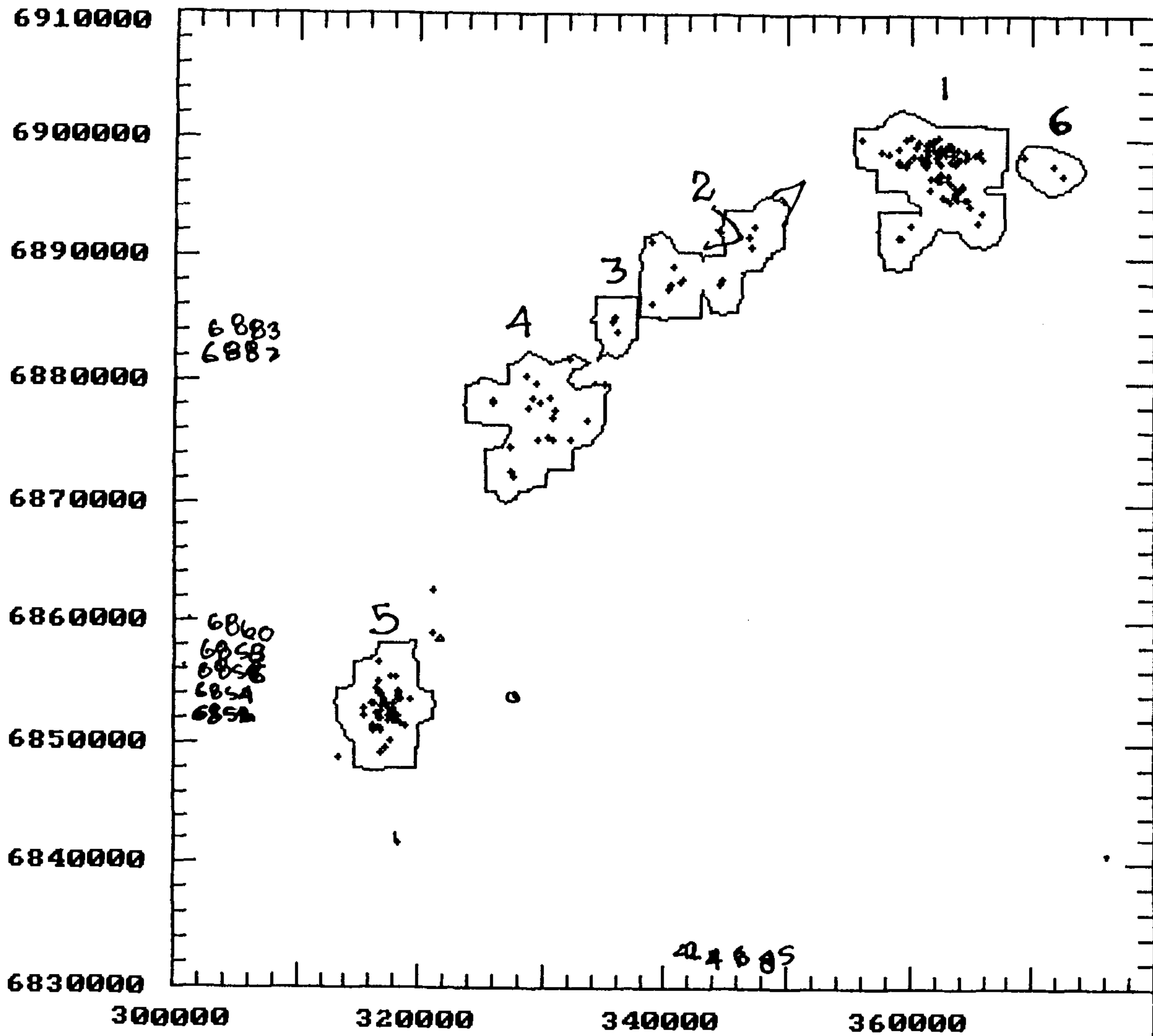


Datafile: 153215.DAT
Output File: 153215.OUT
Display Units: meters
Adaptive Kernel
98P% 8812.000 ha
# of data points: 70
Xmin: 346216.7
Xmax: 386384.3
Ymin: 6860376.
Ymax: 6883592.
Grid Size: 1205.0 m
Avg. Dist: 5178.4 m
Bandwidth: 900.0 m
LSCV score: -.35245E+11

ID 153215- 1986-91 (D:\CALHOME\153215)

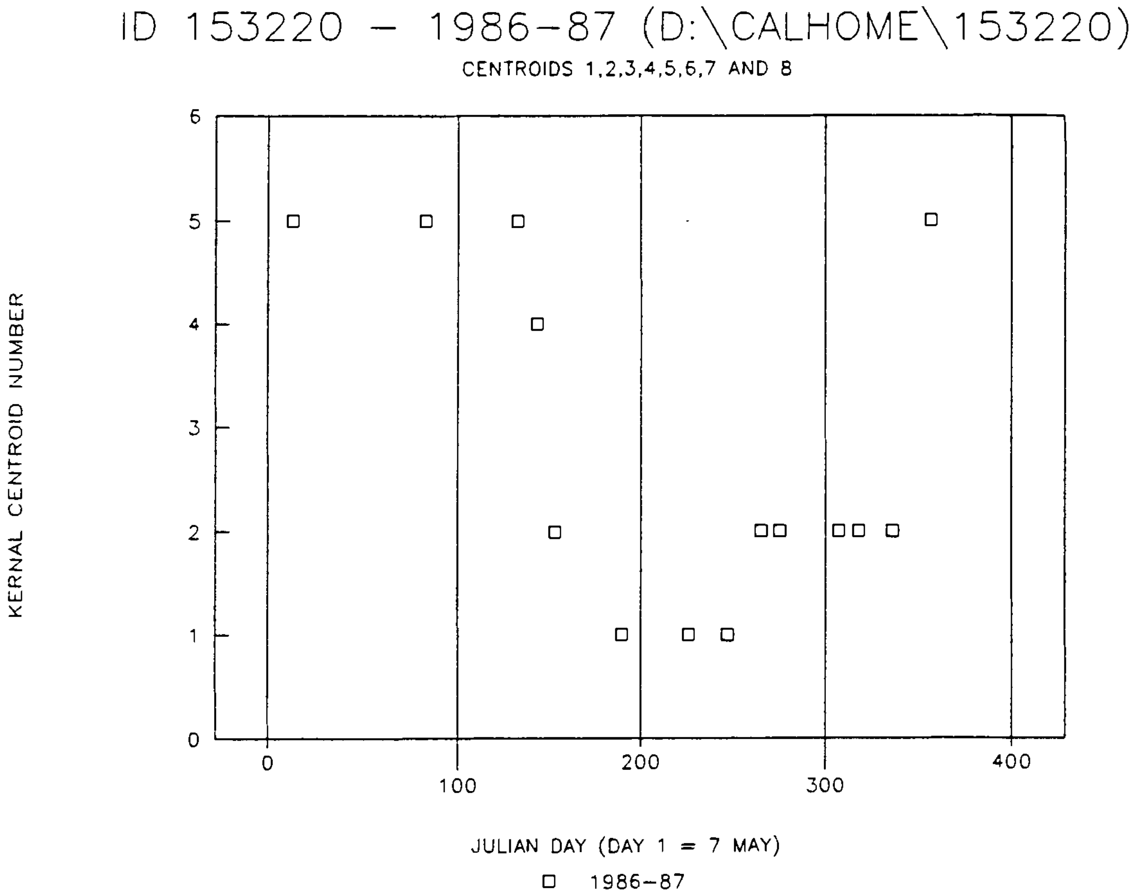



ID 153215- 1985-86 (D:\CALHOME\153215)
OCCURRENCE IN CENTROIDS X JULIAN DAY
KERNAL CNETROID NUMBER
0
1
2
3
4
5
6
0
100
200
300
400
JULIAN DAY (DAY 1 = 7 MAY)
1985-86

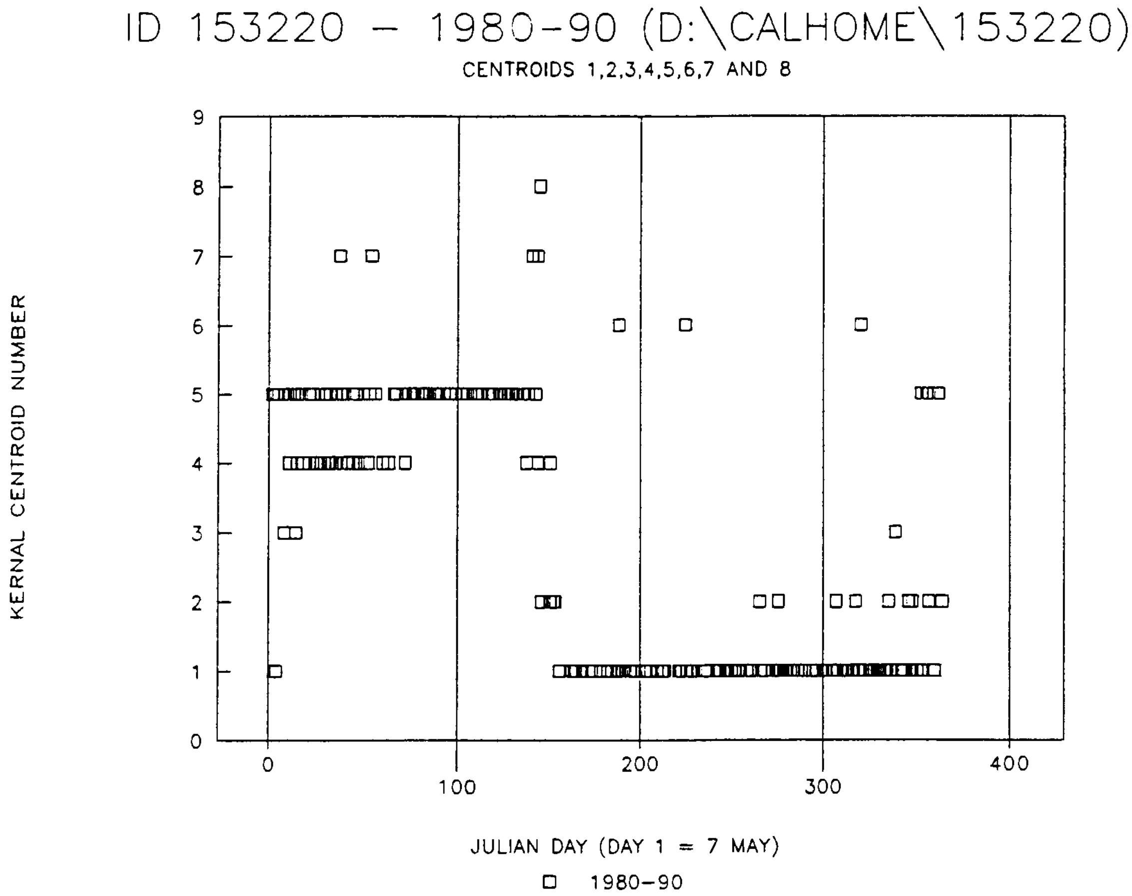


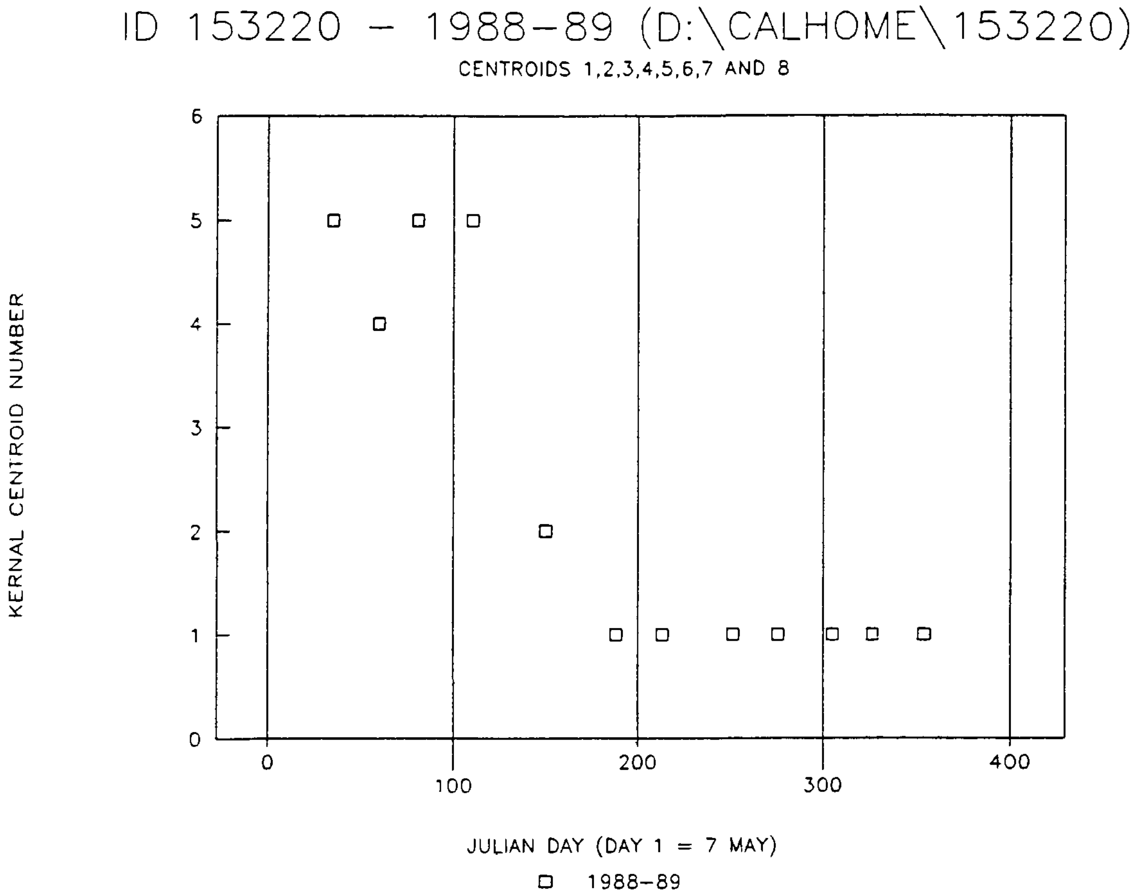
Datafile: 153220.DAT
Output File: 153220.OUT
Display Units: meters
Adaptive Kernel
98P% 35260.00 ha
# of data points: 197
Xmin: 313486.1
Xmax: 372618.2
Ymin: 6841629.
Ymax: 6900163.
Grid Size: 1773.9 m
Avg. Dist: 9610.9 m
Bandwidth: 1200.0 m
LSCV score: .68080E+12

Outliers mean 5 = 7
Outliers mean 2 = 8

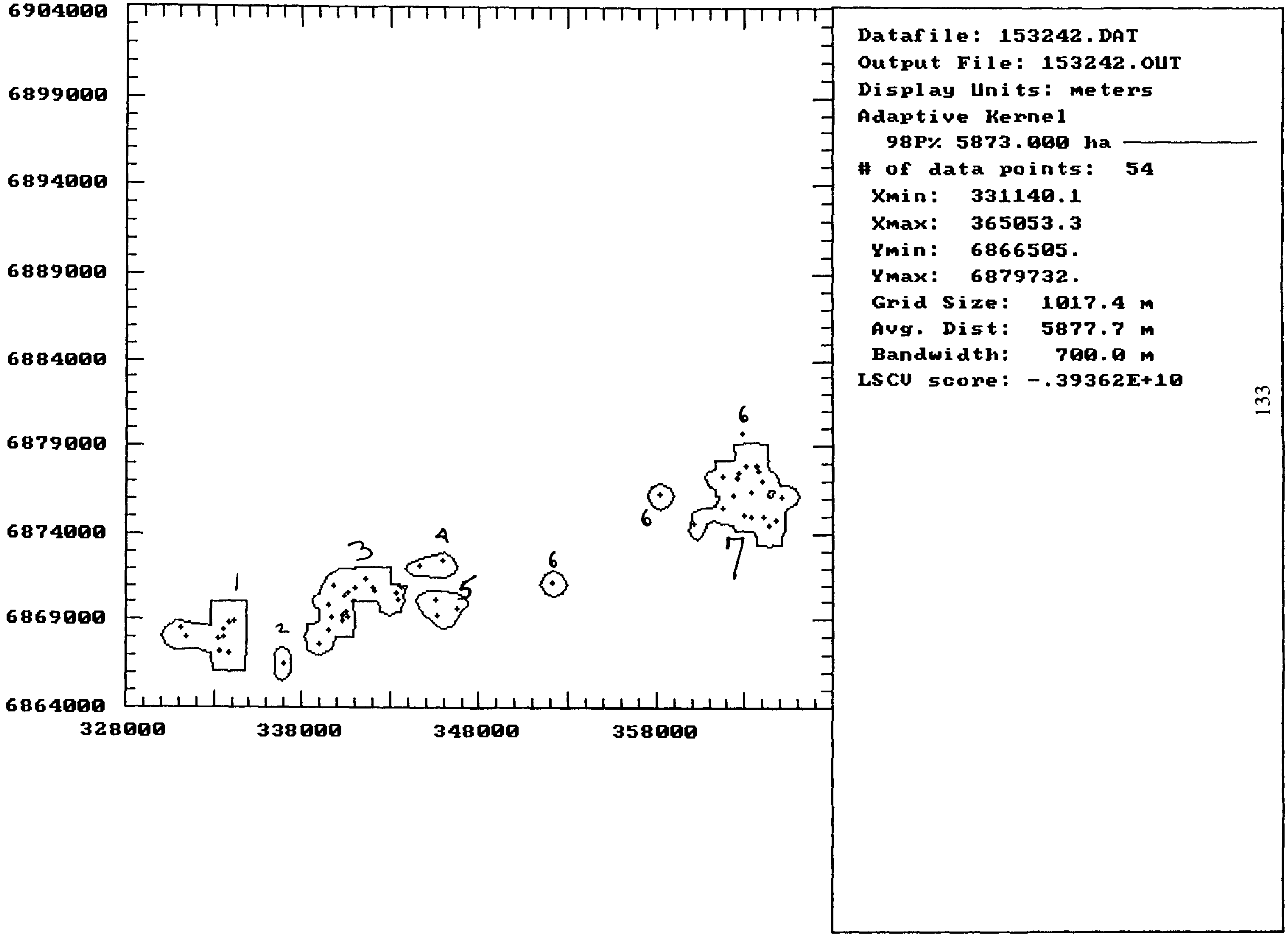


ID 153220 – 1986–87 (D:\CALHOME\153220)
CENTROIDS 1,2,3,4,5,6,7 AND 8
KERNAL CENTROID NUMBER
0
1
2
3
4
5
6
0
100
200
300
400
JULIAN DAY (DAY 1 = 7 MAY)
1986–87


ID 153220 – 1980-90 (D:\CALHOME\153220)
CENTROIDS 1,2,3,4,5,6,7 AND 8
KERNAL CENTROID NUMBER
JULIAN DAY (DAY 1 = 7 MAY)
1980-90
0
100
200
300
400
0
1
2
3
4
5
6
7
8
9

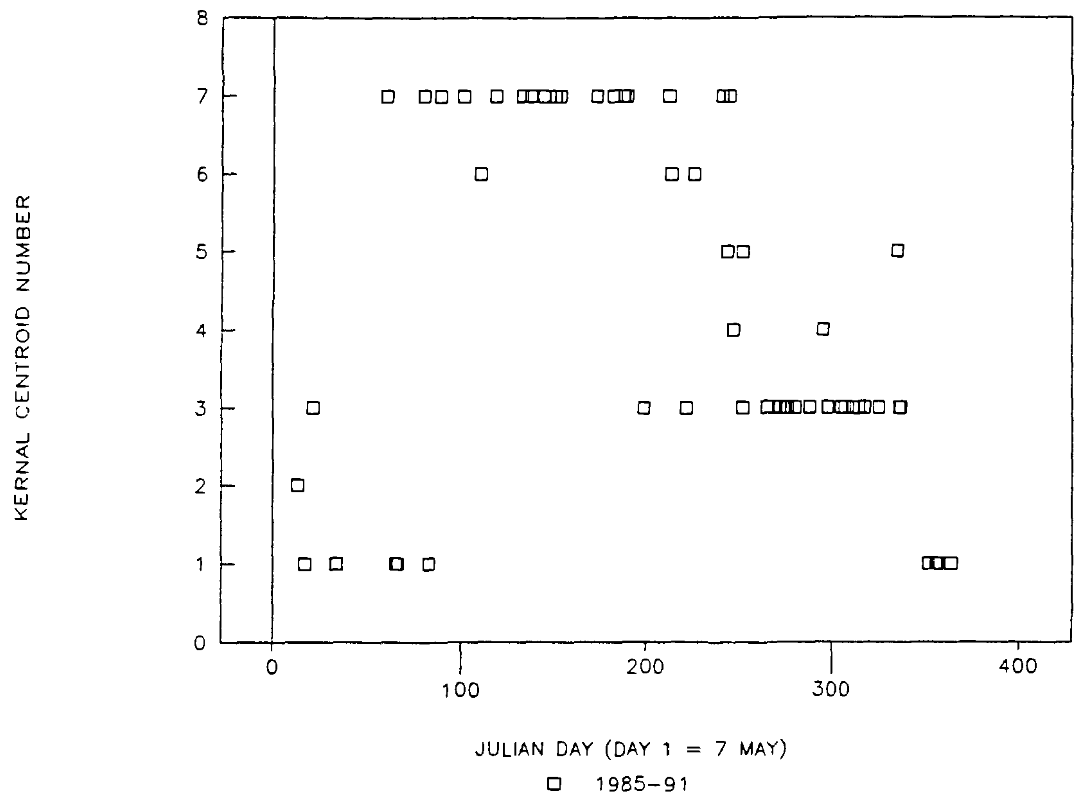


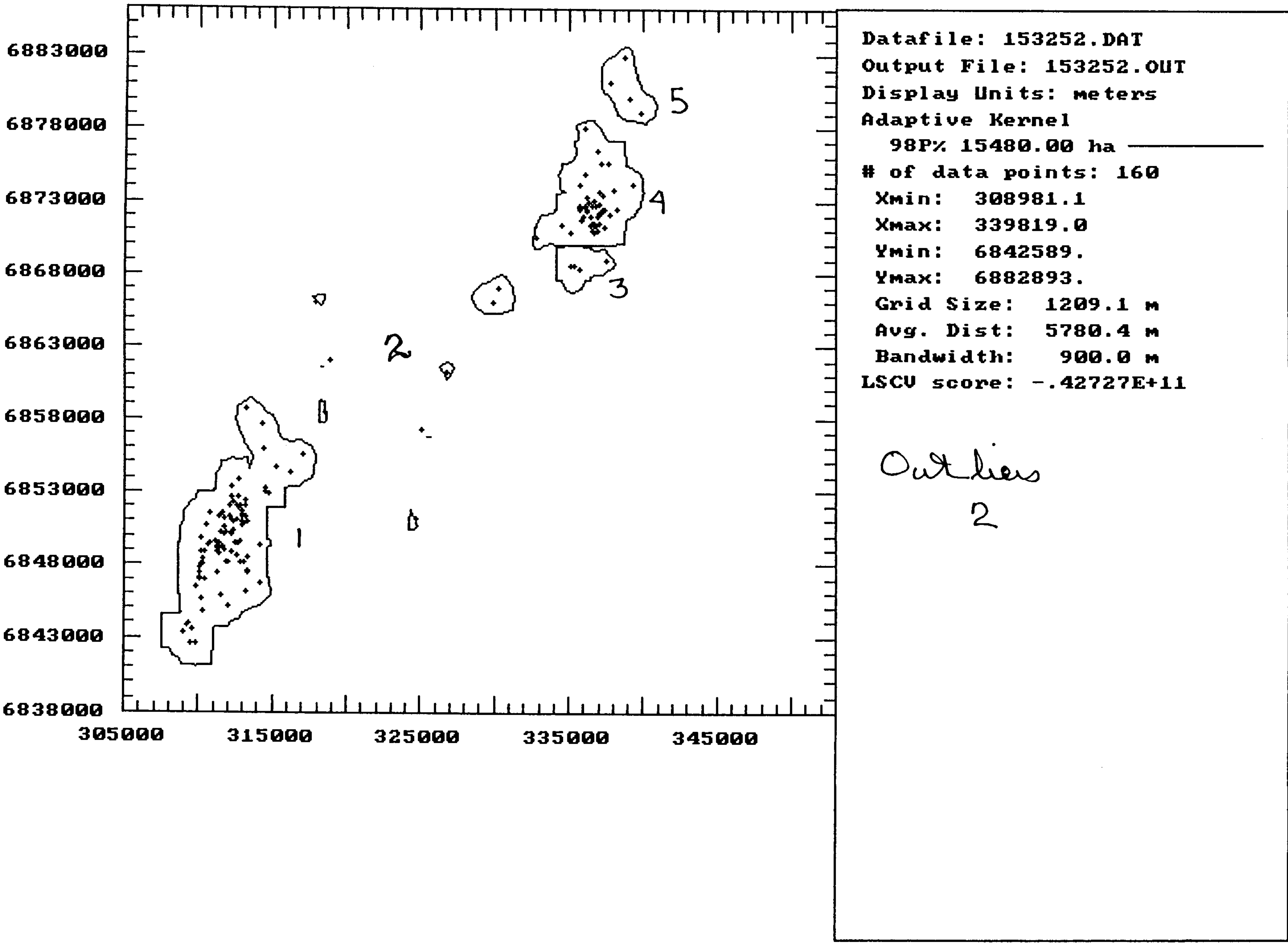
ID 153220 - 1988-89 (D:\CALHOME\153220)
CENTROIDS 1,2,3,4,5,6,7 AND 8
KERNAL CENTROID NUMBER
0
1
2
3
4
5
6
0
100
200
300
400
JULIAN DAY (DAY 1 = 7 MAY)
1988-89

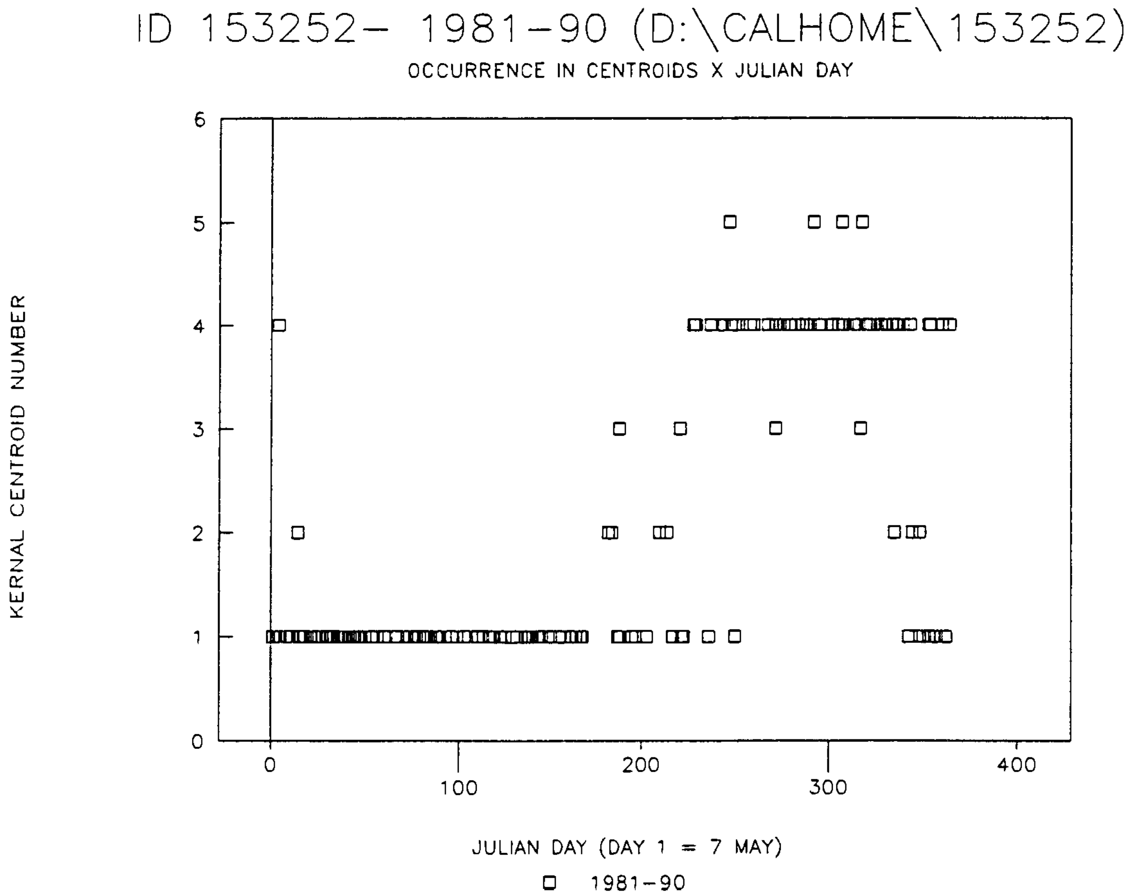

Datafile: 153242.DAT
Output File: 153242.OUT
Display Units: meters
Adaptive Kernel
98P% 5873.000 ha
# of data points: 54
Xmin: 331140.1
Xmax: 365053.3
Ymin: 6866505.
Ymax: 6879732.
Grid Size: 1017.4 m
Avg. Dist: 5877.7 m
Bandwidth: 700.0 m
LSCV score: -.39362E+10
6904000
6899000
6894000
6889000
6884000
6879000
6874000
6869000
6864000
328000
338000
348000
358000

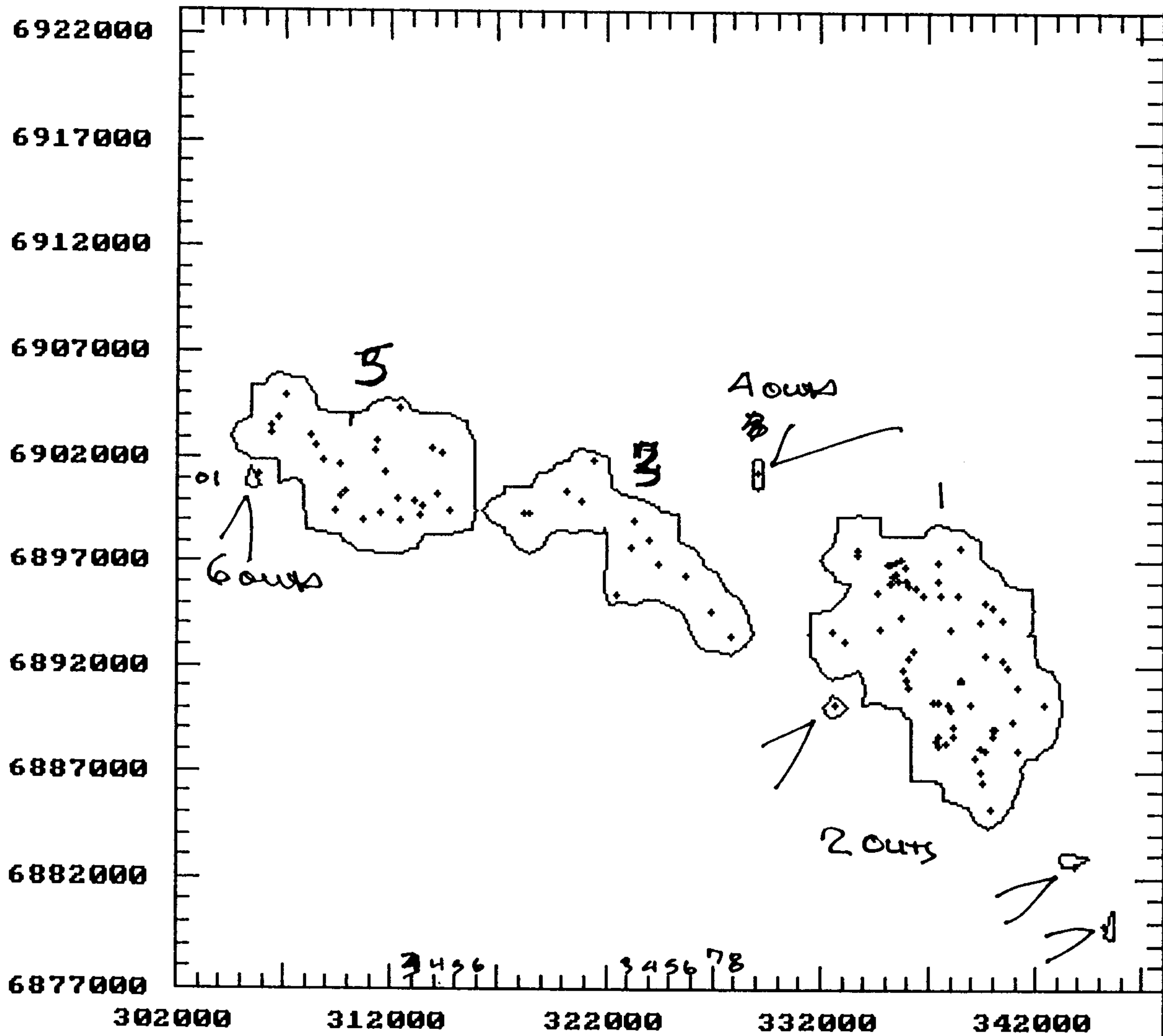
ID 153242 – 1985–91 (D:\CALHOME\15242)

OCCURRENCE IN CENTROID X JULIAN DAY



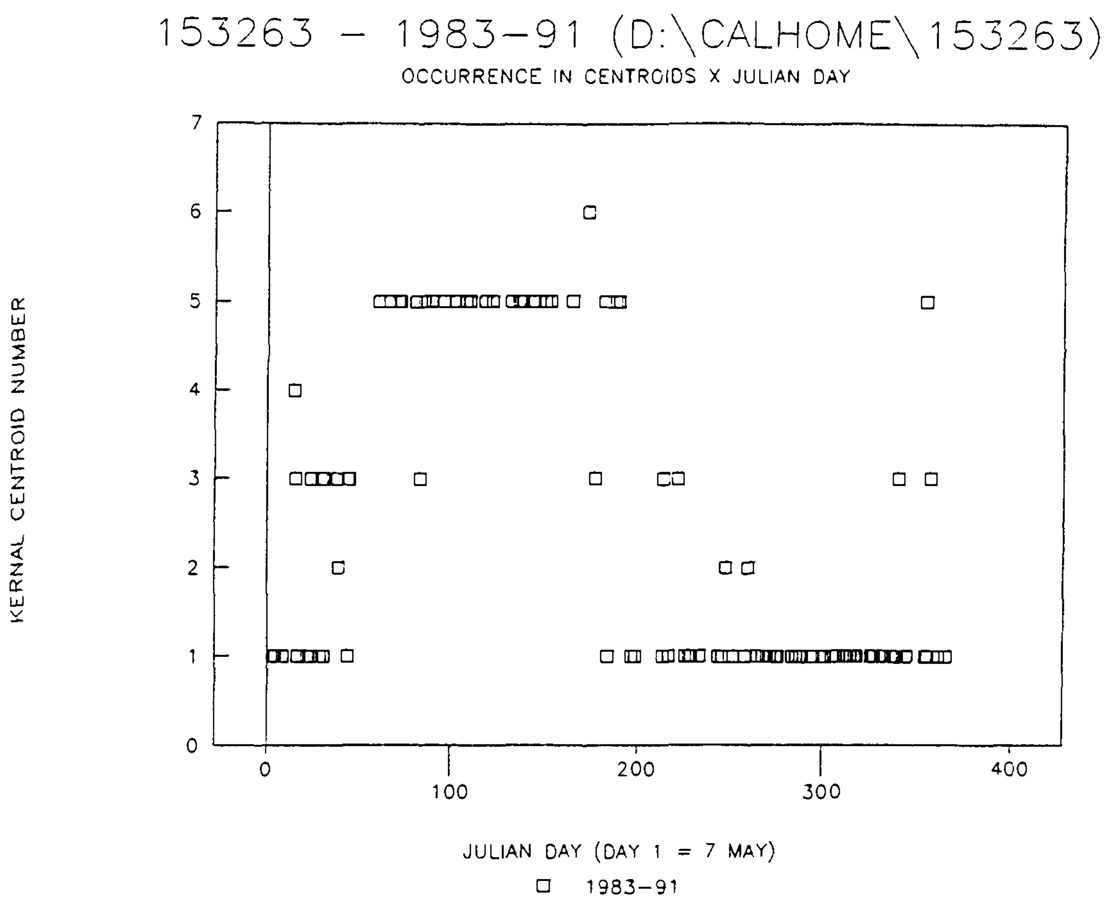

6883000
6878000
6873000
6868000
6863000
6858000
6853000
6848000
6843000
6838000
305000
315000
325000
335000
345000
1
2
3
4
5
Datafile: 153252.DAT
Output File: 153252.OUT
Display Units: meters
Adaptive Kernel
98P% 15480.00 ha
# of data points: 160
Xmin: 308981.1
Xmax: 339819.0
Ymin: 6842589.
Ymax: 6882893.
Grid Size: 1209.1 m
Avg. Dist: 5780.4 m
Bandwidth: 900.0 m
LSCV score: -.42727E+11
Outliers
2

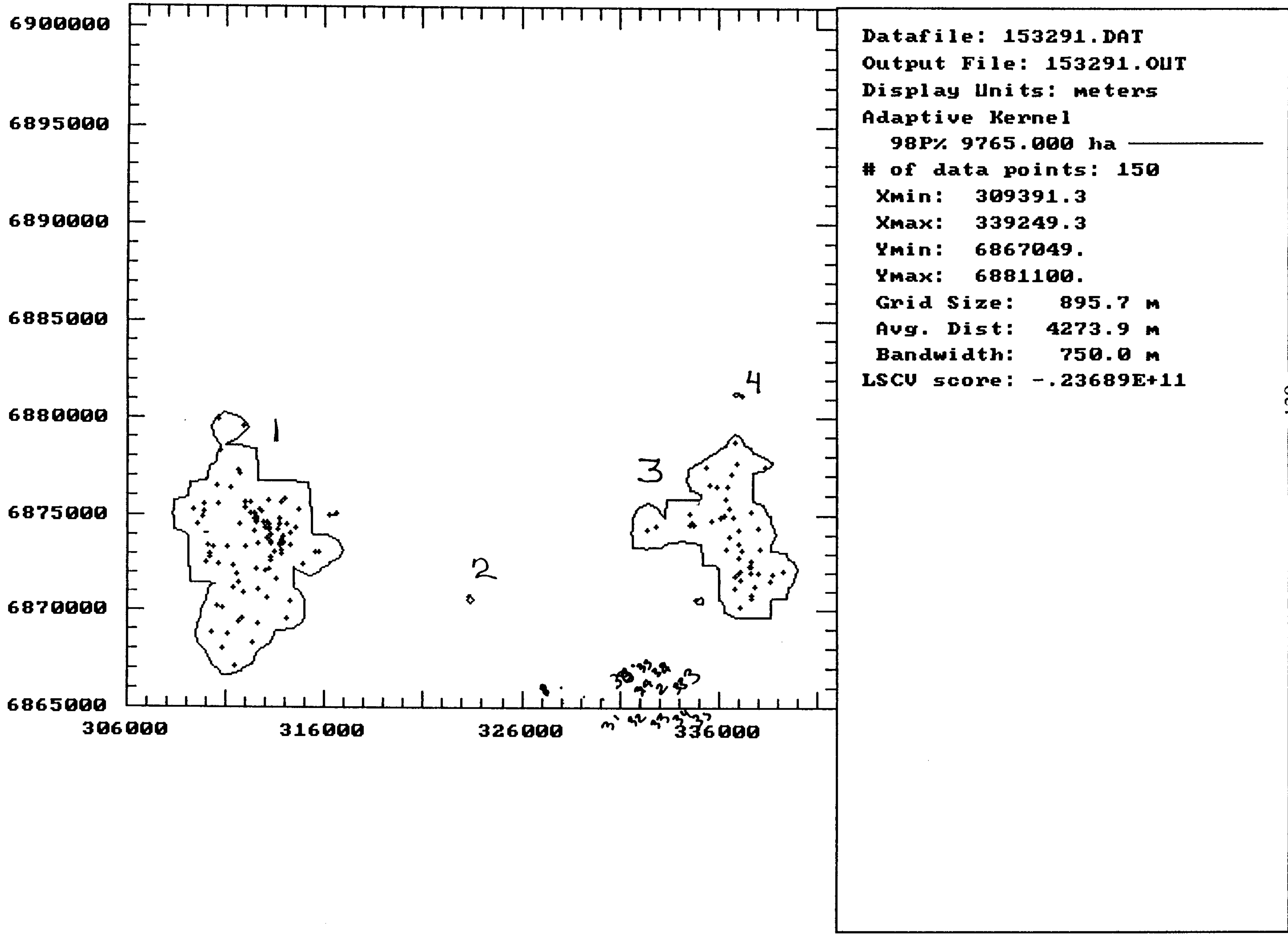

ID 153252- 1981-90 (D:\CALHOME\153252)
OCCURRENCE IN CENTROIDS X JULIAN DAY
KERNAL CENTROID NUMBER
0
1
2
3
4
5
6
0
100
200
300
400
JULIAN DAY (DAY 1 = 7 MAY)
1981-90



Datafile: 153263.DAT
Output File: 153263.OUT
Display Units: meters
Adaptive Kernel
98P% 21390.00 ha
# of data points: 106
Xmin: 305822.3
Xmax: 345236.0
Ymin: 6879945.
Ymax: 6904880.
Grid Size: 1182.4 m
Avg. Dist: 6762.1 m
Bandwidth: 1300.0 m
LSCV score: -.16360E+11

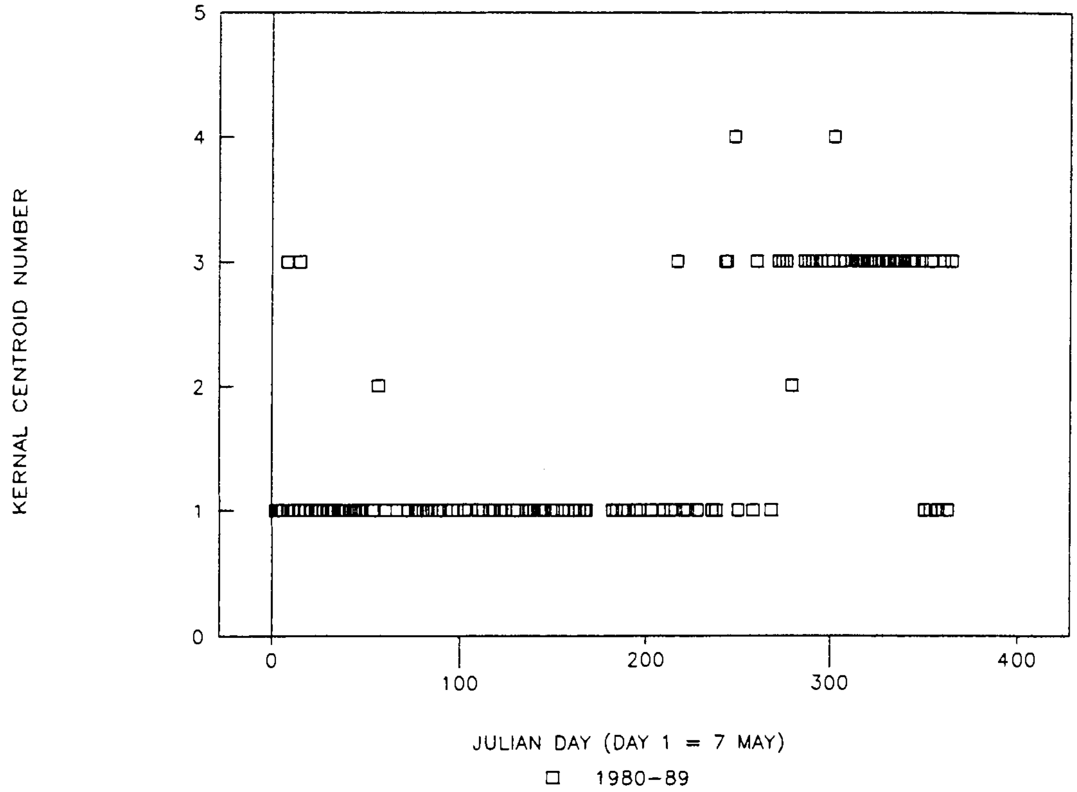
Outliers:
Centroid 2, 4, 6

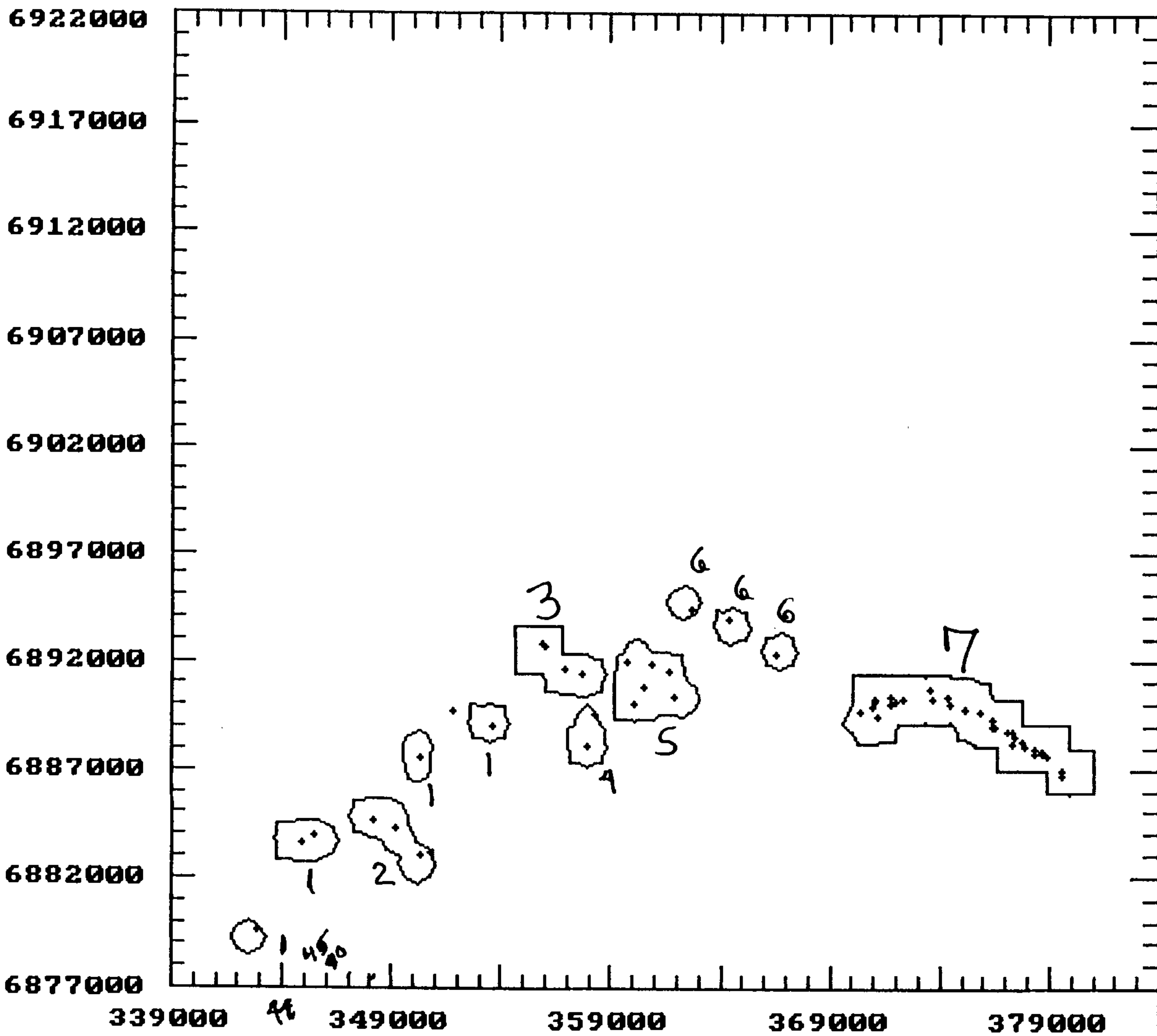

153263 - 1983-91 (D:\CALHOME\153263)
OCCURRENCE IN CENTROIDS X JULIAN DAY
KERNAL CENTROID NUMBER
JULIAN DAY (DAY 1 = 7 MAY)
1983-91


6900000
6895000
6890000
6885000
6880000
6875000
6870000
6865000
306000
316000
326000
336000
1
2
3
4
Datafile: 153291.DAT
Output File: 153291.OUT
Display Units: meters
Adaptive Kernel
98P% 9765.000 ha
# of data points: 150
Xmin: 309391.3
Xmax: 339249.3
Ymin: 6867049.
Ymax: 6881100.
Grid Size: 895.7 m
Avg. Dist: 4273.9 m
Bandwidth: 750.0 m
LSCV score: -.23689E+11

ID 153291– 1980–89 (D:\CALHOME\153291)

OCCURRENCE IN CENTROIDS X JULIAN DAY

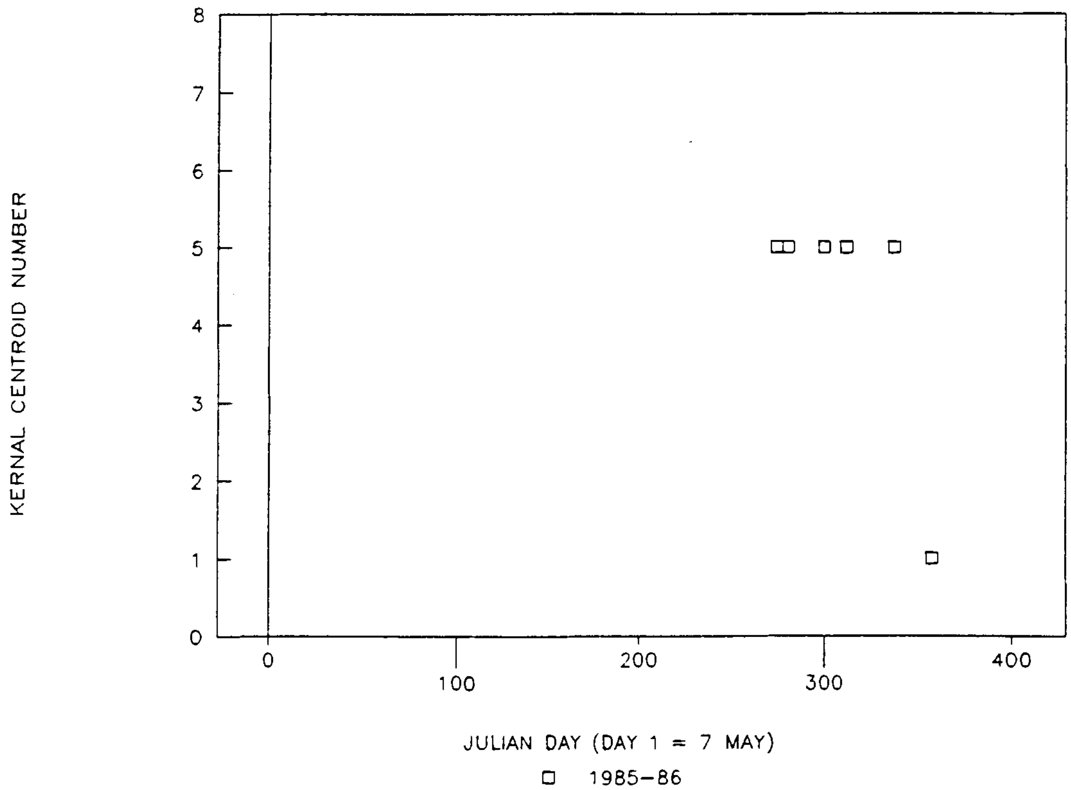


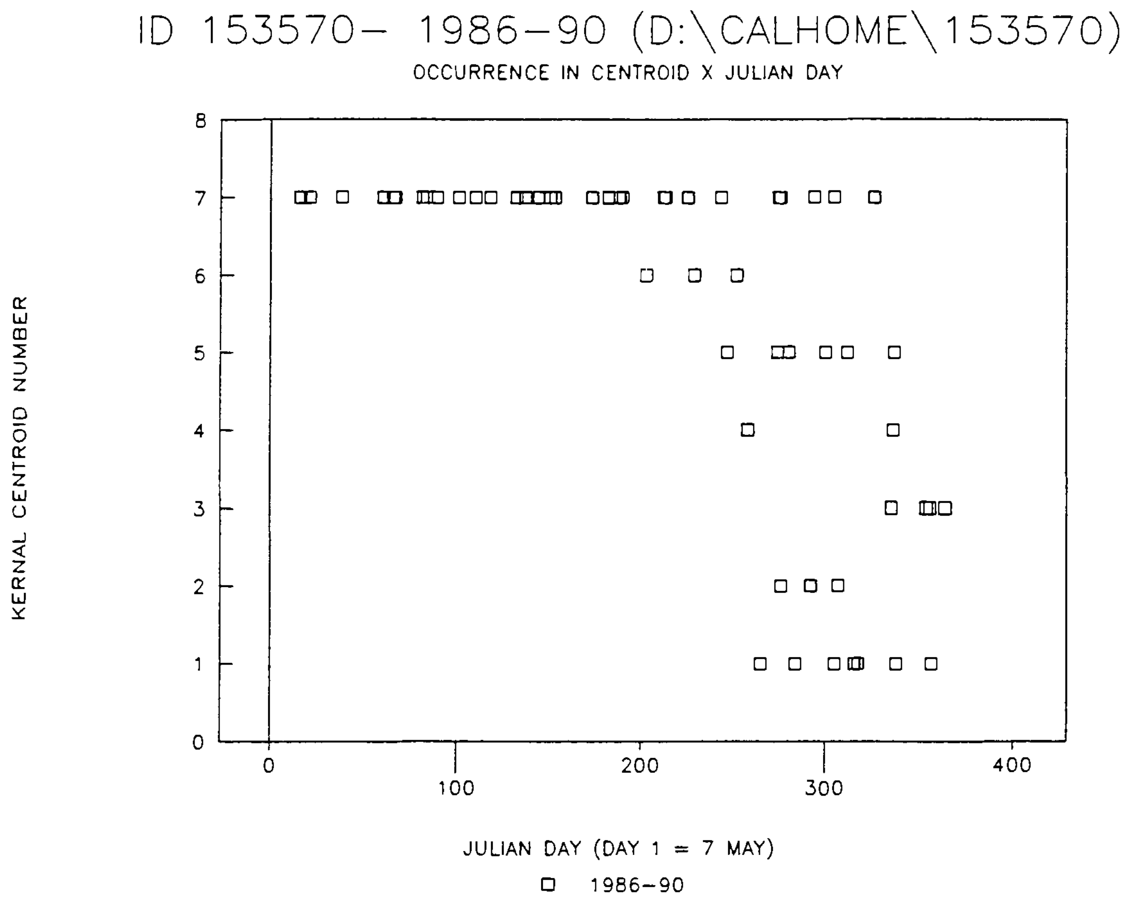


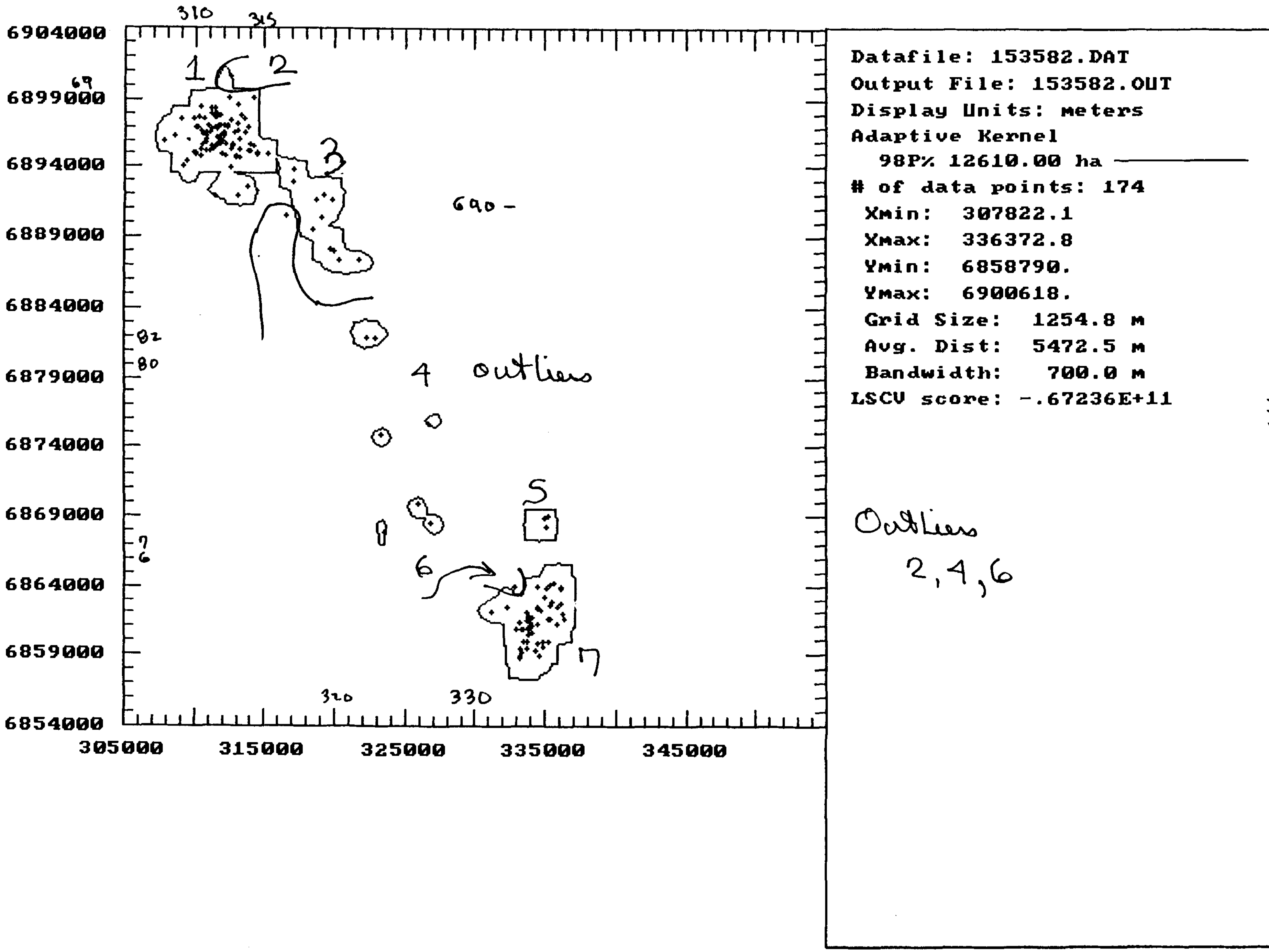
Datafile: 153570.DAT
Output File: 153570.OUT
Display Units: meters
Adaptive Kernel
98P% 7673.000 ha
# of data points: 56
Xmin: 342833.5
Xmax: 379604.0
Ymin: 6879552.
Ymax: 6894355.
Grid Size: 1103.1 m
Avg. Dist: 6572.1 m
Bandwidth: 700.0 m
LSCV score: -.25996E+11

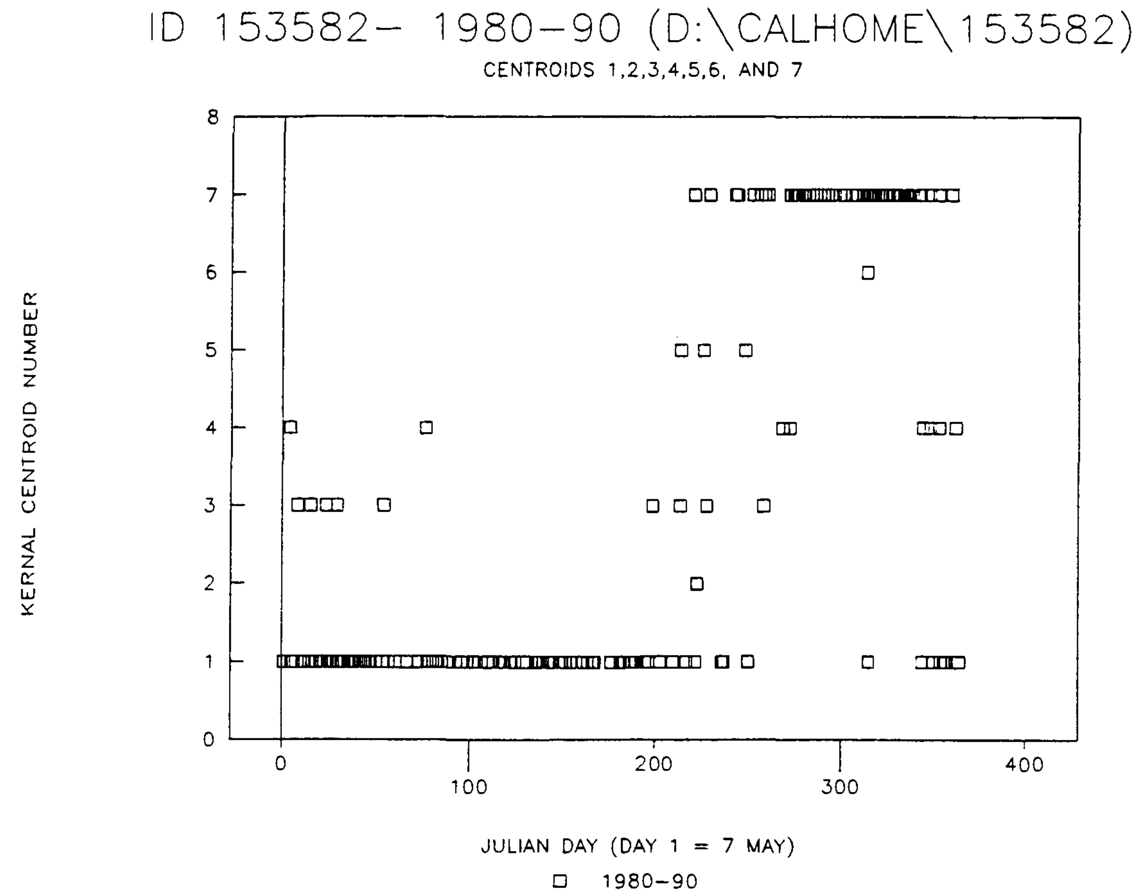
ID 153570– 1985–86 (D:\CALHOME\153570)

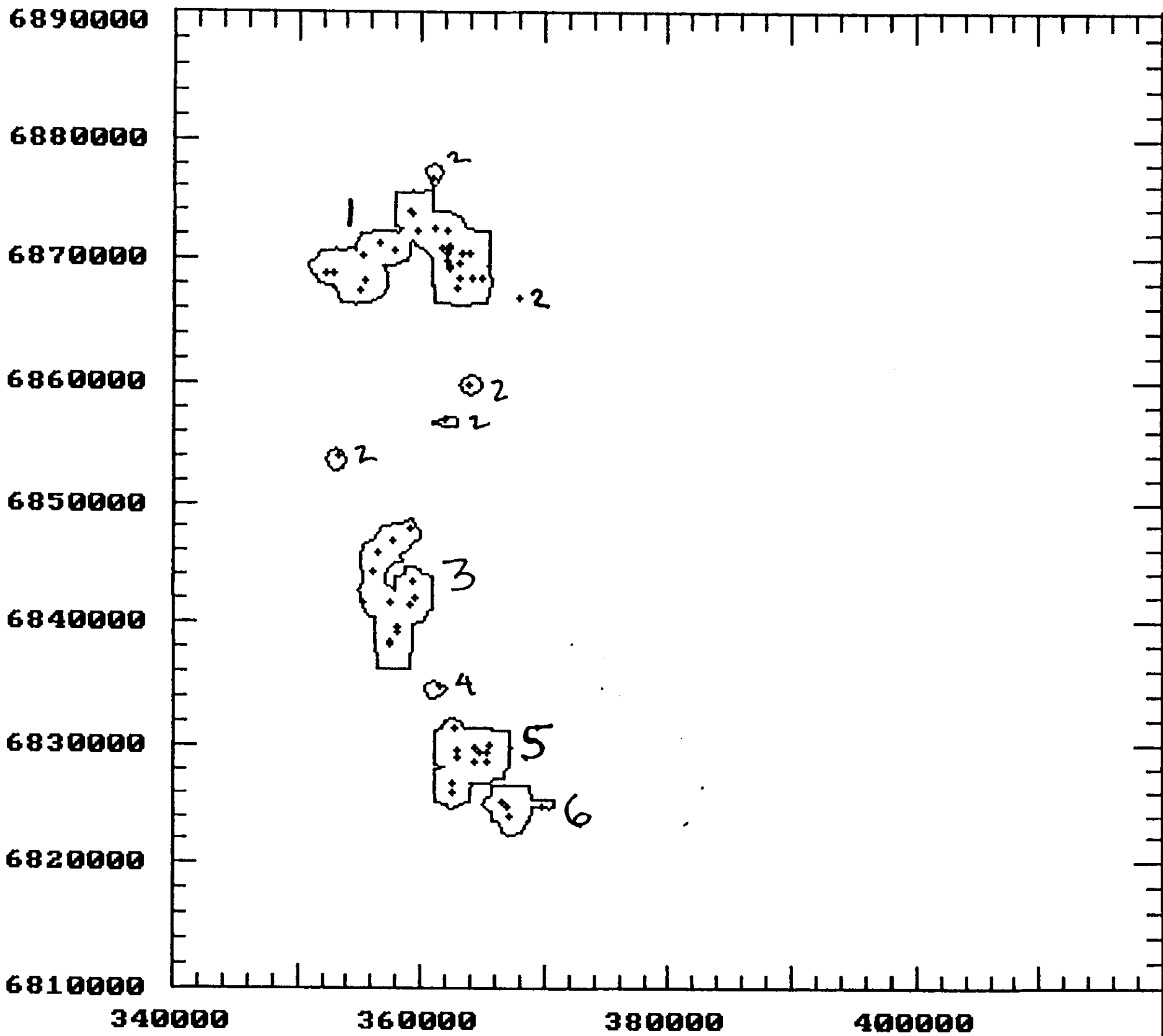
OCCURRENCE IN CENTROID X JULIAN DAY




ID 153570- 1986-90 (D:\CALHOME\153570)
OCCURRENCE IN CENTROID X JULIAN DAY
KERNAL CENTROID NUMBER
0
1
2
3
4
5
6
7
8
0
100
200
300
400
JULIAN DAY (DAY 1 = 7 MAY)
1986-90

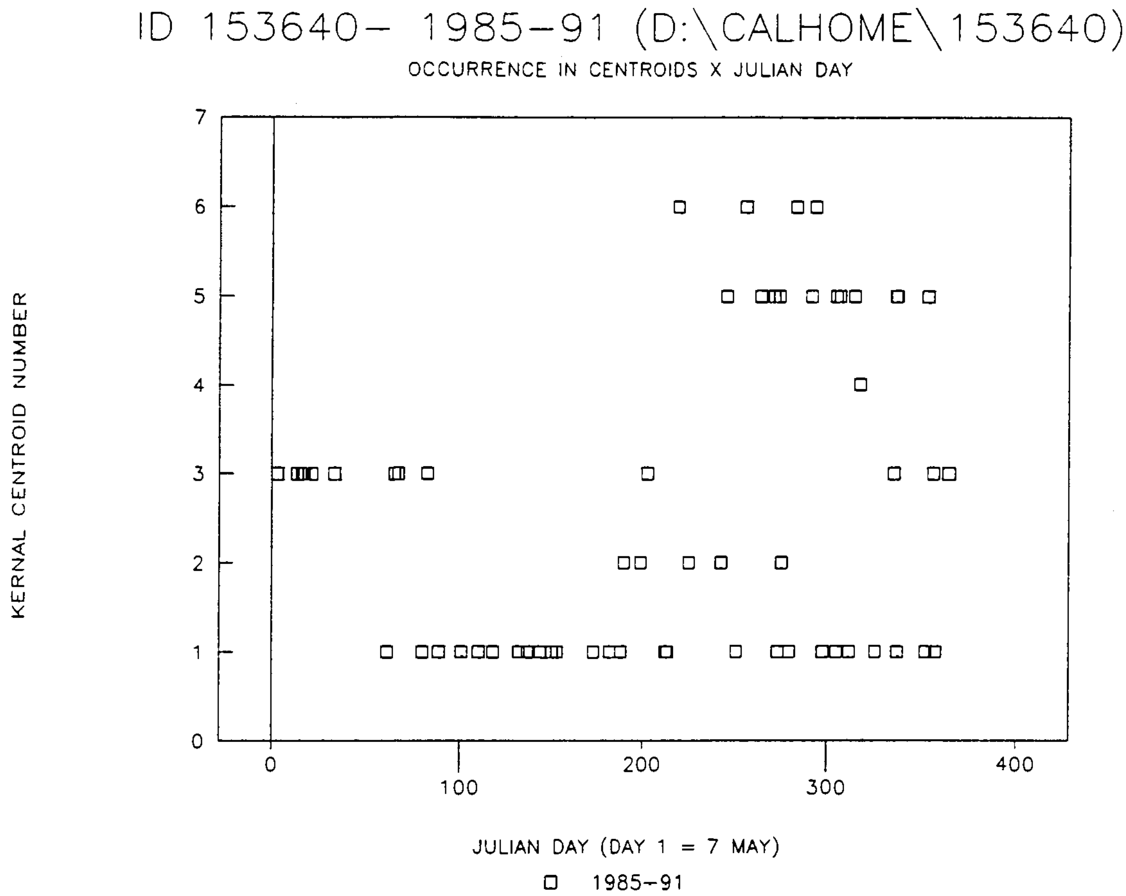

6904000
6899000
6894000
6889000
6884000
6879000
6874000
6869000
6864000
6859000
6854000
305000
315000
325000
335000
345000
1
2
3
4 outliers
5
6
7
310
315
320
330
690 -
Datafile: 153582.DAT
Output File: 153582.OUT
Display Units: meters
Adaptive Kernel
98P% 12610.00 ha
# of data points: 174
Xmin: 307822.1
Xmax: 336372.8
Ymin: 6858790.
Ymax: 6900618.
Grid Size: 1254.8 m
Avg. Dist: 5472.5 m
Bandwidth: 700.0 m
LSCV score: -.67236E+11
Outliers
2,4,6

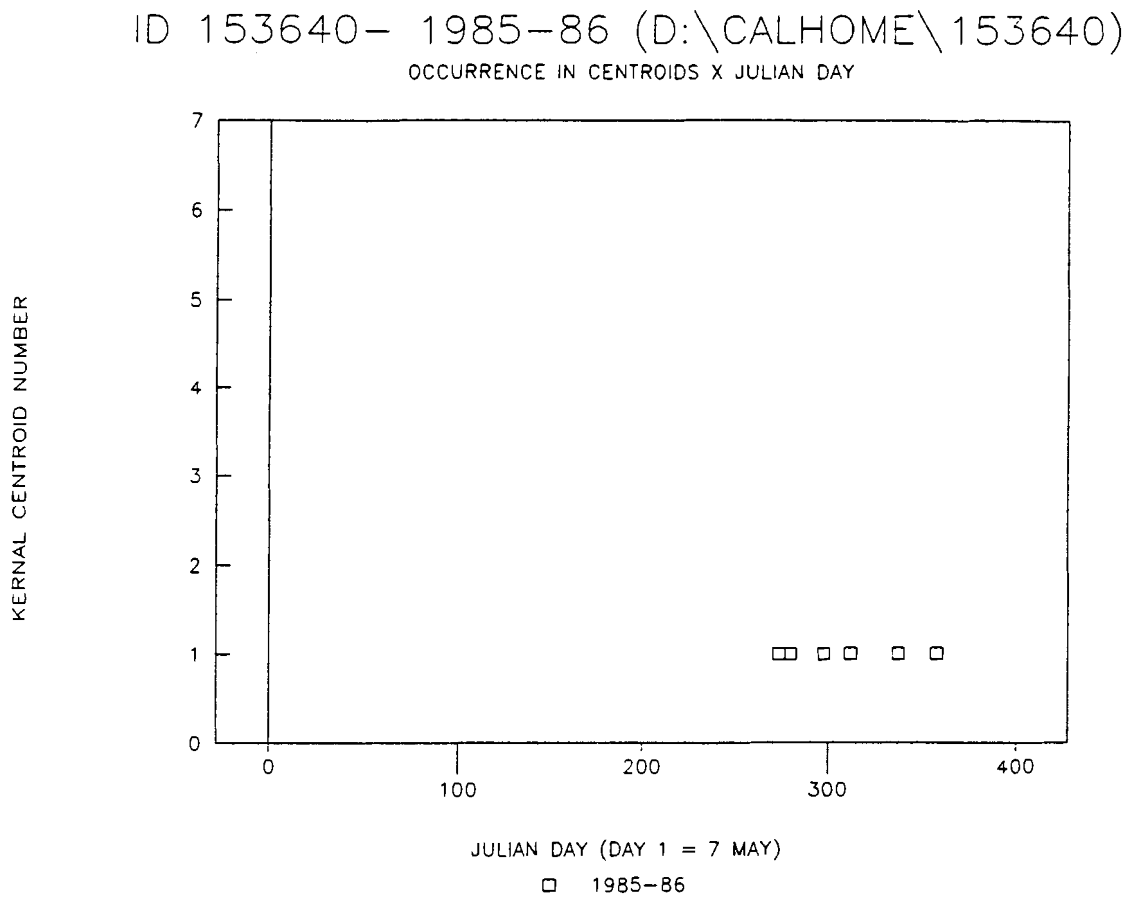

ID 153582- 1980-90 (D:\CALHOME\153582)
CENTROIDS 1,2,3,4,5,6, AND 7
KERNAL CENTROID NUMBER
0
1
2
3
4
5
6
7
8
0
100
200
300
400
JULIAN DAY (DAY 1 = 7 MAY)
1980-90

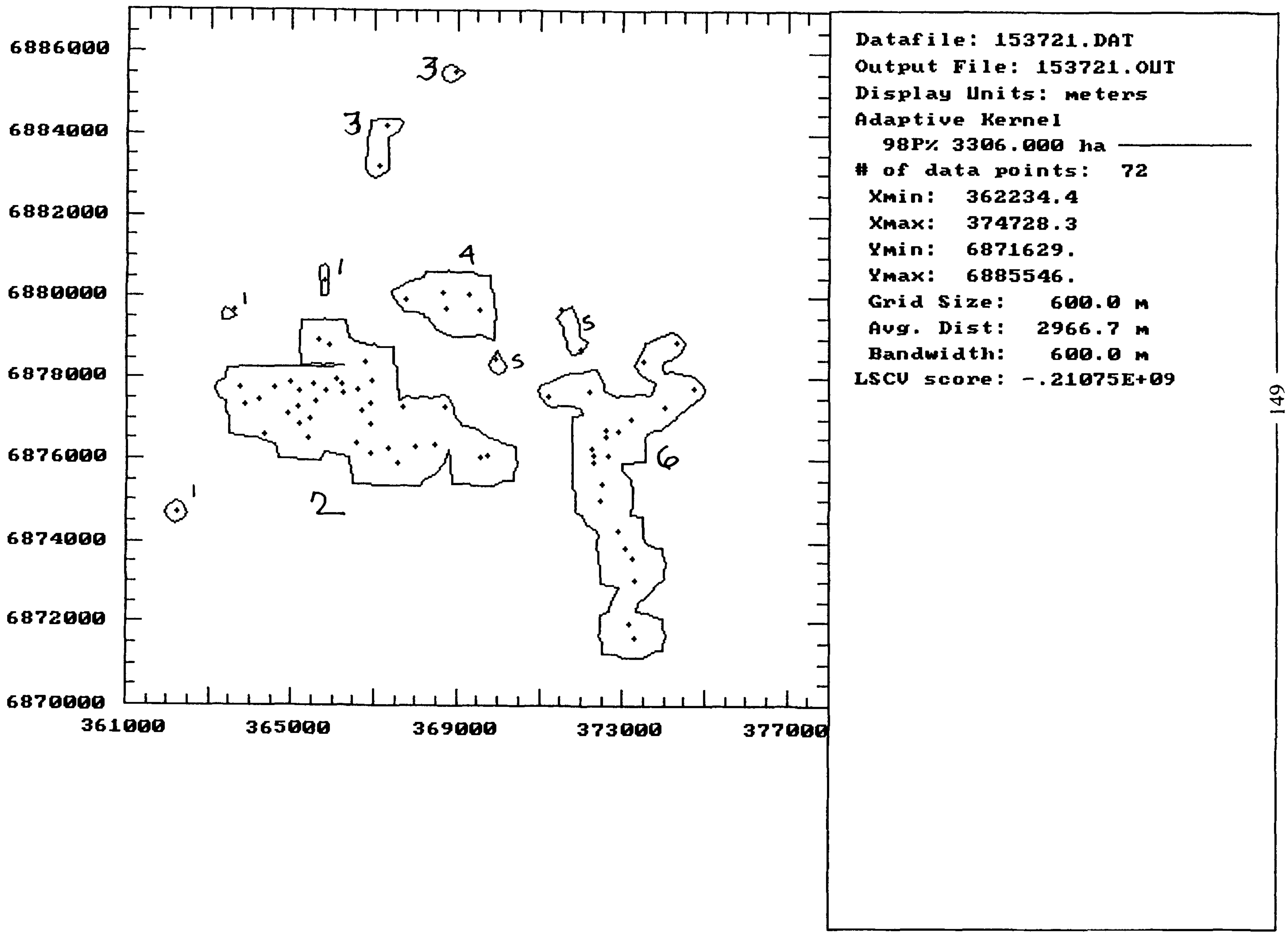


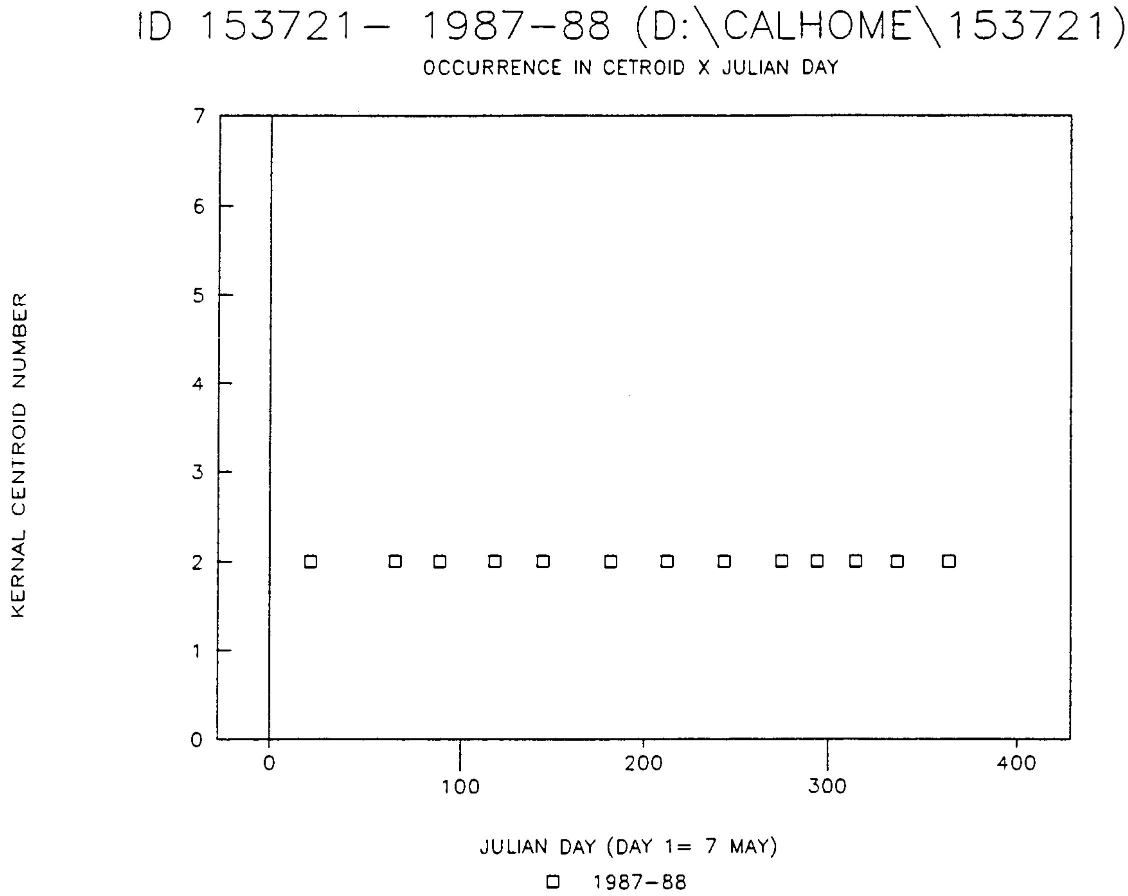
Datafile: 153640.DAT
Output File: 153640.OUT
Display Units: meters
Adaptive Kernel
98P% 17410.00 ha
# of data points: 60
Xmin: 352284.4
Xmax: 369768.3
Ymin: 6823941.
Ymax: 6876743.
Grid Size: 1584.0 m
Avg. Dist: 7856.7 m
Bandwidth: 1300.0 m
LSCV score: -.27025E+11

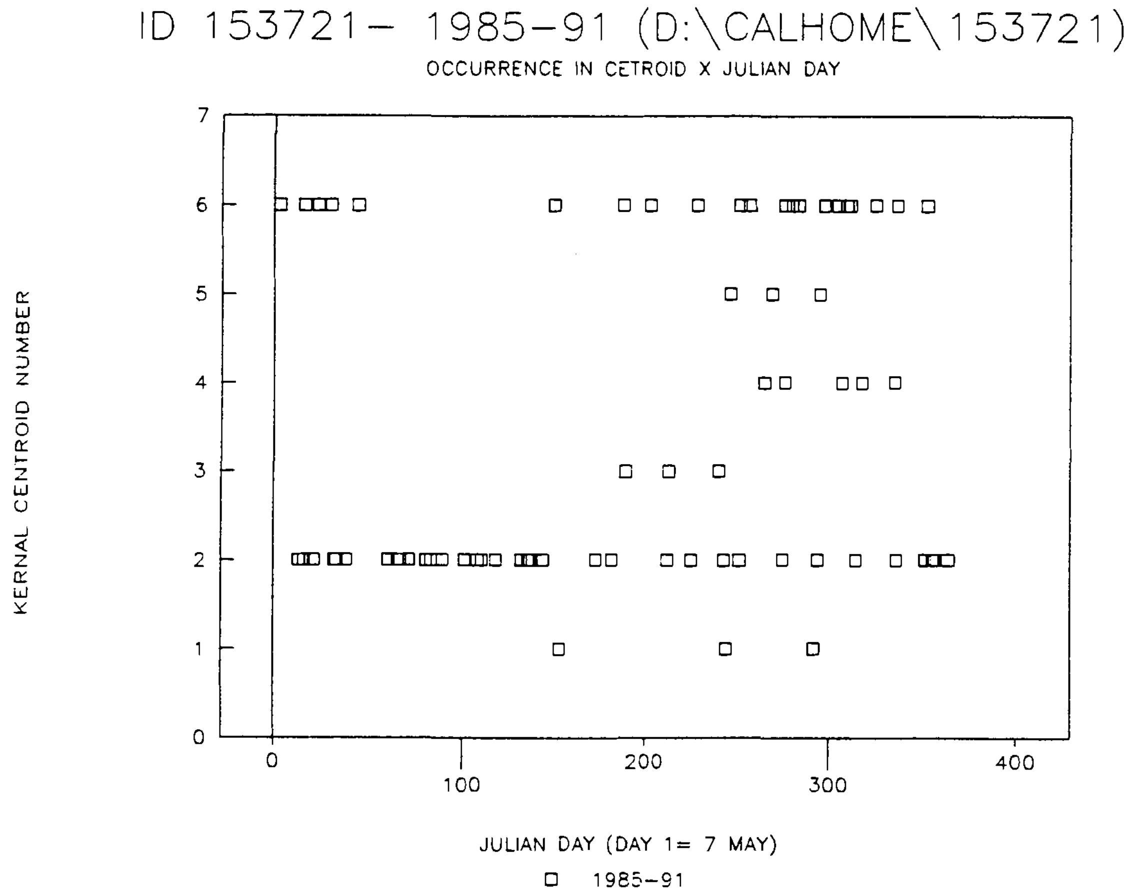
Outliers
2, 4


ID 153640– 1985–91 (D:\CALHOME\153640)
OCCURRENCE IN CENTROIDS X JULIAN DAY
KERNAL CENTROID NUMBER
0
1
2
3
4
5
6
7
0
100
200
300
400
JULIAN DAY (DAY 1 = 7 MAY)
1985–91

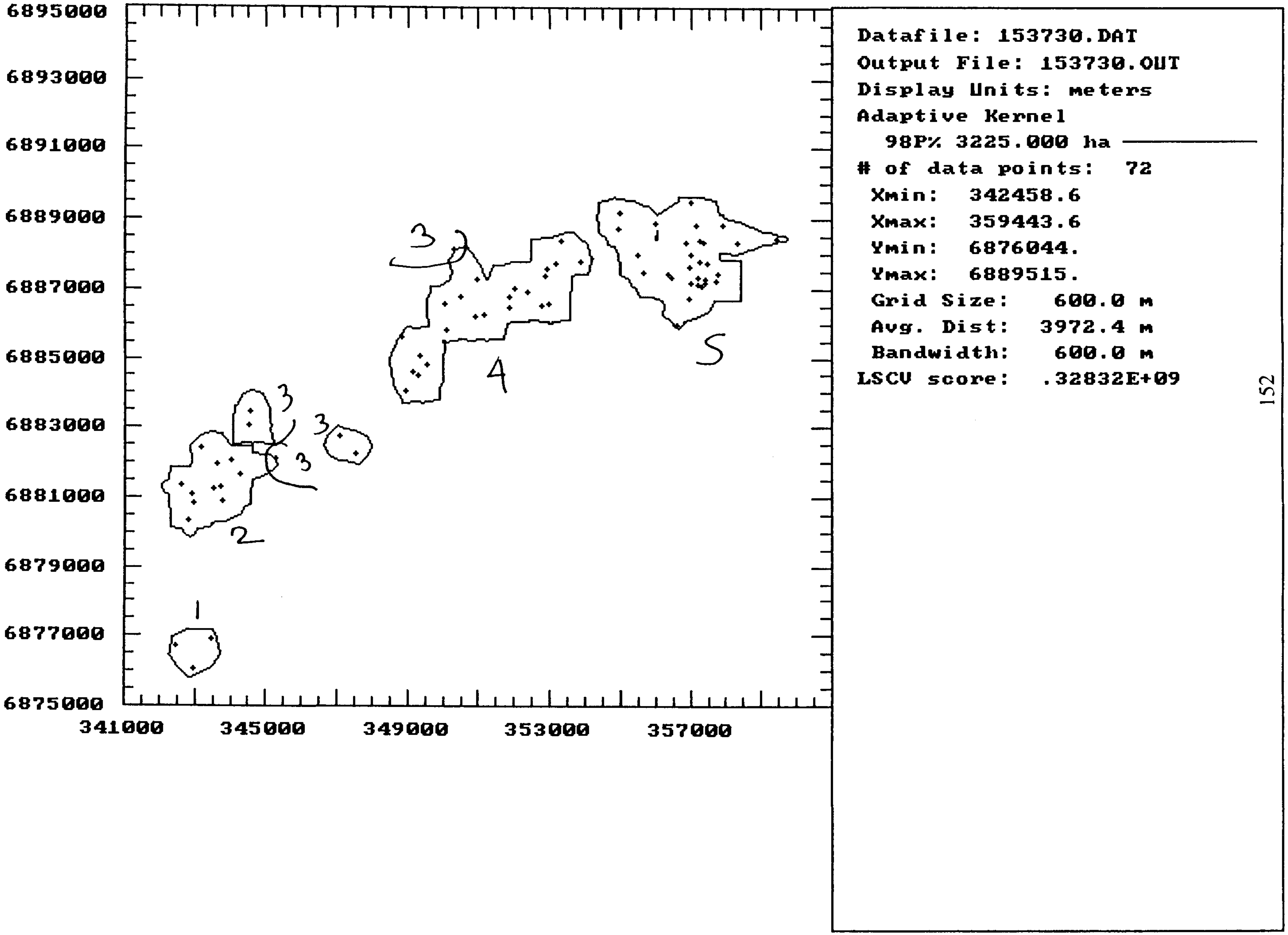

ID 153640– 1985–86 (D:\CALHOME\153640)
OCCURRENCE IN CENTROIDS X JULIAN DAY
KERNAL CENTROID NUMBER
7
6
5
4
3
2
1
0
0
100
200
300
400
JULIAN DAY (DAY 1 = 7 MAY)
1985–86


6886000
6884000
6882000
6880000
6878000
6876000
6874000
6872000
6870000
361000
365000
369000
373000
377000
Datafile: 153721.DAT
Output File: 153721.OUT
Display Units: meters
Adaptive Kernel
98P% 3306.000 ha
# of data points: 72
Xmin: 362234.4
Xmax: 374728.3
Ymin: 6871629.
Ymax: 6885546.
Grid Size: 600.0 m
Avg. Dist: 2966.7 m
Bandwidth: 600.0 m
LSCV score: -.21075E+09

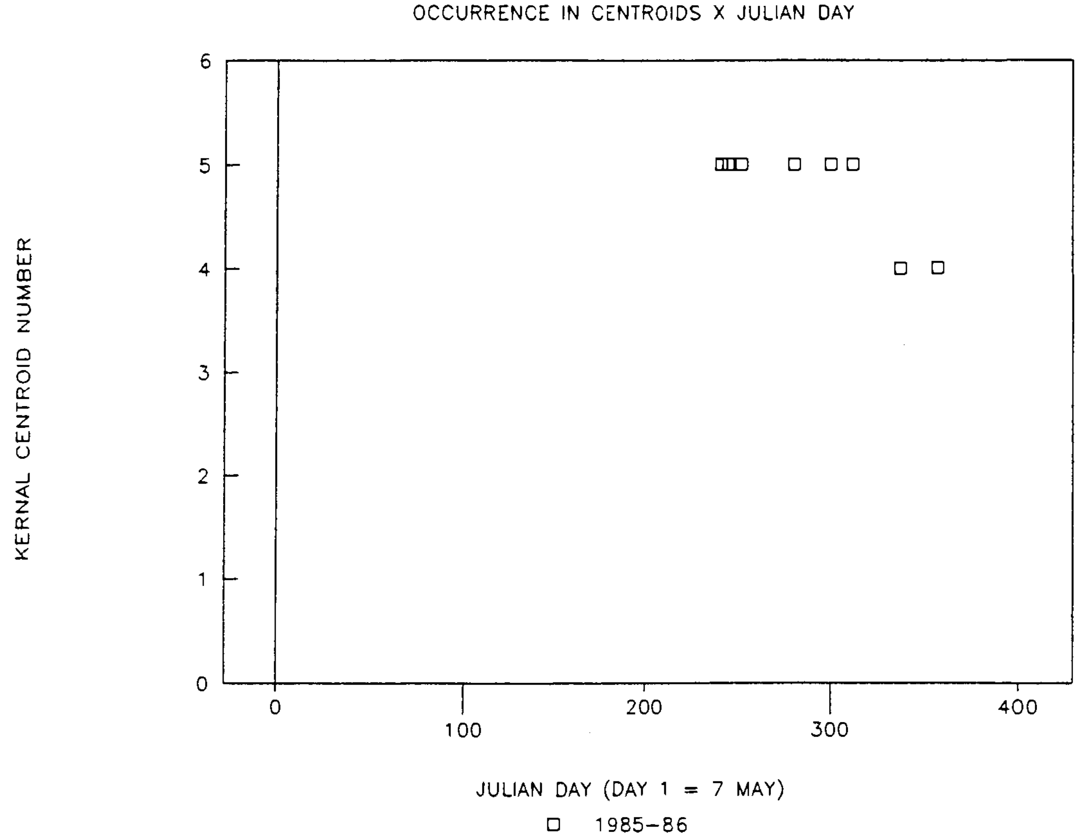

ID 153721- 1987-88 (D:\CALHOME\153721)
OCCURRENCE IN CETROID X JULIAN DAY
KERNAL CENTROID NUMBER
0
1
2
3
4
5
6
7
0
100
200
300
400
JULIAN DAY (DAY 1= 7 MAY)
1987-88

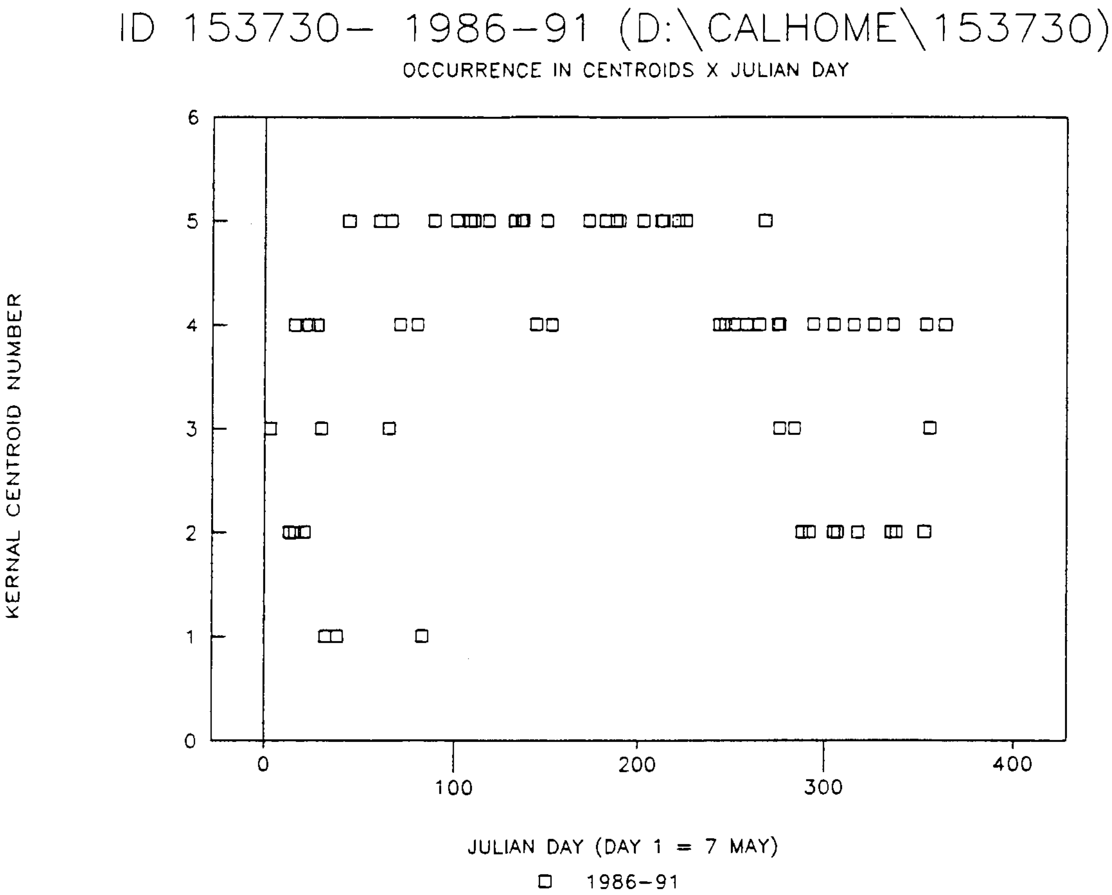


ID 153721- 1985-91 (D:\CALHOME\153721)
OCCURRENCE IN CETROID X JULIAN DAY
KERNAL CENTROID NUMBER
0
1
2
3
4
5
6
7
0
100
200
300
400
JULIAN DAY (DAY 1= 7 MAY)
1985-91

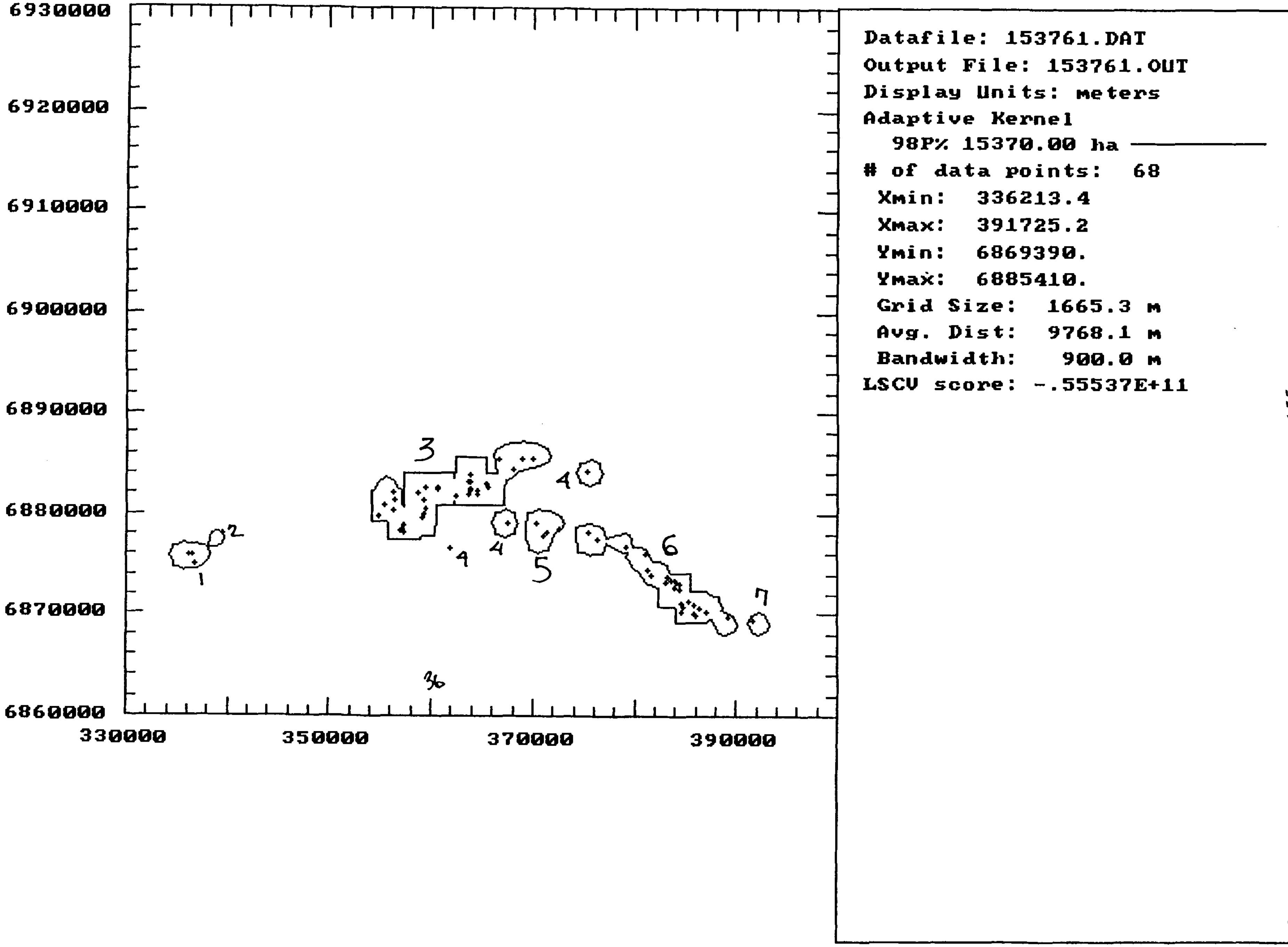

6895000
6893000
6891000
6889000
6887000
6885000
6883000
6881000
6879000
6877000
6875000
341000
345000
349000
353000
357000
1
2
3
3
3
3
3
4
5
Datafile: 153730.DAT
Output File: 153730.OUT
Display Units: meters
Adaptive Kernel
98P% 3225.000 ha
# of data points: 72
Xmin: 342458.6
Xmax: 359443.6
Ymin: 6876044.
Ymax: 6889515.
Grid Size: 600.0 m
Avg. Dist: 3972.4 m
Bandwidth: 600.0 m
LSCV score: .32832E+09

ID 153730- 1985-86 (D:\CALHOME\153730)

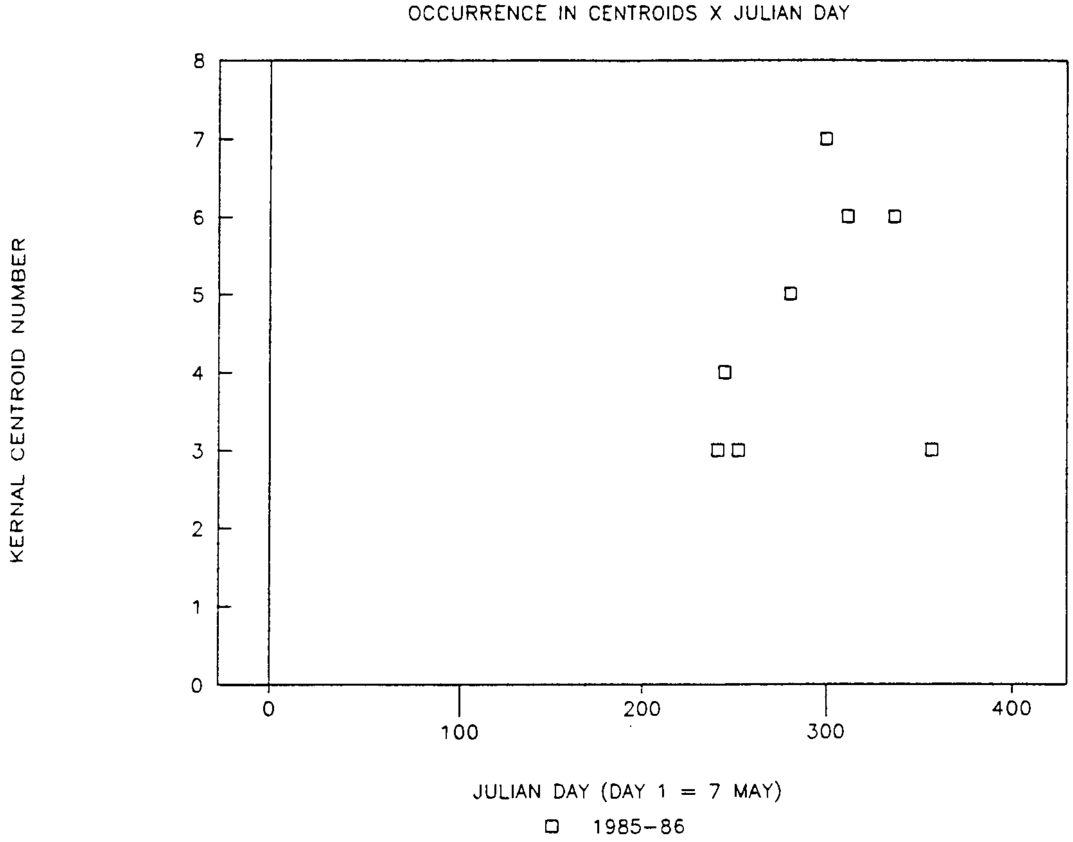


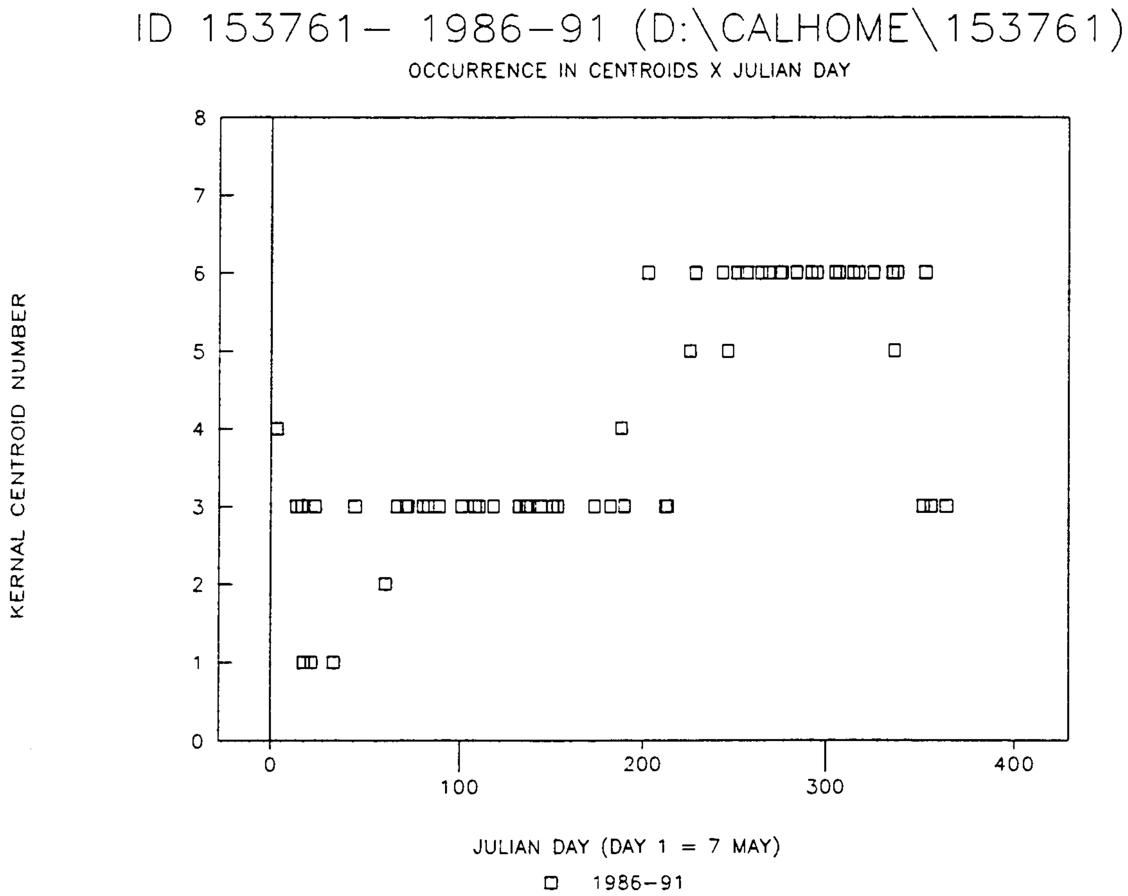


ID 153730– 1986–91 (D:\CALHOME\153730)
OCCURRENCE IN CENTROIDS X JULIAN DAY
KERNAL CENTROID NUMBER
0
1
2
3
4
5
6
0
100
200
300
400
JULIAN DAY (DAY 1 = 7 MAY)
1986–91


6930000
6920000
6910000
6900000
6890000
6880000
6870000
6860000
330000
350000
370000
390000
Datafile: 153761.DAT
Output File: 153761.OUT
Display Units: meters
Adaptive Kernel
98P% 15370.00 ha
# of data points: 68
Xmin: 336213.4
Xmax: 391725.2
Ymin: 6869390.
Ymax: 6885410.
Grid Size: 1665.3 m
Avg. Dist: 9768.1 m
Bandwidth: 900.0 m
LSCV score: -.55537E+11

ID 153761– 1985–86 (D:\CALHOME\153761)




ID 153761– 1986–91 (D:\CALHOME\153761)
OCCURRENCE IN CENTROIDS X JULIAN DAY
KERNAL CENTROID NUMBER
0
1
2
3
4
5
6
7
8
0
100
200
300
400
JULIAN DAY (DAY 1 = 7 MAY)
1986–91

IN UTERO PREGNANCY RATE, TWINNING RATE AND FETUS PRODUCTION FOR AGE-GROUPS OF COW MOOSE IN SOUTH-CENTRAL ALASKA

Ronald D. Modafferi

Alaska Department of Fish and Game, 1800 Glenn Highway, Suite 4, Palmer, AK 99645

ABSTRACT: The relationship of reproductive parameters (i.e., pregnancy rate, twinning rate and fetus production) to 5 age-groups (calf = C, yearling = Y, teen = T, prime = P and senior = S) of cow moose (*Alces alces*) were investigated. Age-class and *in utero* fetus counts from 895 cow moose killed in 14 area-specific antlerless/cow-moose hunts (year/area (Y/A) samples) during November-February, 1964 to 1974, in south-central Alaska were analyzed. Measures of central tendency and dispersion were used to characterize the reproductive parameters in each age-group classification. There was evidence of age-group effects on pregnancy rate ($P = 0.0000$). None of the C moose examined carried a fetus(es). Age-groups ordered by pregnancy rate were Y < T < S < P. The difference in pregnancy rate between P and S age-groups was not statistically significant ($P = 0.1019$). Y/A effects on pregnancy status were insignificant ($P = 0.8414$). There was evidence of age-group effects ($P = 0.0001$) and Y/A effects ($P = 0.0001$) on occurrence of twinning. None of the Y age-group moose examined carried twin fetuses. Age-groups ordered by twinning rate were T < S < P. The difference in twinning rate between T and P age-groups was statistically significant ($P = 0.05$). Age-groups ordered by fetus production (fetuses/100 cows) were Y < T < S < P. Based on the reproductive parameters studied, cow moose attain their maximum productivity after 3-years-of-age. Findings emphasize the importance of considering cow moose reproductive maturity in measuring productivity, interpreting information on productivity, modeling moose population dynamics and implementing selective harvests of cow moose.

ALCES VOL. 28 (1992) pp. 223-234

Simulation models are becoming important tools in everyday management of moose (Page 1987). Population models highlight parameters that are basic and important in understanding moose population dynamics (Karns 1987). Productivity parameters are important, basic components in models of moose population dynamics and in management of moose populations (Simkin 1974, Verme 1974, Moen and Ausenda 1987). Quantitative information on some moose productivity parameters is scarce (Karns 1987, Crichton 1988). Refinements in knowledge about parameters of moose productivity will improve the quality of moose population models and lead to better moose management decisions. In this study, I was not particularly concerned with Y/A effects on cow moose productivity. Rather, the purpose of my study was to: (1) consolidate and analyze archived information on productivity parameters for cow moose in south-central Alaska, (2) explore relationships between productivity parameters and age-class based age-groups and (3) provide moose managers, who are most familiar with net productivity in fall in the form of ratios of calves to adult cows, with baseline information on moose gross productivity.

STUDY AREA

Moose hunts took place in south-central Alaska (Fig. 1). The area included Alaska Game Management Unit (GMU) 7 and Game Management Subunits (GMS) 14A, 14B, 14C, 15A, 15B and 15C. Management Units 7, 15A, 15B and 15C were located on the Kenai Peninsula (Kenai). GMSs 14A and 14B were located in the Matanuska and Susitna River valleys (Mat-Su). The Ft. Richardson hunt area (Ft. Rich) was located in GMS 14C near Anchorage. The Kenai, Mat-Su and Ft. Rich

Appendix H. Draft of manuscript entitled "Survival of radiocollared adult moose in Lower Susitna valley, Southcentral Alaska."

21 July 1994
Ronald D. Modafferi
Alaska Department of Fish and Game
1800 Glenn Highway Suite 4
Palmer, AK 99645
907-745-6890

RH: Adult Moose Survival · Modafferi

SURVIVAL OF RADIO-COLLARED ADULT MOOSE IN LOWER SUSITNA VALLEY, SOUTHCENTRAL ALASKA

Ronald D. Modafferi, Alaska Department of Fish and Game, 1800 Glenn Highway, Suite 4, Palmer, AK 99645

Abstract: Estimates of natural survival for adult moose (*Alces alces*) are presented by sex, season, and year for 204 (66 males) radio-collared adult moose monitored with aircraft in lower Susitna Valley southcentral Alaska during 15 May 1980 through 25 February 1991. Deaths were attributed to capture problems, accidents, defense of life or property, hunter harvest, illegal harvest, train kill, winter kill and other. Hunter harvest and captured related deaths were censored from survival calculations; moose were also censored for loss of signal contact and shedding of collars. Survival varied by sex, season, and calendar year. Summer survival rates were high for both cows (0.98) and bulls (0.99). Survival in autumn was lower for bulls (0.89) than for cows (0.98). Survival in winter and annual survival were highly variable and affected largely by winter-kill deaths attributed to snow accumulations. Survival in winter differed widely among years for both bulls ($P < 0.001$) and cows ($P < 0.001$). Annual survival differed among years for both bulls ($P < 0.001$) and cows ($P < = 0.001$). Sightability varied by sex and season and was attributed to habitat structure, moose behavior, physiology, and nutritive condition. Lower survival of cows (0.98) versus bulls (0.99) during summer was attributed to bear predation on parturient cows and cows with neonates. Lower survival of bulls (0.89) versus cows (0.98) in autumn was ascribed to bullet wounding, illegal harvest, and fatal encounters with bears. Low and highly variable levels of survival in bulls (0.33 to 1.00) and cows (0.70 to 1.00) in winter and large differences in survival of bulls (0.29 to 1.00) and cows (0.65 to 0.99) among years were attributed mainly to snow accumulations. Moose managers must be cognizant of snow conditions through winter to accurately predict size and composition of pre-hunt populations and annual survival. Moose management programs must be sufficiently responsive to modify autumn harvest quotas in accordance with survival data obtained during the previous winter after standard post-hunt population surveys are conducted.

J. WILDL. MANAGE. 00(0):000-000

Key words: adult moose, *Alces alces*, mortality, southcentral Alaska, survival

---

Survival characteristics may provide important insight into factors affecting population change. Ultimately, survival data can be used to model population dynamics thereby strengthening management decisions. As indicated by Van Ballenberghe (1983), the literature contains few estimates of adult moose survival rates. Karns (1987) indicates that estimates of survival rate for adult moose (Mercer and Manuel 1974; Peterson 1977; Hauge and Keith 1981, Mytton and Keith 1981, Gasaway et al. 1983) was less common than for calf moose. Recent literature on survival of moose includes Boar (1988), Bangs et al. (1989) and Larsen et al. (1989). Accidents, disease, habitat, hunting, parasites, pests, poaching, and weather are factors that influence moose survival (Crichton 1987, Lankester 1987).

The purpose of this study was to provide information on the non-hunting aspects of survival of radio-collared adult moose.

I especially thank staff of the Alaska Department of Fish and Game (ADF&G) for helping with various aspects of this study. E. B. Becker provided statistical advice, performed statistical analyses, and clarified analytical concepts. D. C. McAllister, assisted in many aspects of the study. I acknowledge many ADF&G colleagues for assistance in moose capture and radio-tracking procedures. P. A. Arneson provided data on radio-collared moose captured and monitored during April through December 1980. J. B. Faro contributed information on moose captured and monitored in Alaska Game Management Subunit (Subunit) 16B during 1987-88. My supervisors, K. B. Schneider, D. A. Anderson, and C. C. Schwartz provided guidance, assistance and administrative support throughout this study. C. C. Schwartz also reviewed the manuscript and renewed my enthusiasm for completing this paper. S. R. Peterson reviewed a draft of this manuscript and provided many helpful comments. I thank area staff J. C. Didrickson, C. A. Grauvogel, H. J. Griese, and M. W. Masteller for supporting this study. I thank light-aircraft pilots C. A. Allen, Charlie Allen Flight Service, M. Houte, L. Rogers, C. R. and V. L. Lofstedt, Kenai Air Alaska, W. A. Woods, Woods Air Service, and W. D.

Wiederkehr, Wiederkehr Air Inc. for skill, dedication, and enthusiasm on aerial radio-tracking surveys. This study was funded in part by Federal Aid in Wildlife Restoration.

STUDY AREA

Capture, radio-collaring, and radio-tracking of moose took place in a 25,000 km^2 area in the lower Susitna Valley in southcentral Alaska (Fig. 1). The area included portions of Game Management Subunits (Subunits) 13E, 14A, 14B, 16A, and 16B. Climate and geography of the area was described by Viereck and Little (1972) and Modafferi (1991). Snow accumulation varied greatly by year.

In general, moose populations in the region increased during 1980-84 and 1985-87 and decreased in 1984-85 and 1987-91. Moose populations in the area were probably at or very near carrying capacity before winter 1984-85. Moose were hunted during subunit-specific open seasons. In most subunits, male moose were hunted every year during a September season. In some areas, limited numbers of permits were issued for the harvest of antlerless and/or cow moose during the September season and/or a December through February season. Accidental collisions of moose with trains and highway vehicles were noteworthy sources of mortality in the region, particularly, in deep-snow winters (Rausch 1958, Modafferi 1991). Moose predators in the area included wolves (Canis lupus) and brown (Ursus arctos) and black bears (U. americanus).

Information on predator densities in the area was largely circumstantial. Wolf density estimates ranged from about 1-2 wolves/1000 km^2 in Subunits 14A, 14B, and southern 16A to about 2-7 wolves/1000 km^2 in Subunits 13E, 16B, and northern 16A (Ballard 1992a, Masteller 1994). In general, wolf populations probably increased during 1980-91. Brown bear density estimates ranged from 7-25 bears/1000 km^2 in Subunits 14A and 14B to about 12-35 bears/1000 km^2 in Subunits 13E, 16A, and 16B (Miller 1987, Grauvogel 1990, Griese 1993a). Brown bear populations were likely increasing during the study. Black bear density estimates ranged from about 35-104 bears/1000 km^2 in Subunits 14A and 14B (Grauvogel 1990) to about 90-193 bears/1000 km^2 in Subunits 13E, 16A, and 16B (Miller 1987, Griese 1993b). Black bear hunting over bait and increasing brown bear populations probably caused a decrease in black bear populations during the study.

METHODS

Capture, Radio-collaring and Monitoring of Moose

Moose were captured for radio-collaring mainly from a helicopter by darting. Moose were also approached on foot or snowmachine for darting. Moose were immobilized with etorphine hydrochloride (M99, Lemmon Co., Sellersville, Pa.) with or without xylaxine hydrochloride (Rompun, Haver-Lockhart, Shawnee, Kans.) or carfentanil citrate (Wildnil, Wildl. Lab., Fort Collins, Colo.). M99 and Wildnil were antagonized with diprenorphine (M50-50, Lemmon Company, Sellersville, Pa.), naloxone hydrochloride (Dupont Pharmaceuticals, Garden City, N.J.) or naltrexone hydrochloride (Dupont Pharmaceuticals, Garden City, N.J.). Immobilized moose were ear tagged and fitted with a visual-numbered canvas collar (Franzmann et al. 1974) and radiotransmitter with or without a mortality option (Telonics, Mesa, Ariz.). Moose were captured during December through January in alpine postrut concentration areas in Subunits 14A and 14B and during January-April in lowland winter concentration areas in Subunits 13E, 16A, and 16B. Moose were primarily captured in 4 areas: lower Susitna River floodplain between Portage Creek and Cook Inlet in 1980-85; western foothills of the Talkeetna Mountains between South Fork of Montana Creek and the Little Susitna River in 1985-89; Alexander Creek floodplain in 1987, and floodplains of the Yentna and the Skwentna Rivers between Lake Creek and Old Skwentna in 1988-89.

Age of captured moose was estimated mainly by incisor tooth wear. However, early in the study a first incisor tooth was removed from captured moose for cementum aging (Sergeant and Pimlott 1959). Captured moose were >18 months of age and few moose were <30 months. All were considered adults.

Radio-collared moose were visually located 1-5 times each month for visual observation using Cessna-152, -180, and -185 or a Piper Super Cub (PA-18) aircraft and standard aerial radio-tracking procedures. Not all radio-collared moose were located on each survey but it was common to obtain radio-fixes on >60 moose during a single 1-day survey. I searched intensively at each site to confirm precise locations and to confirm that the animal was alive. Moose were monitored from capture to death or date of censor. Death of moose at capture locations or within 4 days after collaring was attributed to capture stress and excluded from survival analyses.

Survival

Radio-collared moose were judged dead by direct observation, by transmitter pulse rate if the transmitter contained the mortality/movement option, or radio-fix location if radio-fix locations on consecutive surveys were identical. When a moose was judged to be dead, an intensive aerial search was conducted to locate the radio-collar, parts of a moose carcass, and/or a disturbed site suggesting the animal was dead. Locations were revisited and aerially searched until sufficient evidence confirmed or refuted that the moose was dead. Lastly, locations were visited on foot to verify death.

Additionally, hunters, the ADF&G, the Alaska Department of Public Safety, Division of Fish and Wildlife Protection, and the Alaska Railroad Corporation provided the date and cause of death of radio-collared moose that died from legal hunter-harvest, illegal harvest, defense of life or property, and collisions with vehicles or trains.

In many instances, the exact cause of death was unknown, but circumstances and/or evidence at the site allowed me to categorize these into 1 of 4 groups: (1) illegal harvest, (2) accident, (3) winter kill, or (4) other. Illegal harvest was assigned mainly to moose radio-tracked to a residential housing development during the hunting season. The accident group included deaths resulting from injuries and drowning. Intact moose carcasses on the snow with no evidence suggesting predation or accident were considered winter killed. Winter kill included deaths from starvation and/or inclement weather. The remaining group, other, included deaths caused by predation and wounding injuries. Several moose deaths assigned to the other group were bulls that died in late-September during or shortly after start of hunting season. The category other also included cows that died in the period mid-May through July. Death of cows in this calendar period likely resulted from complications with birthing (Markgren 1969:195-196) and/or confrontations with bears (Ballard 1992b:163).

Precise date of death was known for train kills, hunter harvest, illegal harvest, and kills in defense of life or property. For deaths in which the date was unknown, the mid-point date between the last two surveys was used. This interval was ≤15 days in 30% of the deaths, ≤35 days in 65% of the deaths, but ≥45 days in 6 deaths.

Censoring

Moose were censored from the database if: (1) the transmitter was lost or failed, (2) an animal emigrated from the study area, or (3) when the study was terminated. Lost or failed transmitters were censored on the midpoint between the dates of the last 2 radio-fixes. Hunter harvested moose were censored on the reported date of kill.

Censoring of hunter harvested moose could impact estimates of survival if moose mortality in the winter following hunting season was compensatory with hunter harvest of moose. I used regression analysis to examine for evidence of a compensatory relationship between hunter harvest in autumn and mortality the following winter. Hunter bull harvest was regressed on bull deaths assigned to all sources, winter kill, and other. Analyses encompassed calendar years 1980-90.

Survival Rate Estimation

Survival estimates were computed separately for males and females with staggered entry Kaplan-Meier procedure (Kaplan and Meier 1958, Pollock et al. 1989). I tested for differences among years and lumped data with similar survival functions. A modified SAS (SAS Inst. Inc. 1985) statistical procedure which accommodated left (Hasbrouck et al. 1992) as well as right censored data was used to compute a K-sample test for equality. I accepted the null hypothesis that all annual Kaplan-Meier survival curves (Lee 1980) were equal and rejected it if at least 1 curve was monotonically larger or smaller than the rest. Following a rejection of the null hypothesis, the annual survival curve responsible for the largest contribution to the $\underline{X}^2$ statistic was identified by year and compared for statistical similarity versus the survival curve representing the rest of the years. The process was repeated until a non-significant $\underline{X}^2$ statistic was obtained. Identical rational and hypothesis testing procedures were used to examine survival by season for differences in survival curves among years.

I calculated annual survival rates based on a calendar year starting on 16 May. Seasonal survival rates were calculated for summer (16 May through 31 August), autumn (1 Sep through 31 December), and winter (1 January through 15 May) during 1980-91. Because winter-related mortality of moose can span into early May in a long and/or late winter, the 16 May through 15 May calendar year aligned winter mortality with the appropriate winter and year.

Snow Conditions

Snowpack depth measurements were used to appraise snow conditions. These measurements were obtained from Alaska Climatological Data Reports, U.S. Department of Commerce, NOAA, National Environmental Satellite, Data and Information Service, National Climate Data Center, Asheville, North Carolina for October throught April during 1980-91. Snow conditions were characterized using maximum snowpack depth and the duration of deep snowpack from October through April. Duration of deep snow was the number of months that snow depth was ≥110 cm, the approximate chest of adult Alaskan moose. Measurements at Wasilla, Willow, Talkeetna, and Skwentna weather stations were used to reflect general snow conditions in the study area. In a few instances, snow measurement data were unavailable for a particular month at a weather station. In these cases, data from the next nearest weather station were used to proportionalize maximum snow depth for the month in question.

RESULTS

Capture, Radio-collaring, Monitoring, Moose Sightability, and Population Sampling

During 1980-91, 204 moose (138 F) were captured, radio-collared, and monitored in lower Susitna Valley in southcentral Alaska. Number of moose monitored and at risk varied by calendar year; these ranged from 6 to 25 in males and from 29 to 89 in females (Fig. 2). Moose were radio-tracked 9,754 times during 363 aerial surveys. Annual monitoring effort varied in relation to the number of radio-collared moose at risk (Fig. 2). Surveys ranged from 16 in 1985-86 to 43 in 1989-90. Fifteen moose (10 F) died from problems with capture and were omitted from survival analyses. Eighty-six of 128 females were monitored over 3 years and 25 females were monitored over 6 years (Fig. 3A). Sixteen of 61 males were monitored over 3 years while no males were monitored longer than 6 years (Fig. 3B).

Sightability of moose varied by season and sex (Fig. 4). Monitoring effort was high during parturition (May-June), hunting season (September), and winter (January-April). Sightability was high from October through March when deciduous vegetation was leafless, snow cover was present, and moose were in shrub dominated open-canopy habitats. This situation coincided with aggregation of moose in postrut and winter concentration areas. However, sightability decreased from April through June when snow was patchy, leaf-out occurred, and moose dispersed from winter concentration areas. Moose sightability was particularly low in August when moose were in forest habitats. Sightability of cow moose was higher in late-May vs. early-May , June or July. While bulls easier to see in July vs. late-May, June or August. Bull moose were seen more frequently than cows in both August and September.

Moose monitored for survival varied widely (Hair 1980). Home range size of moose monitored >9 years ranged from 70 km^2 to 1200 km^2. I monitored both migratory and non-migratory individuals (LeResche 1974, Sweanor and Sandegren 1988) that moved <10 km and >35 km, respectively, between winter and summer ranges. Annual home ranges at low (46-91 m) or high (914-2560 m) elevation or annual ranges included seasonal ranges at both low and high elevations (91-1920 m). Monitored moose lived year-round in remote areas or in areas in close proximity to roadways, railways and humans, or year-round ranges overlapped both types of landscape. Home ranges could be adjacent to marine tidal flats or up to 100 km inland. Winter ranges of individuals were at both low (<100 m) and high (>1800 m) elevations. Postrutting areas were in alpine shrub and lowland mixed forest habitat. Winter areas were on lowland floodplains and in high elevation watersheds.

Censorship, Mortality, and Causes of Mortality

Twenty-three (15 F) of 189 collared moose (128 F) were censored before the end of the study because they had either shed their collar or I lost contact. Fifty-three moose (47 F) were alive at the end of the study. Twenty-nine (5F) of 113 moose (66 F) monitored until death, were killed by hunters. Consequently, survival was based on 84 (61 F) deaths.

In total, 10 collared moose (5 F, 5 M) were censored for shed collars of which 8 were censored <3 months after capture. I expected some bulls to shed collars. Collars were fitted loosely on bulls to accommodate rut related increases in neck size. Additionally, moose slipped collars in spring and early summer when neck hair was shedding and animals lowered their heads to feed on field layer vegetation. Of 7 moose deaths (5 F, 2 M) assigned to illegal harvest, radio fix sites of 3 were in residential housing developments. Another illegal harvest involved a radio-collared cow observed in winter with a calf near an occupied remote cabin. On the subsequent survey, the radio-fix was at the cabin and a lone calf was nearby. That radio-signal was not heard on subsequent surveys. Another illegal kill, a male moose, was radio-tracked and observed near a well travelled highway. On the next survey the radio-fix was in the Talkeetna landfill.

Ten moose deaths (9 F, 1 M) were ascribed to accidents. The accident classification included moose that had fallen or slipped, drowned and/or died from exposure. Accidents included 1 in an ice jam during spring break-up, 1 in a log jam during spring high water, 2 in flowing water at the base of 70-100 m high steep rocky cliffs, 2 with only a head and neck protruding through iced-covered streams, 2 in open water leads of ice-cover rivers, and 1 with spayed hind legs on glare-ice of a frozen river. The 1 defense of life or property death was a bull shot by a rural homeowner because it aggressively precluded access to an out-building.

I did not detect a relationship between hunter harvest of bull moose in autumn and moose deaths in the following winter assigned to all other sources ($\underline{b}_1$ = 0.087, R^2 = 0.006), winter kill ($\underline{b}_1$ = 0.059 R^2 = 0.003), or other ($\underline{b}_1$ = 0.024, R^2 = 0.001).

Snowpack Depth

Maximum snowpack ranged from 10 to 276 cm among 4 snow stations and 6 months during October through April, 1980-90 (Fig.

5A). Snowpack depth was greatest at Skwentna in 9 of 10 years and lowest at Wasilla in all years. Among years and snow stations calendar year maximum snowpack ranged from 46 to 276 cm. In 1985-86, maximum snowpack was not >46 cm and in 1980-83, it was not >89 cm. During 1980-91, snowpack at Wasilla was not >69 cm. In 1984-85 and 1989-90, maximum snowpack was >110 cm at 3 or 4 snow stations but in 1989-90, snowpack depth was >225 cm at those 3 stations (Fig 5B). In 1989-90, maximum snowpack was >110 cm in 4 or 5 months at 3 snow stations. Winter in both 1984-85 and 1989-90 was considered severe with deep persistent snow for most of the winter. October and November maximum snowpack at Talkeetna and Skwentna were more than 50% greater in 1989-90 than in 1984-85 (Fig. 6). Talkeetna and Skwentna maximum snowpacks were greater in January 1990 than in October-April in 1984-85. Talkeenta and Skwentna maximum snowpacks during January-April was greater month by month in 1989-90 than in 1984-85. Early accumulation of deep snow and long duration of deep snow in 1989-90, provide evidence that winter conditions for moose, were more severe in 1989-90 than in 1984-85.

Annual and Seasonal Survival

Annual survival curves for cow moose differed among calendar years 1980-91 ($\underline{X}^2$ = 57.9642, 10 df, $\underline{P}$ = 0.0000) with 1989-90 significantly lower (0.65) ($\underline{X}^2$ = 49.3981, 1 df, $\underline{P}$ = 0.0000) than the other years (Fig. 7A and Table 3). Survival did not differ among the remaining 10 years 1980-89 and 1990-91 (0.92) ($\underline{X}^2$ = 14.198, 9 df, $\underline{P}$ = 0.115), despite the relatively low overall survival in 1984-85 (0.815). Apparently, above average survival through autumn moderated the effects of below average survival in winter on the cumulative survival distribution in 1984-85.

Cow survival was not different among years within summer (X^2 = 8.335, 9 df, P = 0.501) and autumn (X^2 = 7.192, 9 df, P = 0.617)) seasons, so yearly data were combined within summer and autumn seasons to generate a single survival curve for summer (0.98) and fall (0.98) and the calendar period, summer through autumn. Winter survival of cows was significantly different among years 1980-90, with 1989-90 lower (0.70) X^2 = 67.482, 10 df, P = 0.0000) than the rest. After removing 1989-90 winter data from the analysis, a difference was detected in winter survival curves among the remaining 9 years (1980-89 and 1990-91) (X^2 = 22.159, 8 df, P = 0.005); survival in 1984-85 was lower (0.82) (X^2 = 5.258, 1 df, P = 0.022). After removing both 1984-85 and 1989-90 data no difference among the remaining 8 years was detected (X^2 = 2.509, 7 df, P = 0.926) so data were pooled over years to generate a single survival estimate (0.97) for a winter with normal accumulations of snow. Cow survival estimates from 1984-85 and 1989-90 were not different (X^2 = 2.509, 7 df, P = 0.926), thus data from these years were pooled to generate a single survival estimate (0.74) for cows during a deep-snow winter.

Annual survival curves of bulls differed among calendar years 1980-91 (X^2 = 26.34, 10 df, P = 0.003) with 1989-90 significantly lower (0.29) (X^2 = 17.379, 1 df, $P < 0.001$) than the other years (Fig. 7B and Table 3). Survival of bulls did not differ among the remaining years, 1980-89 and 1990-91 (0.84) (X^2

= 14.543, 9 df, $\underline{P}$ = 0.104). Bull survival was lower in 1984-85 (0.69) than the average (0.83) but small sample sizes decreased power of the test.

Bull survival was not different among years within the summer (0.99) ($\underline{X}^2$ = 5.985, 10 df, $\underline{P}$ = 0.817) and autumn (0.90) ($\underline{X}^2$ = 8.117, 10 df, $\underline{P}$ = 0.617) season, so yearly data were combined within summer and autumn seasons to generate a single survival curve for summer (0.99) and autumn (0.90) and the calendar period, summer through autumn. Survival of bulls was lower (95% CIs) in autumn than in summer. Winter survival of bulls was significantly different ($\underline{X}^2$ = 31.717, 9 df, $\underline{P}$ < 0.001) among years (1980-90) with 1989-90 lower (0.33) ($\underline{X}^2$ = 23.94, 1 df, $\underline{P}$ < 0.001) than the rest. After removing the 1989-90 winter data from the analysis, I failed to detect a difference among the remaining 8 years ($\underline{X}^2$ = 13.411, 8 df, $\underline{P}$ = 0.098) so data were pooled over the years 1980-90 to generate a single survival estimate for bulls (0.94) in a winter with normal accumulations of snow. Data from winter 1989-90 provided a survival estimate (0.33) for bulls in a deep-snow winter.

Timing and Cause of Mortality

During 16 May 1980 through 25 February 1991, 112 radio-collared moose (66 F) died (Tables 1 and 2). Twenty-nine (5 F) of the 112 deaths were hunter kills and were excluded from this analysis. Frequency of cow moose deaths peaked in winter in March (26%) (Fig. 8A); number of deaths was higher in winter (65%) than in spring (16%) and/or autumn (18%) (Fig. 9A). No cow deaths occurred in November. Frequency of bull moose deaths was low in May through August (4%), whereas 28% of the cow moose died during May through August. However, during September and October, frequency of deaths was clearly higher in bulls (39%) than in cows (12%) (Fig. 9A). The frequency of deaths for all moose was highest in winter (62%) with 38% in February through March and 26% in March. In years with deep-snow, 83% of the moose that died, did so in winter; 56% in February through March, and 44 in March (Fig. 8B). However, in normal snow years, 60% of the bulls died in autumn; 53% in September and October (Fig. 8C). In 1980-91, the frequency of moose deaths was highest in March with 23% of bulls and 26% of cows dying. In bulls, there was little difference between the frequency of death in autumn (46%) and winter (50%) (Fig. 9A), but in cows, there was a small difference between deaths in summer (16%) and autumn (18.3) and a large difference between those values and frequency of death in winter (66%) (Fig. 9A). In deep-snow years, 85% of the cow deaths and 75% of the bull deaths occurred in winter (Fig. 9B). In 1984-85 the year deep snow accumulated late in winter (January through March), frequency of deaths was higher in cows than in bulls, whereas in 1989-90 the year deep snow accmulated early in winter during October through January, frequency of deaths was higher in bulls than in cows and bulls died earlier (0% after April in the winter than cows (24% after April). In normal snow accumulation years, frequency of deaths in cows was highest in winter (43%) and lowest in autumn (25%), whereas in males, frequency of deaths was highest in autumn (60%) and lowest in summer (0%) (Fig. 9C).

Cause of death was known for 42 (15 F) of 113 (66 F) moose monitored until death (Tables 1 and 2): 10 (8 F) were ascribed to train, 28 (4 F) to hunter harvest, 1 (1F) to defense of life or property, and 2 (1 F) to illegal harvest. Cause of death for 71 (51 F) moose was not verified. Of these 71, 35 (26 F) were assigned to winter kill, 10 (9 F) to accidents, 5 (4 F) to illegal harvest, and 21 (12 F) to other. Hunter harvest was omitted from succeeding analyses. Frequency of deaths and cause of death varied in relation to snow accumulation and by sex of moose (Fig. 10). In 1980-91, frequency of winter kill in moose was 42%; 43% in females and 39% in males. In 1984-85 and 1989-90, the years with deep accumulaitons of snow in winter, frequency of winter kill was 66%; 63% in females and 75% in males. In 1980-84, 1985-89 and 1990-91, the years with normal accumulations of snow in winter, frequency of winter kill was 19%; 18% in females and 20% in males. In males, in years 1980-84, 1985-89, and 1990-91 combined and in 1980-91, the cause of death with highest frequency was other (47% and 39%, respectively). In 1980-91, percent of moose deaths attributed to accidents was >3 times greater in cows (15%) than in bulls (4%) whereas, in the same years, the number of deaths ascribed to other was >2 higher in males (39%) than in females (20%). In 1980-84, 1985-89, and 1990-91, the years with normal accumulations of snow, frequency of moose deaths was similar among accidents (19%), illegal harvest (16%), and winter kill (19%).

DISCUSSION

One goal of this study was to provide moose managers with guideline data on survival to use in models of moose population dynamics. To refine survival data for this use, hunter harvest, a highly variable anthropogenic component of mortality was censored from derivation of survival estimates. However, censoring of the reported hunter harvest probably did not completely cleanse survivorship data of effects of hunters and hunting; death data likely remained confounded by death of moose from hunter inflicted bullet wounds (Lykke and Cowan 1968, Gasaway et al. 1983, Fryxell et al. 1988), unreported hunter harvest (Rausch et al. 1974:710), and illegal harvest (Crichton 1987, Bangs et al. 1989). I found no evidence of compensatory relationship between hunter harvest of bulls in autumn and all deaths, winter-kill deaths, or unknown cause deaths of bulls the following winter.

Annual survival of adult moose in lower Susitna Valley in southcentral Alaska was greatly influenced by highly variable snow conditions during winter. Survival rate for both bulls and cows was highest and varied the least during spring and summer. Survival rate for cows in autumn was not different from summer. Survival rate for bulls was lower in autumn than in spring and lower than that for cows in autumn. These findings re-emphasize the fundamental importance of snow conditions and winter-related mortality in the ecology and population dynamics of moose suggested previously for Alaska (Bishop and Rausch 1974, Coady 1974, Gasaway 1983:29, Ballard et al. 1991:34-35, Modafferi 1991) and elsewhere (Peterson and Allen 1974, Saether 1985, Mech et al.

1987, Anderson et al. 1991, Child et al. 1991). Snow conditions, which influence movements (Sweanor et al. 1992), distribution (Modafferi 1991) and mobility (Kelsall and Prescott 1971) predictably affect survival of moose. Moose survive poorly in early, long, deep-snow winters (Bishop and Rausch 1974, Peterson and Allen 1974, Ballard et al. 1991). Moose survival during the late May-early May calendar year, which included the deep-snow winter of 1989-90 (females 0.65, males 0.29) was lower than survival rates in many other moose studies (Albright and Keith 1981, Mytton and Keith 1981, Messier and Crete 1985, Boar 1988, Fryxell et al. 1988, Bangs et al. 1989). However, in lower Susitna Valley moose, survival was relatively high (cows 0.92 and bulls 0.84) in 7 of 9 years with snow accumulations that were relatively deep (81-157 cm) compared to snow accumulations that resulted in high mortality or limited distribution of moose in other populations (Nasimovich 1955, Kelsall and Telfer 1974, Peterson and Allen 1974, Wilhelmson and Sylven 1979). Clearly, the accumulation of snow that elicites a "severe" winter with respect to moose varies within a wide range of depths depending on location over the global distribution of moose.

My data showing differences in timing and magnitude of deaths of cows and bulls within and between the 2 deep-snow winters, 1984-85 and 1989-90, provide evidence of sex-based differences in winter survival of moose. Sex differences in survival in winter may be related to differences in seasonal dynamics of the nutritive condition and physiology of cow and bull moose. Nutritive condition of bull moose is at a low point after the autumn rut in early winter (Regelin et al. 1985, Schwartz et al. 1987). Males must recoup their nutritive losses in early winter to survive through winter. Whereas, nutritional demands on cows are especially high during the final stages of pregnancy in late winter (Schwartz et al. 1984, Schwartz et al. 1987). Females must sustain growth and maintenance of reproductive tissues and a fetus(es) as well as maintain their nutritive condition to survive through winter and support lactation immediately following winter. Therefore, I believe that in 1984-85, the accumulation of deep snow in late winter was more harsh on cows than on bulls, but, in 1989-90, the accumulation of deep snow in early winter was more stressful on bulls than on cows. These findings suggest that the temporal patterns of snow accumulation are important factors effecting survival and the population dynamics of moose. Clearly, my data point-out that 1) moose are subject to major die-offs in winter after standard autumn post-hunt population surveys are conducted (Gasaway et al. 1986); 2) managers must be cognizant of snow conditions throughout winter to accurately assess the survival and population status of moose; and 3) management programs must have the flexibility to respond to late winter die-offs of moose when setting autumn harvest levels.

In other moose studies, high survival of adults was associated with low rates of predation (Ballard and Larsen 1987). However, predation was not identified as a prominent factor affecting survival of adult moose in lower Susitna Valley. Wolves were present in the study area, but there was no evidence of wolf predation on collared moose. During 11 years, I observed evidence of wolf predation on moose only one time. In this instance, there was evidence that 2 moose were killed by wolves in the extreme northern part of the study area. Other predators, including black bears, brown bears, and coyotes were observed in encounters with cow moose with neonate(s). Nevertheless, I never observed bears or coyotes killing or consuming moose. However, my data show that from late-May through August survival of cows was lower than bulls and that survival of cows from late-May through June was lower than in July though August. These data suggest that cow moose were vulnerable to sex x time specific mortality associated with parturition and/or neonates. In other moose studies, mortality of adult cows during this calendar period was attributed to predation by brown bears (Boertje et al. 1988, Larsen et al. 1989). Bear predation was the most probable cause of cow moose deaths during this calendar period in my study.

The sex-biased mortality of bull moose in autumn, during hunting season and through the rut, was not unexpected. In other studies, death of moose, primarily males, during autumn was attributed to hunter inflicted bullet wounds (Gasaway et al. 1983, Fryxell et al. 1988), wounds from rut-related fights with other moose (Bubenik 1987:351-352, Gasaway 1992:28), and illegal harvest (Mytton and Keith 1981, Bangs et al. 1989, McDonald 1991). Although these are the most probable causes of bull moose mortality in autumn, wounds or predation from brown bears (Boertje et al. 1988, Larsen et al. 1989) that respond to vocalizations of rutting bulls, were also potential sources of bull moose mortality.

Many investigators point out that accidents are a source of moose mortality (Bangs et al. 1989, Larsen et al. 1989, Cederlund and Sand 1991, Child et al. 1991, Lavsund and Sandegren 1991,). However, I am aware of only 1 study (Danilov 1987:519-520) that indicated accidents were a prominent source. In my study, in years with normal accumulations of snow and excluding moose deaths from collisions with trains or vehicles, 27% of the cow moose mortality could be attributed to accidents. During 1980-91, with train-kills omitted, 17% the cow moose deaths were from accidents. Accidents and train-kills combined accounted for 28% of the cow moose deaths. Collision with trains is a notable source of moose mortality in the lower Susitna Valley (Modafferi 1991), as in other jurisdictions (Child 1983, Andersen et al. 1991), because a railway crosses major summer-winter migration routes and winter ranges and in deep-snow years large numbers of migrating moose aggregate in winter areas along the railway corridor.

In many jurisdictions moose-vehicle collisions were an important source of mortality (Child et al. 1991, Lavsund and Sandegren 1991, McDonald 1991, Oosenburg et al. 1991). However, in my study, although a high-volume roadway was located roughly parallel to the railway, no collared moose were killed in collisions with vehicles. This incongruity between railway (N = 10) and roadway moose kill rates may be attributed to age of the moose I studied and to age-related learning processes. In another moose study in Alaska, road-kill calf ratios were >3 times higher than the overall population calf ratios in the area (Del Frate and Spraker 1991). Moose I studied were adults; at the time of collaring no moose were <18 months. Perhaps, moose learn to avoid collisions with vehicles through non-lethal collisions with vehicles, whereas, few moose learn to avoid collisions with trains because most moose-train collisions are lethal.

Previous research indicates that moose select habitat based on many factors including availability of cover, overstory and/or forage (Peek et al. 1976, Pierce and Peek 1984). My radio-tracked moose corroborate data from other studies that show overstory and cover characteristics of habitats utilized by moose differ by sex and time of year. Both sexes of moose were seen most frequently in winter when moose utilize shrub dominated open habitats in alpine or lowland landscapes. Cows were observed more frequently than bulls in early-May and June when parturient cows utilize wet, open black spruce bog climax communities (LeResche et al. 1974:157, Bailey and Bangs 1980). Cow moose were seen less frequently in June than in May. Decreased observability of cows during early-summer through August may be attributed to movement from the relatively open habitats used during parturition to denser forest habitats that cows with neonates utilize for concealment and isolation from other moose (Miquelle et al. 1992), predators (Stringham 1974, Stephens and Peterson 1984) and/or access to higher quality forage in shaded forests (Hjeljord 1992). Higher observability of bulls in July than in late-May-September and higher observability of bulls than cows in July and August may be related to antler growth. Whereas, cows with neonates select relative dense habitats in late summer, bulls may avoid dense forests because their antlers are growing (Bubenik and Bubenik 1987, Verme 1988). Damage to growing antlers would be painful and malformed antlers would affect the status of a male. Higher observability of bulls in July than in August may be related to several factors including nutritional requirements and forage quality in sunny versus shaded growth sites (Hjeljord 1992). The higher observability of both cows and bulls in October and November than in summer correlates with movement of moose into open shrub dominated alpine habitat after the rut. This movement is likely influenced by forage quality (Thompson et al. 1981, Modafferi 1991). The decrease in moose sightability during November through December correlates with the movement of moose from open shrub dominated postrut concentration areas through forest habitats to shrub dominated winter areas (Modafferi 1991).

MANAGEMENT IMPLICATIONS

Accumulation of snow was a prominent and highly variable source of mortality affecting annual survival of moose in lower Susitna Valley in southcentral Alaska. My data indicate survival of 33% and 74% for bulls and cows, respectively, in winter (1 January though 15 May) after traditional autumn post-hunt population surveys are conducted. Clearly, annual management decisions and harvest policies should not be solidified before information on winter survival is available and analyzed.

Ideally, moose management programs should have provisions for reacting to winter die-offs of moose and reevaluating modifying management decisions and harvest policies formulated in late autumn.

If winter die-offs of moose periodically perturb manipulatively managed populations (Caughley and Sinclair 1994:2), should harvest policies and goals be commensurate with K carrying capacity in a normal snow winter or a deep-snow winter? To knowledgeably evaluate alternative forms of moose harvest policy, managers must utilize simulation models (Erickson and Sylven 1979, Sylven et al. 1987) to obtain baseline informatio on population dynamics and public processes to solicite input on allocation from social, political, and economic interests.

My data suggest that illegal harvest, unreported harvest, and other mortality related to hunting caused significant mortality in bulls in autumn. Moose managers should be aware of these less perceptible forms of mortality that are additive byproducts of hunter harvest.

Finally, my data indicate that in the absence of high densities of predators, snow accumulation in winter is a recurrent perturbing factor with large effects on size and composition of moose populations in lower Susint Valley. If predator densities increased to higher levels, winter weather perturbations could cause moose populations to be at lower density equilibria maintained by predators (i.e., a predator pit) (Van Ballenberghe 1987).

LITERATURE CITED

Albright, C. A., and L. B, Keith. 1987. Populaitons dynamics of moose, Alces alces, on the South-coast Barrens of Newfoundland. Can. Field. Nat. 101:373-387.

Andersen, R. A., B. Wiseth, P. H. Pederson, and V. Jaren. 1991. Moose-train collisions: effects of environmental conditions. Alces 27:79-84.

Ballard, W. B. 1992a. Modelled impacts of wolf and bear predation on moose calf survival. Alces 28:79-88.

_____. 1992b. Bear predation on moose: a review of recent North American studies and their management implications. Alces. Suppl. 1:162-176.

_____, and D. G. Larsen. 1987. Implications of predator-prey relationships to moose management. Swed. Wildl. Res. (Suppl.) 1:581-602.

_____, J. S. Whitman, and D. J. Reed. 1991. Population dynamics of moose in south-central Alaska. Wildl. Monogr. 114. 49pp.

Bailey, T. H., and Bangs E. E. 1980. Moose calving areas and use on the Kenai National Moose Range. N. Amer. Moose Conf. Workshop 16:289-313.

Bangs, E. E., T. H. Bailey, and M. F. Portner. 1989. Survival rates of adult female moose on the Kenai Peninsula, Alaska. J. Wildl. Manage. 53:557-563.

Bishop, R. H., and R. A. Rausch. 1974. Moose population fluctuations in Alaska. Nat. Can. (Que.) 101:559-593.

Boar, A. H. 1988. Mortality rates of moose in New Brunswick: a life table analysis. J. Wildl. Manage. 52:21-25.

Boertje, R. D., W. C. Gasaway, D. V. Grangaard, D. V. Kelleyhouse. 1988. Predation on moose and caribou by radio-collared grizzly bears in eastcentral Alaska. Can. J. Zool. 66:2492-2499.

Bubenik, A. B. 1987. Behavior of moose (Alces alces ssp) of North America. Swedish Wildl. Res. (Suppl.) 1: 333-365.

Bubenik, G. A., and A. B. Bubenik. 1987. Recent advances in studies of antler development and neuroendocrine regulation of the antler cycle. Pages 99-109 in C. M. Wemmer, ed. Biology and Management of the Cervidae. Smithsonian Institution Press, Wash. D.C.

Caughley, G., and A. R. E. Sinclair. 1994. Wildlife ecology and management. Blackwell Scientific Publications, Boston, Mass. 334pp.

Cederlund, G. N., and H. K. G. Sand. 1991. Population dynamics and yield of a moose population without predators. Alces 27:31-40.

Child, K. N. 1983. Railways and moose in the central interior of British Columbia: a recurrent management problem. Alces 19:118-135.

_____, S. P. Barry, and D. A. Aitken. 1991. Moose mortality on highways and railways in British Columbia. Alces 27: 41-49.

Coady, J. W. 1974. Influence of snow on behavior of moose. Nat. Can. (Que.) 101:417-436.

Crichton, V. F. J. 1987. Moose management in North America. Swed. Wildl. Res. (Suppl.) 1:541-551.

Danilov, P. I. 1987. Population dynamics of moose in USSR (Literature survey, 1970-83). Swed. Wildl. Res. (Suppl.) 1:503-523.

Del Frate, G. G., and T. H. Spraker. 1991. Moose vehicle interactions and an associated public awareness program on the Kenai Peninsula, Alaska. Alces 27:1-7.

Erickson, J.-A., and S. Sylven. 1979. Results of simulation studies for optimum meat production from the Swedish moose population. Alces 15:32-53.

Franzmann, A. W., P. D. Arneson, R. E. LeResche, and J. L. Davis. 1974. Developing and testing new techniques for moose management. Alaska Dep. Fish and Game, Fed. Aid in Wildl. Restor. Final Rep., Proj. W-17-2, W-17-3, W-17-4, W-17-5, and W-17-6. 54pp.

Fryxell, J. M., W. G. Mercer, and R. B. Gellately. 1988. Population dynamics of Newfoundland moose using cohort analysis. J. wildl. Manage. 52:14-21.

Gasaway, W. C., R. O. Stephenson, J. L. Davis, and O. E. Burris. 1983. Interrelationships of wolves, prey, and man in interior Alaska. Wildl. Monogr. 84. 50pp.

_____, S. D. DuBois, S. D. Reed, and S. J. Harbo. 1986. Estimating moose population parameters from aerial surveys. Biol. Pap. Univ. Alaska. 22, 108pp.

_____, R. D. Boertje, D. V. Grangaard, D. G. Kelleyhouse, R. O. Stephenson, and D. G. Larsen. 1992. The role of predation in limiting moose at low densities in Alaska and Yukon and implications of conservation. Wildl. Monogr. 120. 59pp.

Geist, V. 1986. New evidence of high frequency of antler wounding in cervids. Can J. Zool. 64:380-384.

Grauvogel, C. A. 1990. Unit 14 brown bear survey-inventory progress report. Pages 84-94 in S.O. Morgan, ed. Annual report of survey-inventroy activities. Part V. Brown/grizzly bears. Vol. XX. Alaska Dep. Fish and Game . Fed. Aid in Wildl. Rest. prog. Rep. Proj. W-23-2. Study 4.0. Juneau. 189pp.

Griese, H. J. 1993a. Unit 16 brown/grizzly bear survey-inventory progress report. Pages 136-151. in S. A. Abbott, ed. Management Report of Survey-Inventory Activities. Brown Bear. Alaska Dep. Fish and Game. Fed. Aid in Wildl. Rest. Prog. Rep. Proj. W-23-4 and W-23-5. Study 4.0. Juneau. 283pp.

_____. 1993b. Unit 14 black bear survey-inventory progress report. Pages 99-111. in S. A. Abbott, ed. Management Report of Survey-Inventory Activities. Black Bear. Alaska Dep. Fish and Game. Fed. Aid in Wildl. Rest. Prog. Rep. Proj. W-23-4 and W-23-5. Study 17.0. Juneau. 159pp.

Hair, J. D. 1980. Measurement of ecological diversity. Pages 269-275. S. D. Schemnitz, ed. Wildlife Management Techniques Manual. The Wildlife Society. Wash. D. C.

Hauge, T. M., and L. B. Keith. 1981. Dynamics of moose populations in northeastern Alberta. J. Wildl. Manage. 45:573-597.

Hasbrouck, J. J., W. R. Clark, and R. D. Andrews. 1992. Factors associated with raccoon mortality in Iowa. J. Wildl. Manage. 56:693-699.

Hjeljord, O. 1992. Sunny and shaded growth sites - influences on moose forage quality. Alces (Suppl.) 1:112-114.

Kaplan, E. L., and P. Meier. 1958. Nonparametric estimation from incomplete observations. J. Am. Stat. Assoc. 52:457-481.

Karns, P. D. 1987. Moose population dynamics in North America. Swed. Wildl. Res. (Suppl.) 1:423-429.

Kelsall, J. P., and W. Prescott. 1971. Moose and deer behavior in snow. Can Wildl. Serv. Rep. Ser. 15. 27 pp.

_____, J. P., and E. S. Telfer. 1974. Biogeography of moose with particular reference to western North America. Nat. Can. (Que) 101:117-130.

Lankester, M. W. 1987. Pests, parasites and diseases of moose (Alces alces) in North America. Swed. Wildl. Res. (Suppl.) 1:461-489.

Larsen, D. G., D. A. Gauthier, and R. L. Markel. 1989. Causes and rate of moose mortality in the southwest Yukon. J. Wildl. Manage. 53:548-577.

Lavsund, S., and F. Sandegren. 1991. Moose-vehicle relations in Sweden: a review. Alces. 27:118-126.

Lee, E. T., 1980. Statistical methods for survival data analysis. Lifetime Learning Publications. Belmont, Calif. 557pp.

LeResche, R. E. 1974. Moose migrations in North America. Nat. Can (Que.) 101:393-415.

_____, R. H. Bishop, and J. W. Coady. 1974. Distribution and habitats of moose in Alaska. Nat. Can. (Que.) 101:143-178.

Lykke, J., and I. McT. Cowan. 1968. Moose management and population dynamics on the scandanavian peninsula, with special reference to Norway. Proc. N. Amer. Moose Workshop 5:1-22.

Markgren, G. 1969. Reproduction of moose in Sweden. Viltrevy 6:127-299.

Masteller, M. 1994. Unit 16 wolf survey-inventory progress report. 1-16 in S. A. Abbott, ed. Management Report of Survey-Inventory Activities. Brown bear. Alaska Dep. Fish and Game. Fed. Aid in Wildl. Rest. Prog. Rep. Proj. W-23-4 and W-23-5. Study 4.0. Juneau. In prep.

Mech, L. D., R. E. McRoberts, R. O. Peterson, and R. E. Page. 1987. Relationship of deer and moose populations to previous winters' snow. J. Anim. Ecol. 56:615-627.

Mercer, W. E., and F. Manuel. 1974. Some aspects of moose management in Newfoundland. Nat. Can. (Que.) 101:675-691.

Miller S. D. 1987. Susitna Hydroelectric Project Final Rep. Big Game Studies. Vol. 6-black bear and brown bear. Alaska Dep. Fish and Game, Anchorage. 276pp.

Miquelle, D. L., J. M. Peek, and V. Van Ballenberghe. 1992. Sexual segregation in Alaskan moose. Wildl. Monogr. 122. 57pp.

Modafferi, R. D. 1991. Train moose-kill in Alaska: characteristics and relationship with snowpack depth and moose distribution in lower Susitna Valley. Alces 27:193-207.

Mytton, W. R., and L. B. Keith. 1981. Dynamics of moose populations near Rochester, Alberta, 1975-1978. Can. Field Nat. 95:39-49.

McDonald, M. G. 1991. Moose movement and mortality associated with the Glenn Highway expansion, Anchorage, Alaska. Alces 27:208-219.

Nasimovich, A. A. 1955. the role of the regime of snow cover in the life of ungulates in the USSR. Akad. Nauk SSSR. Moskva, 430pp. Transld. Russian Can. wildl. Serv., Ottawa.a

Oosenburg, S. M., E. W. Mercer, and S. H. Ferguson. 1991. Moose-vehicle collisions in Newfoundland-management considerations for the 1990's. Alces 27: 220-225.

Peek, J. M., D. L. Urich, and R. J. Mackie. 1976 Moose habitat selection and relationships to forest management in northeastern Minnesota. Wildl. Monogr. 48. 65pp.

_____, V. Van Ballenberghe, and D. G. Miquelle. 1986. Intensity of interactions between rutting bull moose in central Alaska. J. Mammal. 67:423-426.

_____, R. J. Mackie, and G. I. Dusek. 1992. Over-winter survival strategies of North American cervidae. Alces. (Suppl.) 1:156-161.

Peterson, R. O. 1977. Wolf ecology and prey relationships on Isle Royle. National Park Serv. Sci. Mono. Ser. 11. 210pp.

_____, and D. L. Allen. 1974. Snow conditions as a parameterin moose-wolf relationships. Nat. Can. (Que.) 101:481-492.

Pierce, D. J., and J. M. Peek. 1984. Moose habitat use and selection patterns in north-central Idaho. J. Wildl. Manage. 48: 1335-1343.

Pollock, K. H., S. R. Winterstein, and C. M. Bunck. 1989. survival analysis in telemetry studies: the staggered entry design. J. Wildl. Manage. 53:7-15.

Rausch, R. A. 1958. The problem of railroad-moose conflicts in the Susitna Valley. Alaska Dept. Fish and Game, Fed. Aid in Wildl. Rest. Final Rep., Proj. W-3-R. 116pp.

_____, R. A., R. J. Somerville, and R. H. Bishop. 1974. Moose management in Alaska. Nat. Can. (Que.) 101:705-721.

Regelin, W. L., C. C. Schwartz, and A. W. Franzmann. 1985. Seasonal energy metabolism of adult moose. J. Wildl. Manage. 49:388-396.

Saether, B-E. 1985. Annual variation in carcass weight of Norwegian moose in relation to climate along a latitudinal gradient. J. Wildl. Manage. 49:977-983.

SAS Institute Inc. 1985. SAS user's guide: statistics. Version 5. SAS Inst. Inc., Cary, N. C. 956pp.

Schwartz, C.C., W. L. Regelin, and A. W. Franzmann. 1985. Seasonal dynamics of food intake in moose. Alces 20:223-237.

_____, _____, and _____. 1987. Seasonal weight dynamics of moose. Swed. Wildl. Res. (Suppl.) 1:301-310.

Sergeant, D. E., and D. H. Pimlott. 1959. Age determination in moose from sectioned incisor teeth. J. Wildl. Manage. 23:315-321.

Stephens, P. W., and R. O. Peterson. 1984. Wolf-avoidance strategies of moose. Holarct. Ecol. 7:239-244.

Stringham, S. F. 1974. Mother-infant relations in moose. Nat. Can. (Que.) 101:325-369.

Sweanor, P. Y., and F. Sandegren. 1988. Migratory behavior of related moose. Holarct. Ecol. 11:190-193.

_____, _____, F. Bergstrom and G. Cederlund. 1992. A synopsis of moose movement studies in Furudal, Sweden. Alces. (Suppl.) 1: 115-120.

Sylven, S., G. Cederlund, and H. Haagenrud. 1987. Theoretical considerations on regulated harvest of a moose population. Swed. Wildl. Res. (Suppl.) 1: 643-656.

Thompson, I. D., D. A. Welsh, and M. K. Vukelich. 1981. Traditional use of early winter concentration areas by moose in northwestern Ontario. Alces. 17:1-14.

Van Ballenberghe, V. 1983. Rate of increase in moose populations. Alces. 19:98-117.

_____. 1987. Effects of predation on moose numbers: A review of recent North American studies. Swed. Wildl. Res. (Suppl.) 1: 431-460.

Verme, L. J. 1988. Niche selection by male white-tailed deer: an alternative hypothesis. Wildl. Soc. Bull. 16:448-451.

Viereck, L. A., and E. L. Little, Jr. 1972. Alaska trees and shrubs. U. S. Dept. Agric. Forest Serv. Handbook. No. 410. 265pp.

Wilhelmson, M., and S. Sylven. 1979. The Swedish moose population explosion, preconditions, limiting factors and regulations for maximum meat production. Proc. N. Amer. Moose Conf. Workshop. 15:19-31.

List of Figure Titles

Fig. 8. Mortality of radio-collared adult male and female moose monitored with aircraft in lower Susitna Valley in southcentral Alaska, 1980-91.

Fig. 9. Mortality of radio-collared adult moose monitored with aircraft during 3 seasons in lower Susitna Valley in southcentral Alaska, 1980-91.

Fig. 10. Cause of death of radio-collared adult moose monitored with aircraft in lower Susitna Valley, southcentral Alaska, 1980-91. WK = winter kill, TK = train kill, AC = accidents, IH = illegal harvest, DP = defense of life or property, and OT = other.

FIG. 1

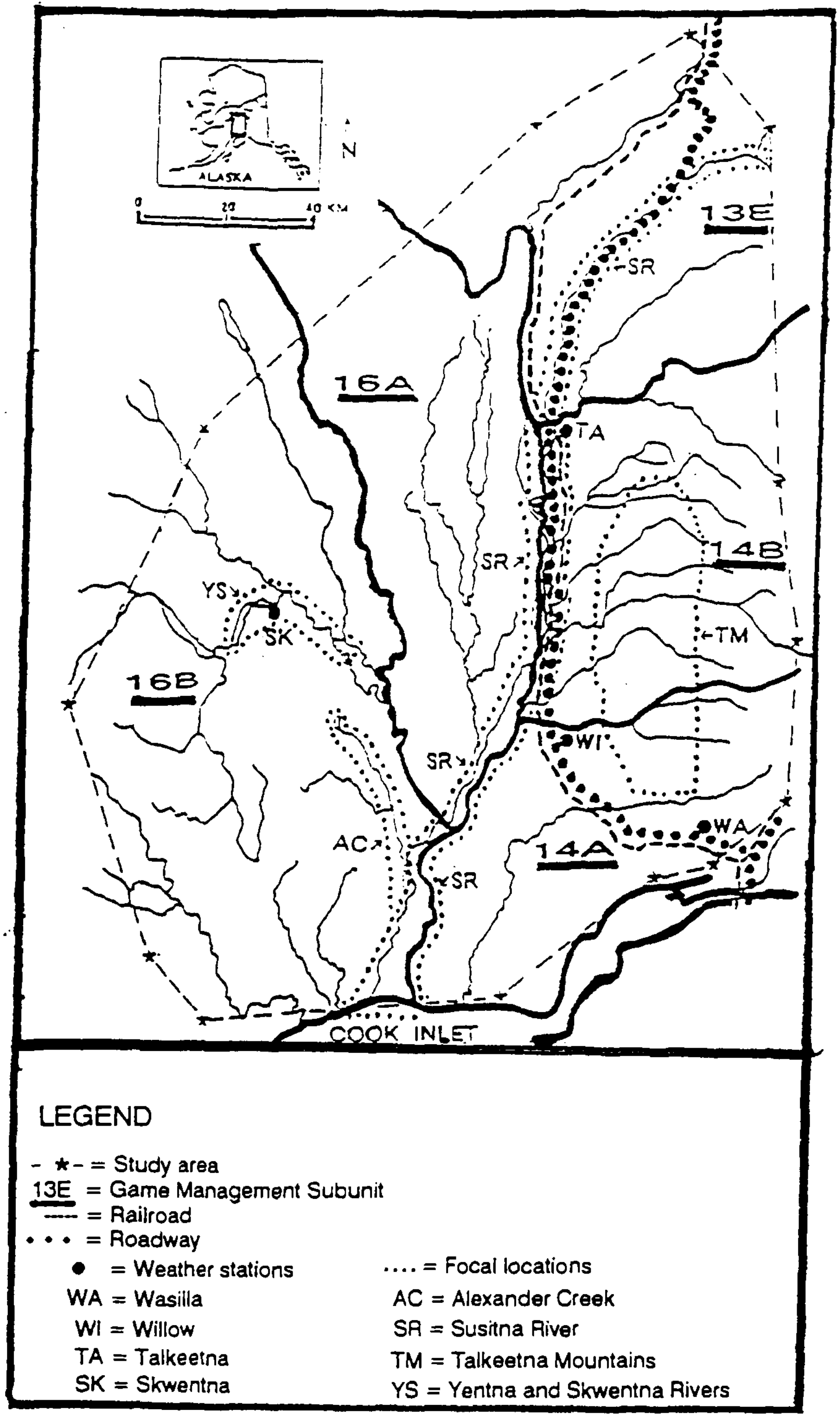
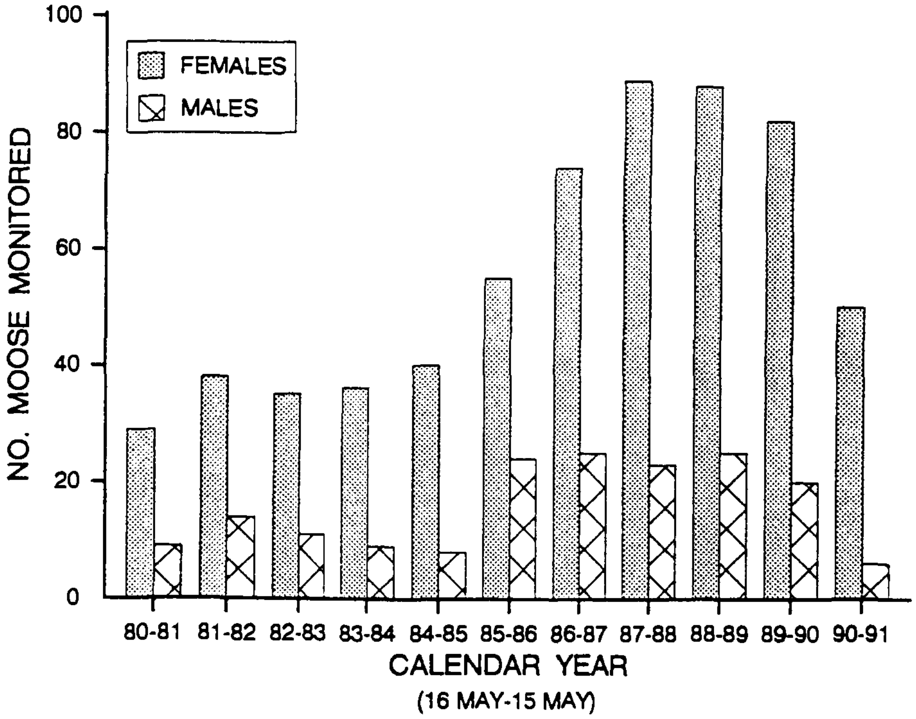

ALASKA
N
0 20 40 KM
13E
SR
16A
TA
14B
SR
YS
SK
TM
16B
WI
SR
AC
WA
14A
SR
COOK INLET
LEGEND
- ★ - = Study area
13E = Game Management Subunit
= Railroad
• • • = Roadway
● = Weather stations
WA = Wasilla
WI = Willow
TA = Talkeetna
SK = Skwentna
.... = Focal locations
AC = Alexander Creek
SR = Susitna River
TM = Talkeetna Mountains
YS = Yentna and Skwentna Rivers

FIG. 2.



100
80
60
40
20
0
NO. MOOSE MONITORED
FEMALES
MALES
80-81
81-82
82-83
83-84
84-85
85-86
86-87
87-88
88-89
89-90
90-91
CALENDAR YEAR
(16 MAY-15 MAY)

FIG. 3.

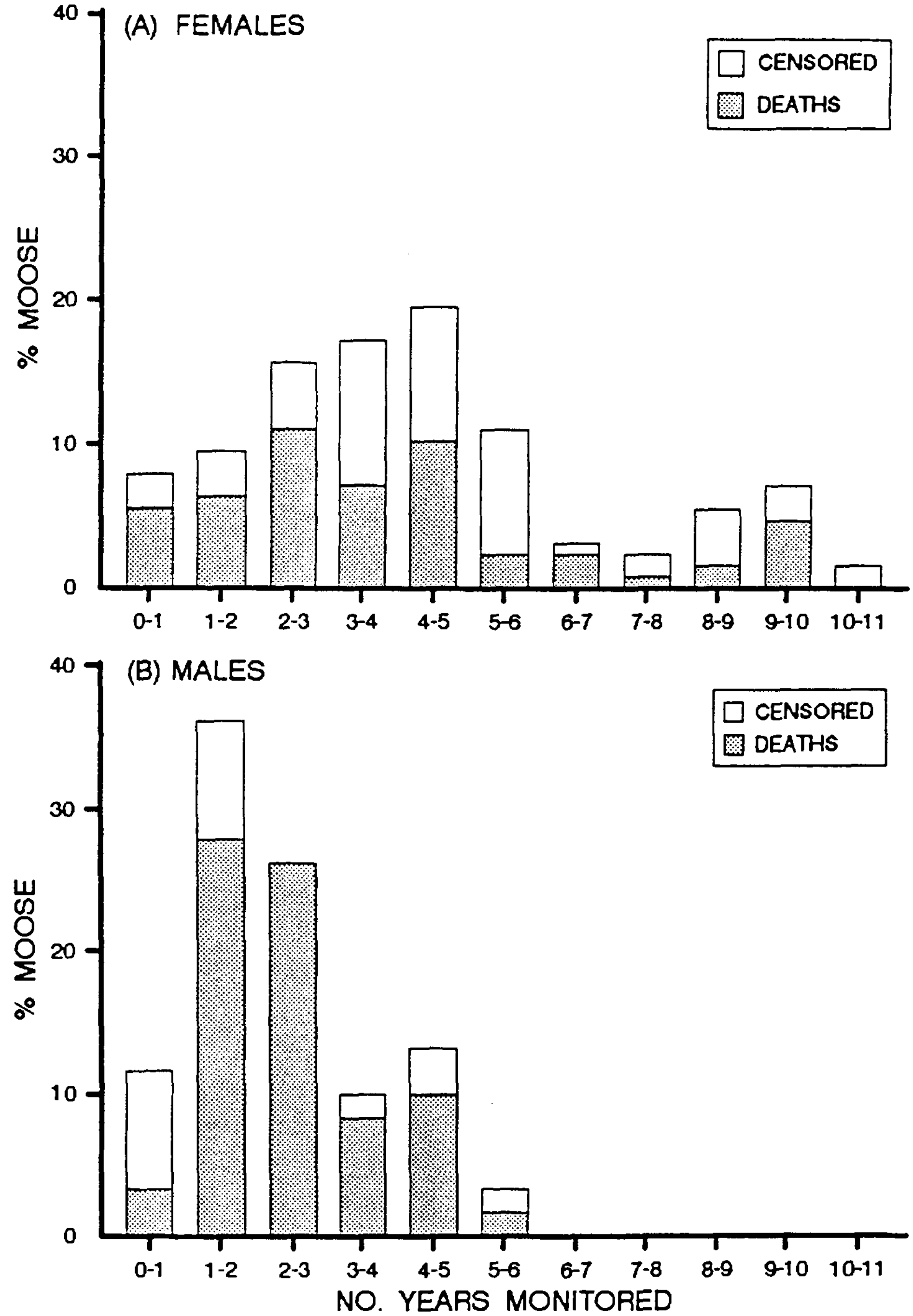
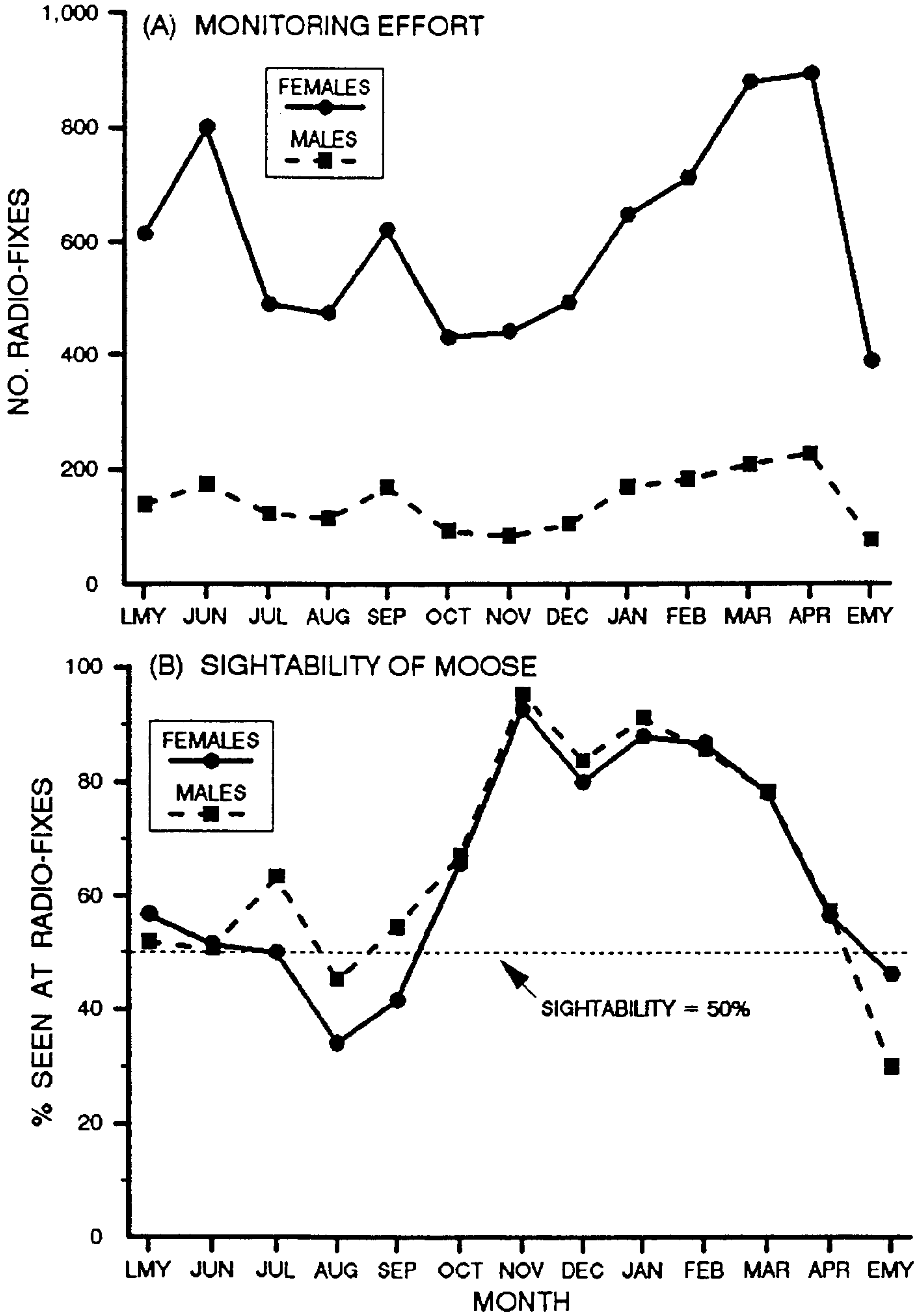

(A) FEMALES
CENSORED
DEATHS
% MOOSE
0
10
20
30
40
0-1
1-2
2-3
3-4
4-5
5-6
6-7
7-8
8-9
9-10
10-11
(B) MALES
CENSORED
DEATHS
% MOOSE
0
10
20
30
40
0-1
1-2
2-3
3-4
4-5
5-6
6-7
7-8
8-9
9-10
10-11
NO. YEARS MONITORED

FIG. 4



(A) MONITORING EFFORT
NO. RADIO-FIXES
1,000
800
600
400
200
0
FEMALES
MALES
LMY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR EMY
(B) SIGHTABILITY OF MOOSE
% SEEN AT RADIO-FIXES
100
80
60
40
20
0
FEMALES
MALES
SIGHTABILITY = 50%
LMY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR EMY
MONTH

FIG. 5.

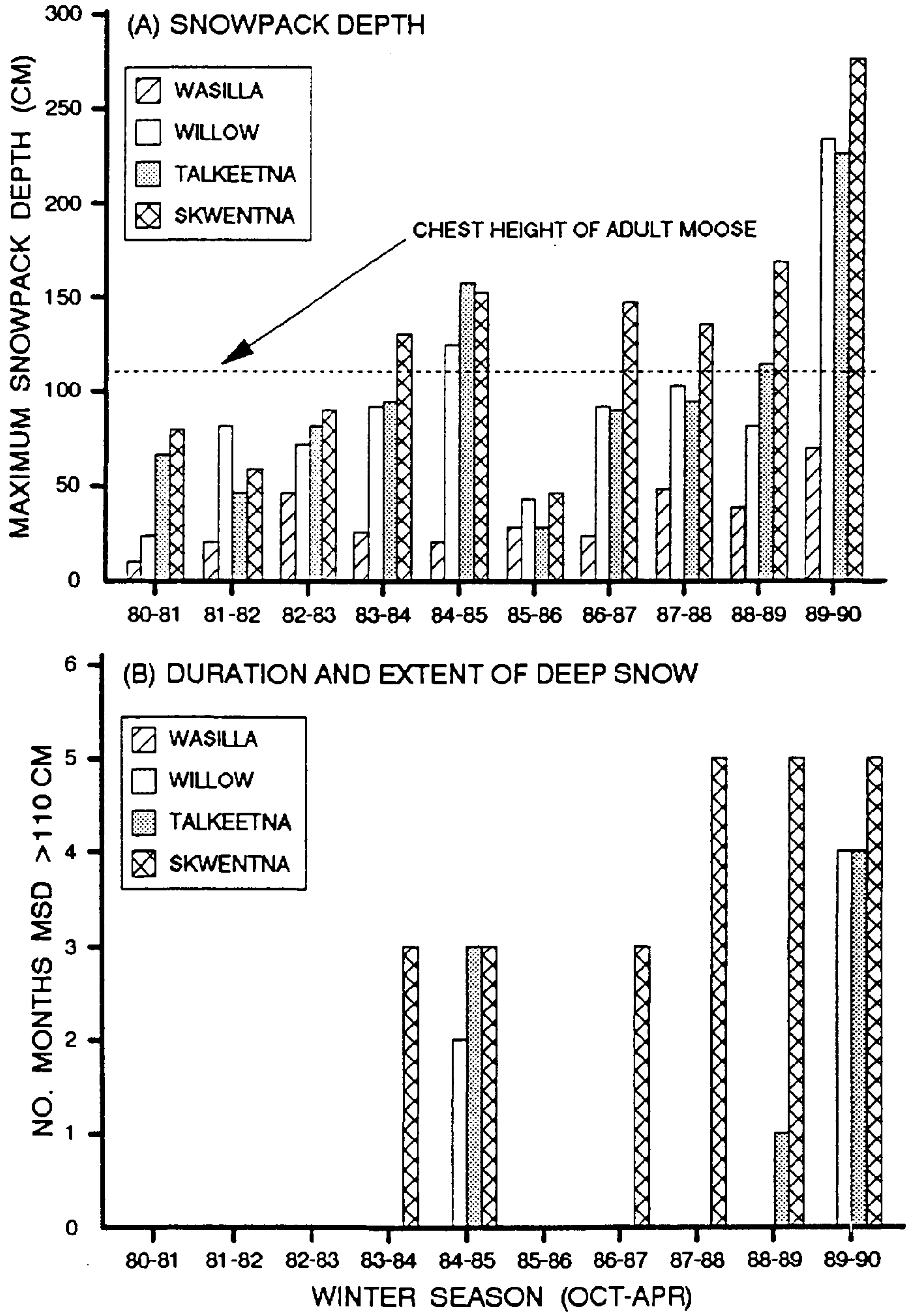

(A) SNOWPACK DEPTH
MAXIMUM SNOWPACK DEPTH (CM)
300
250
200
150
100
50
0
WASILLA
WILLOW
TALKEETNA
SKWENTNA
CHEST HEIGHT OF ADULT MOOSE
80-81
81-82
82-83
83-84
84-85
85-86
86-87
87-88
88-89
89-90
(B) DURATION AND EXTENT OF DEEP SNOW
NO. MONTHS MSD >110 CM
6
5
4
3
2
1
0
WASILLA
WILLOW
TALKEETNA
SKWENTNA
80-81
81-82
82-83
83-84
84-85
85-86
86-87
87-88
88-89
89-90
WINTER SEASON (OCT-APR)

FIG. 6

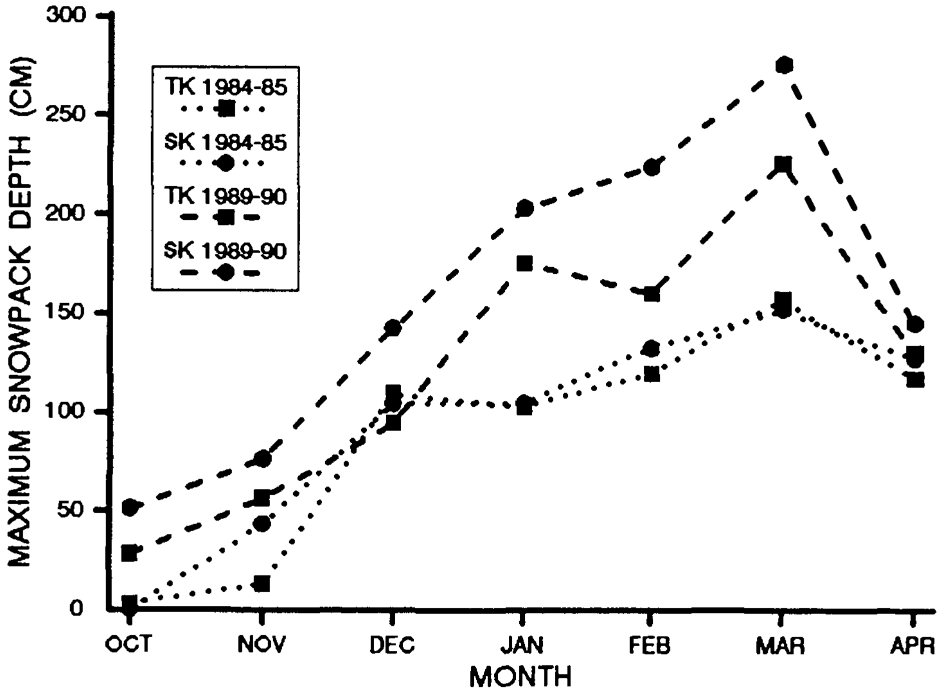
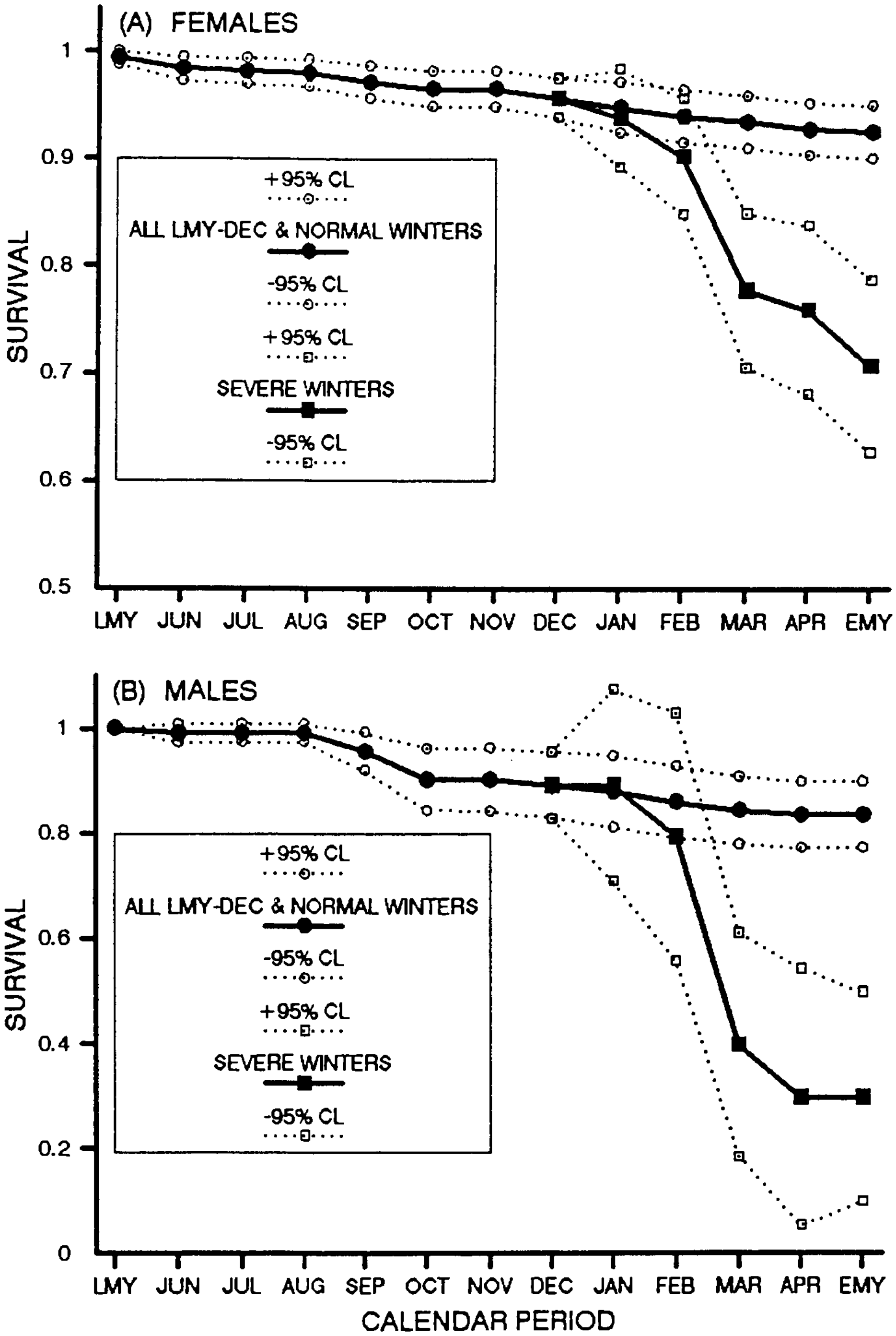

TK 1984-85
SK 1984-85
TK 1989-90
SK 1989-90
MAXIMUM SNOWPACK DEPTH (CM)
300
250
200
150
100
50
0
OCT
NOV
DEC
JAN
FEB
MAR
APR
MONTH

FIG. 7


(A) FEMALES
SURVIVAL
1
0.9
0.8
0.7
0.6
0.5
+95% CL
ALL LMY-DEC & NORMAL WINTERS
-95% CL
+95% CL
SEVERE WINTERS
-95% CL
LMY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR EMY
(B) MALES
SURVIVAL
1
0.8
0.6
0.4
0.2
0
+95% CL
ALL LMY-DEC & NORMAL WINTERS
-95% CL
+95% CL
SEVERE WINTERS
-95% CL
LMY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR EMY
CALENDAR PERIOD

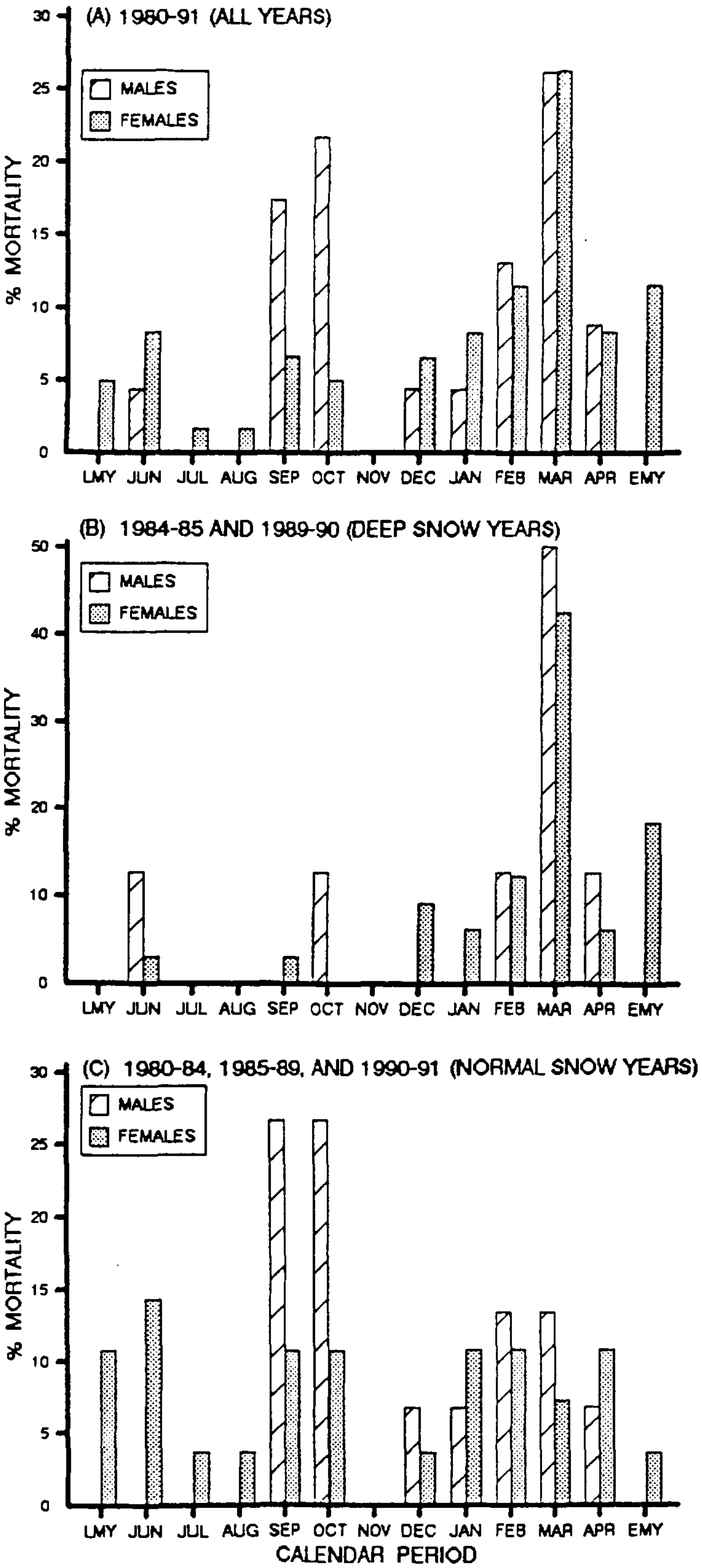

(A) 1980-91 (ALL YEARS)
MALES
FEMALES
% MORTALITY
0
5
10
15
20
25
30
LMY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR EMY
(B) 1984-85 AND 1989-90 (DEEP SNOW YEARS)
MALES
FEMALES
% MORTALITY
0
10
20
30
40
50
LMY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR EMY
(C) 1980-84, 1985-89, AND 1990-91 (NORMAL SNOW YEARS)
MALES
FEMALES
% MORTALITY
0
5
10
15
20
25
30
LMY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR EMY
CALENDAR PERIOD

FIG. 9.

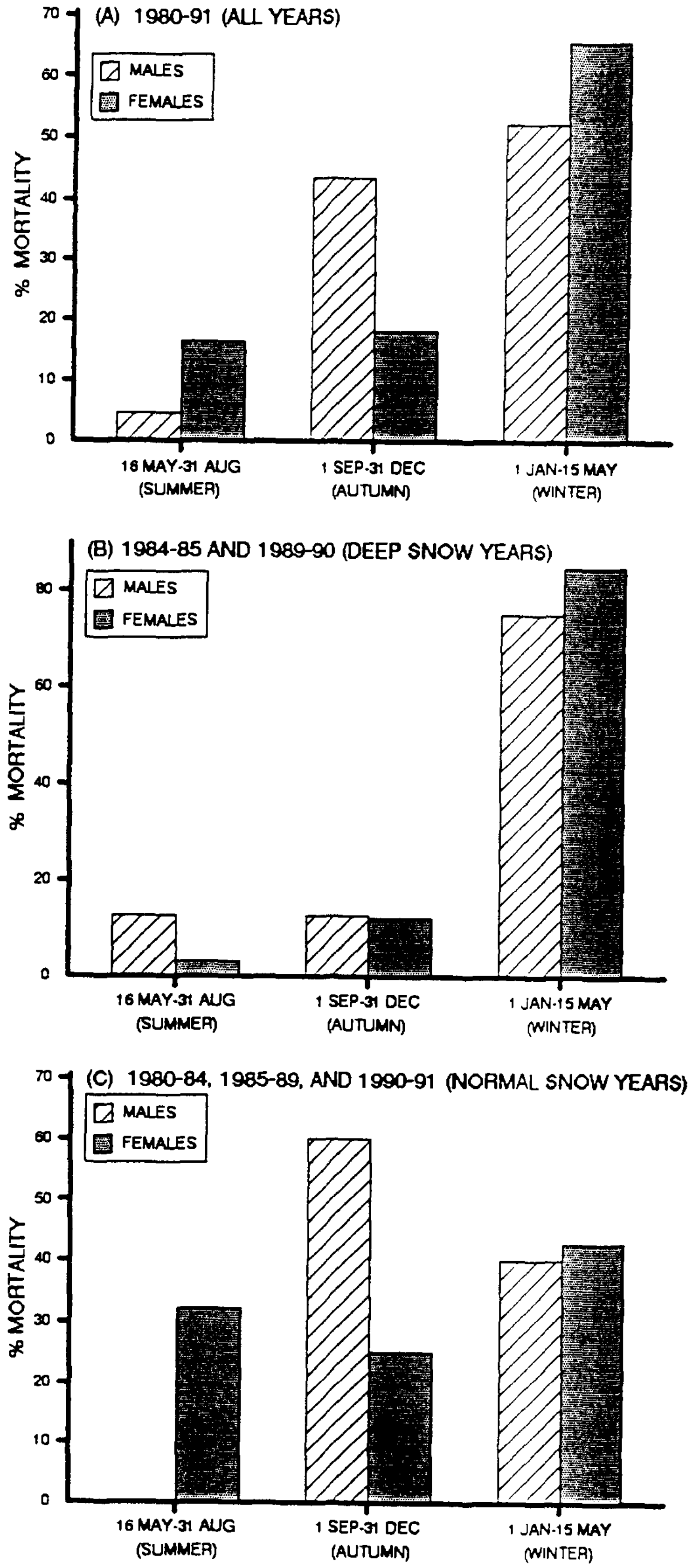
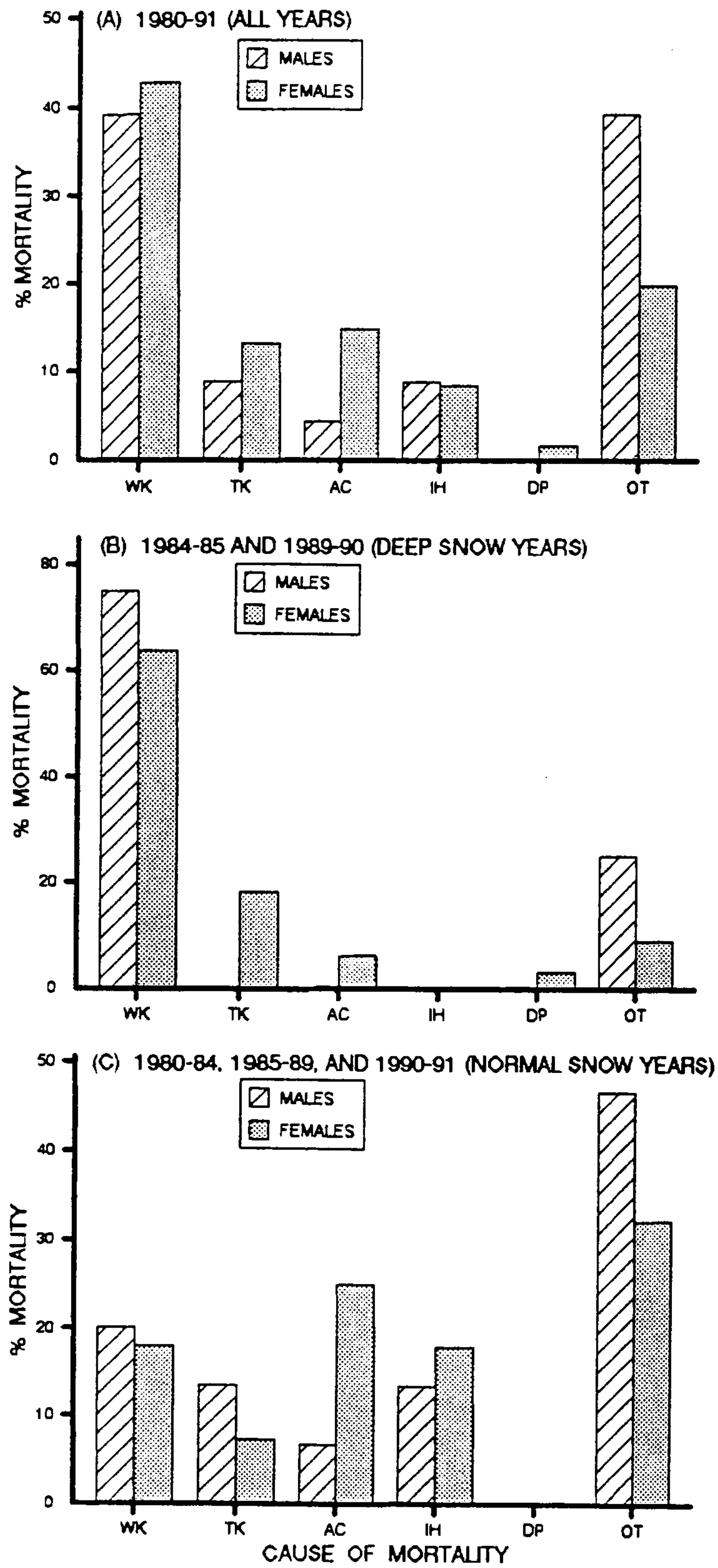

(A) 1980-91 (ALL YEARS)
MALES
FEMALES
% MORTALITY
0
10
20
30
40
50
60
70
16 MAY-31 AUG (SUMMER)
1 SEP-31 DEC (AUTUMN)
1 JAN-15 MAY (WINTER)
(B) 1984-85 AND 1989-90 (DEEP SNOW YEARS)
MALES
FEMALES
% MORTALITY
0
20
40
60
80
16 MAY-31 AUG (SUMMER)
1 SEP-31 DEC (AUTUMN)
1 JAN-15 MAY (WINTER)
(C) 1980-84, 1985-89, AND 1990-91 (NORMAL SNOW YEARS)
MALES
FEMALES
% MORTALITY
0
10
20
30
40
50
60
70
16 MAY-31 AUG (SUMMER)
1 SEP-31 DEC (AUTUMN)
1 JAN-15 MAY (WINTER)

FIG. 10.



(A) 1980-91 (ALL YEARS)
MALES
FEMALES
% MORTALITY
50
40
30
20
10
0
WK
TK
AC
IH
DP
OT
(B) 1984-85 AND 1989-90 (DEEP SNOW YEARS)
MALES
FEMALES
% MORTALITY
80
60
40
20
0
WK
TK
AC
IH
DP
OT
(C) 1980-84, 1985-89, AND 1990-91 (NORMAL SNOW YEARS)
MALES
FEMALES
% MORTALITY
50
40
30
20
10
0
WK
TK
AC
IH
DP
OT
CAUSE OF MORTALITY

Table 1. Fate of 138 adult female radio-collared moose in lower Susitna Valley, in southcentral Alaska, 1979-91.

Fate	Susitna River	Talkeetna Mountains	Alexander Creek	Yentna Skwentna Rivers	All
Captured	54	50	17	17	138
Death at capture	3	5	2	0	10
Monitored	51	45	15	17	128
Censored	13	0	1	1	15
Lost signal contact	9	0	1	0	10
Shed collar	4	0	0	1	5
Deaths	34	19	6	7	66
Cause of death verified	10	3	1	1	15
Train kill	7	1	0	0	8
Hunter harvest	2	1	1	1	5
Illegal harvest	0	1	0	0	1

Table 1. Continued.

Fate	Susitna River	Talkeetna Mountains	Alexander Creek	Yentna Skwentna Rivers	All
Defense of life or property	1	0	0	0	1
Cause of death unverified[a]	24	16	5	6	51
Winter kill[b]	14	5	3	4	26
Accident/injury	6	3	0	0	9
Illegal harvest	1	3	0	0	4
Other[c]	3	5	2	2	12
Survivors	4	26	8	9	47

Table 1. Continued.

Fate	Susitna River	Talkeetna Mountains	Alexander Creek	Yentna Skwentna Rivers	All

[a] Cause of death determined by circumstances and evidence at site of radio-fix and/or radio-collar.

[b] Winter kill = no evidence of predation, accident or illegal kill and substrate covered with snow.

[c] Other = circumstantial evidence insufficient to assign to a classification.

Table 2. Fate of 66 adult male radio-collared moose in lower Susitna Valley, in southcentral Alaska, 1979-91.

Fate	Susitna River	Talkeetna Mountains	Alexander Creek	Yentna Skwentna Rivers	All
Captured	23	27	3	13	66
Death at capture	2	2	0	1	5
Monitored	21	25	3	12	61
Censored	4	2	0	2	8
Lost signal contact	1	2	0	0	3
Shed collar	3	0	0	2	5
Deaths	17	19	2	9	47
Cause of death verified	12	11	1	3	27
Train kill	2	0	0	0	2
Hunter harvest	10	10	1	3	24
Illegal harvest	0	1	0	0	1

Table 2. Continued.

Fate	Susitna River	Talkeetna Mountains	Alexander Creek	Yentna Skwentna Rivers	All
Defense of life or property	0	0	0	0	0
Cause of death unverified[a]	5	8	1	6	20
Winter kill[b]	2	2	0	5	9
Accident/injury	0	1	0	0	1
Illegal harvest	1	0	0	0	1
Other[c]	2	5	1	1	9
Survivors	0	4	1	1	6

Table 2. Continued.

Fate	Susitna River	Talkeetna Mountains	Alexander Creek	Yentna Skwentna Rivers	All

[a] Cause of death determined by circumstances and evidence at site of radio-fix and/or radio-collar.

[b] Winter kill = no evidence of predation, accident or illegal kill and substrate covered with snow.

[c] Other = circumstantial evidence insufficient to assign to a classification.

Table 3. Kaplan-Meier survival estimates for radio-collared adult female and male moose monitored with aircraft in lower Susitna Valley, southcentral Alaska 1980-91.

Sex	Year (16 May-15 May)	Season[a]	No. monitored[b]	Survival estimate[c]	95% CI
Female	1980-89, 1990-91	Annual	534	0.9174	0.8928-0.9420
	1989-90	Annual	82	0.6499	0.5483-0.7516
	1980-91	Summer	489	0.9795	0.9668-0.9921
	1980-91	Autumn	486	0.9765	0.9628-0.9902
	1980-84, 1985-89	Winter-N	421	0.9671	0.9501-0.9841
	1984-85, 1989-90	Winter-S	111	0.7394	0.6605-0.8183
Male	1980-89, 1990-91	Annual	154	0.8412	0.7782-0.9041
	1989-90	Annual	20	0.2865	0.0928-0.4801
	1980-91	Summer	117	0.9914	0.9745-1.0083
	1980-91	Autumn	128	0.8879	0.8235-0.9522
	1980-89	Winter-N	117	0.9366	0.8922-0.9811
	1989-90	Winter-S	13	0.3333	0.1156-0.5511

Table 3. Continued.

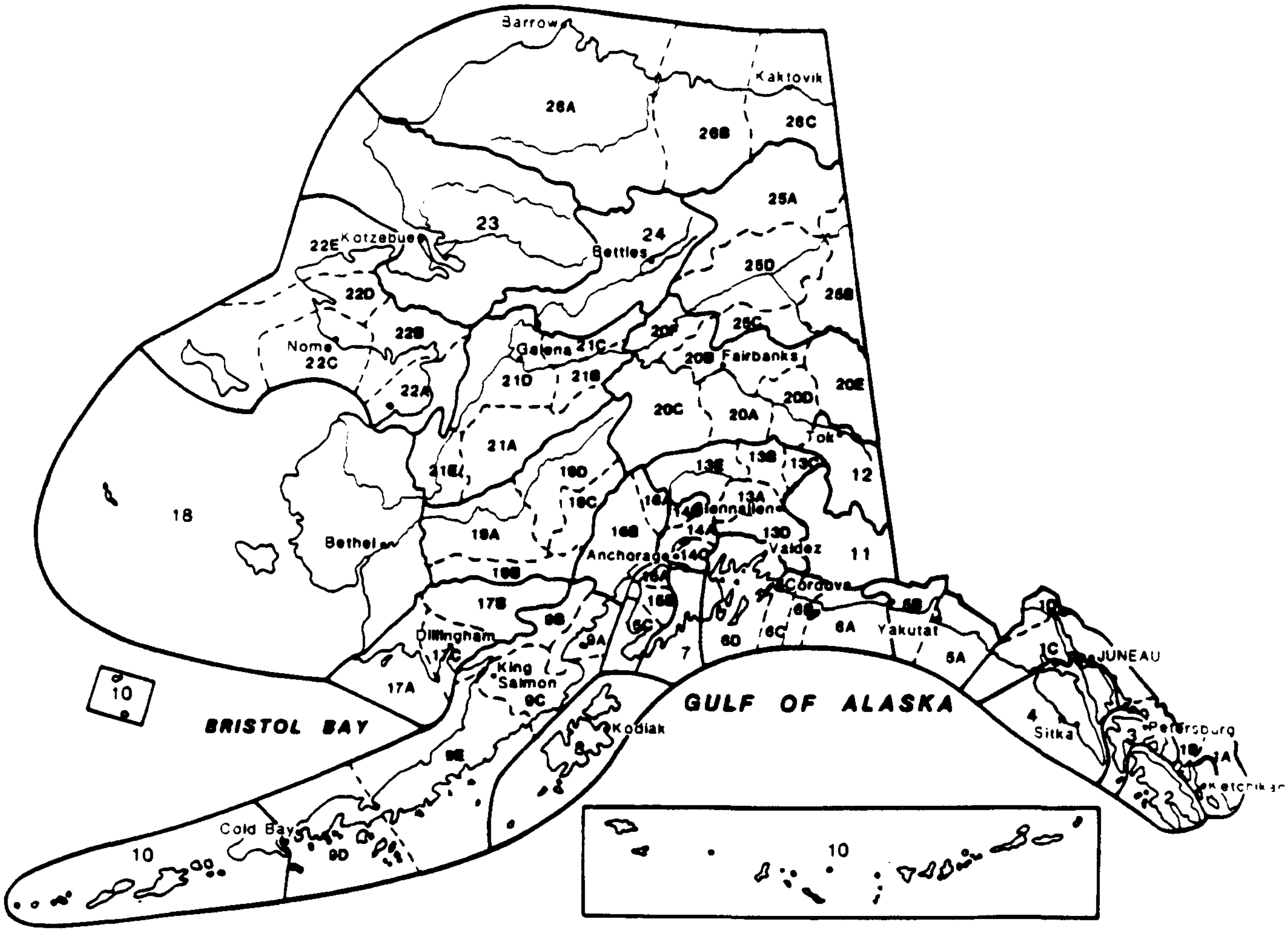
Sex	Year (16 May-15 May)	Season[a]	No. monitored[b]	Survival estimate[c]	95% CI

[a] Annual = 16 May-15 May; Summer = 16 May-31 Aug; Autumn = 1 Sep-31 Dec; and winter = 1 Jan-15 May. N = winter(s) with normal accumulations of snow. S = winter(s) with deep accumulations of snow.

[b] Includes individuals added in staggered entry but does not include moose that died from problems with capture.

[c] Pollock et al., 1989.

Alaska's Game Management Units



The Federal Aid in Wildlife Restoration Program consists of funds from a 10% to 11% manufacturer's excise tax collected from the sales of handguns, sporting rifles, shotguns, ammunition, and archery equipment. The Federal Aid program allots funds back to states through a formula based on each state's geographic area and number of paid hunting license holders. Alaska receives a maximum 5% of revenues collected each year. The Alaska Department of Fish and Game uses federal aid funds to help restore, conserve, and manage wild birds and mammals to benefit the public. These funds are also used to educate hunters to develop the skills, knowledge, and attitudes for responsible hunting. Seventy-five percent of the funds for this report are from Federal Aid.


Pat Costello