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Lower Susitna Valley Moose Population Identity and Movement Study

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SUMMARY

This report describes movement patterns of radio-marked moose (*Alces alces*) captured between 23 December 1985 and 14 December 1987 in alpine habitat postrutting areas of the western foothills of the Talkeetna Mountains in Southcentral Alaska. Additional pertinent location data gathered from radio-marked moose captured between 17 April 1980 and 3 January 1985 during previous studies in wintering areas along the Susitna River floodplain between Devil Canyon and Cook Inlet are also included. Point location data collected between 17 April 1980 and 14 February 1990 were analyzed; however, discussions focus on moose movements documented from 23 December 1985 through 14 February 1990.

Point locations from surveys conducted at 2- to 4-week intervals were used to document movements, annual ranges, and habitat use for individual radio-marked moose and groups of moose ("subpopulations") marked at 5 winter range areas along the Susitna River floodplain and at 7 alpine habitat moose postrutting areas in the Talkeetna Mountains.

Annual range for groups of moose differed in size and shape. Moose groups from the Bald and Brownie Mountain postrutting areas and Susitna River No. 1 winter range area exhibited relatively compact annual ranges. Moose groups from the Willow and Sunshine Mountain postrutting areas and Susitna River Nos. 2, 3, 4, and 5 winter range areas exhibited larger annual ranges. Annual range size and shape for moose groups were influenced by the lengths of migrations to winter range and calving areas. Lengthy migrations (>20 km) were not essential for moose from the Bald Mountain postrutting area. A major moose winter range was located nearby, and females from Bald Mountain calved between their winter range and postrutting area. Extensive migrations south to the winter range (>35 km) and west to calving areas (>20 km) resulted in large annual ranges for moose from the Willow Mountain postrutting area.

Individual moose captured at each site generally exhibited similar ("subpopulation specific") seasonal movement patterns. Numerous marked moose from the Willow Mountain postrutting area behaved similarly and migrated south in winter to lowlands in the

Palmer-Wasilla area. Moose from different groups tended to migrate differently and use different seasonal ranges. Marked moose from the Brownie Mountain postrutting area remained at high elevations throughout the year and did not make extensive migrations south in winter, as did moose from the Willow Mountain postrutting area. Movement patterns and seasonal range use were described for each moose group and representative individual moose.

Annual differences in movements of moose and their use of alpine habitat postrutting areas and winter ranges were documented from point locations provided by radio-marked moose. Data from marked moose indicated that major portions of moose subpopulations occurring in alpine areas of the Talkeetna Mountains during the postrutting period moved to lower elevations and other habitat types in the winters of 1986-87, 1987-88, and 1988-89. During the winter of 1985-86, most marked moose remained in alpine postrutting areas and near timberline ecotone habitat. In the winter of 1989-90, many marked moose moved to winter ranges before mid-November. Annual differences in movement patterns of moose were related to snowfall and snowpack depth. During the winters of 1987, 1988, and 1989, few moose occupied the Willow Mountain Critical Habitat area (WMCH); however, in 1985-86 there were many marked moose there from the postrutting period through the winter.

Monthly changes in moose distribution, habitat use, and occurrence in the WMCH and the Kashwitna Corridor Forest area (KCF) were assessed. In October many marked moose were located below timberline in forest habitats, including the WMCH and the KCF. Peak moose use of alpine postrutting areas occurred in November. In December marked moose migrated from some alpine postrutting areas, and many were located in the WMCH and KCF; at the same time, other marked moose were located on the lowland winter ranges in the Palmer-Wasilla area. In January few marked moose remained in alpine postrutting areas, as most of them had moved to lowland wintering areas. Timing of winter migrations from postrutting areas was related to snowfall and snowpack depth. Most marked moose were located on winter ranges in February and March. In April many had vacated winter ranges and were located in subalpine forest habitats, including the KCF. In May and June, when female moose are involved with calving or neonate calves, marked females from several alpine postrutting areas in Subunit 14B were located across the Susitna River in Subunit 16A. In June many marked moose occurred in forest habitats, including the KCF. In July marked migrant females from Subunit 14B remained in Subunit 16A, and many moose were located at higher elevations near or above the timberline ecotone habitat, including the WMCH. In August marked moose continued to concentrate at higher elevations near timberline ecotone habitat and on the periphery of postrutting areas, including the WMCH and higher elevations of the KCF; however, some individuals remained in lowland areas and in Subunit 16A. In September most marked moose were distributed at lower elevations below timberline in forest habitats, including the WMCH and the KCF.

Point location data from moose radio-marked in alpine postrutting areas of Subunits 14A and 14B and in winter range areas of Subunits 13E, 16A, and 16B indicated that some individuals traversed subunit boundaries during migrations to and from winter ranges and calving and rutting areas. In winter migrations, marked moose traversed boundaries between the following Subunits: 16A and 14B, 16A and 14A, 16B and 14A, 13E and 14B, 13E and 16A, 14B and 14A, and 14B and 16A. Significant numbers of moose migrated across the boundaries from the following subunits: 14B into 14A, 16A into 14B, and 16A into 14A. During spring migrations, significant numbers of marked female moose migrated from Subunit 14B to Subunit 16A. In mid-May a marked two-year-old male moose traversed the boundary between Subunits 14A and 16B; this movement (about 100 km) was considered a range extension and not a migration.

Factors influencing moose migrations and annual range size were discussed. Compact annual ranges for individual moose as well as groups included topography with significant elevational variation. Large annual ranges for individual moose groups frequently included topography with little elevational variation. Migrational distance to and from winter ranges and calving areas influenced the annual size of the range. Timing and extent of winter migrations were related to snowfall and snowpack depth. It was hypothesized that predator avoidance, forage quality, or particular habitat components were related to spring migrations of female moose.

Relationships between migrations of females and calf recruitment were discussed. Other studies indicated that calf recruitment was likely related to summer range conditions and environmental factors during the winter (e.g., snow conditions) and was independent of the migrational distance to winter range. I hypothesized that female migrants to wintering areas in the Palmer-Wasilla area, where forage is abundant and snowpacks are shallow, have higher calf recruitment rates than nonmigrant females that remained in areas where snowpacks were deeper. I also hypothesized that female migrants to calving areas in Subunit 16A experience higher calf recruitment rates than those that do not make lengthy spring migrations to calving areas. Importance of maintaining, conserving, and protecting moose winter ranges that traditionally have shallow snowpacks was emphasized. I hypothesized that moose migratory patterns may be useful in identifying high-quality winter ranges and calving areas.

Seasonal movement patterns and habitat use documented for radio-marked moose in alpine habitat postrutting areas in the Talkeetna Mountains were outlined and discussed in relation to aspects of life history, snowfall and snowpack depth, occurrence and

distribution in the Parks Highway and Alaska Railroad corridors, and open hunting seasons.

Data on occurrence of moose in WMCH and KCF areas obtained from radio-marked point locations were discussed in relation to seasonal conditions. Large numbers of marked moose occurred in forest portions of WMCH and KCF in April and early May and in September and early October. In June and July moose concentrations occurred above timberline in the WMCH. During mild winters (e.g., 1985-86), alpine postrutting areas, including portions of WMCH, function as winter ranges for moose.

Point location data from marked moose that traversed subunit boundaries were presented and discussed in relation to collecting biological data, conducting moose surveys, analyzing biological data, allocating mortality to subunits, and implementing findings into management programs. Movement and subpopulation identity studies of moose provide management biologists with knowledge about potential violations in the assumption that subunits are closed systems. Significant seasonal interchanges in moose occurred between Subunits 14A, 14B, and 16A. Subunits 13E and 16B were involved in less significant interchanges of moose. Herd composition surveys and censuses, particularly in Subunits 14A, 14B, and 16A, should be conducted before moose begin winter migrations and subpopulations become mixed. Surveys of females or calves during parturition are not recommended in Subunits 16A and 14B, if data are to be applied to a specific subunit. Positive or negative impacts to small portions of habitat (e.g., Palmer-Wasilla winter range and Subunit 16A calving habitat) can affect moose from areas beyond subunit boundaries.

Effects of moose migrations on late-winter moose hunts in Subunit 14B were discussed. Previous contentions regarding movements of moose from Subunit 14B were partly invalidated. Data indicated moose from remote portions of Subunit 14B north of Sheep Creek could harvested most effectively by hunters along the road-rail corridor during severe winters. Radio-marked moose from remote portions of Subunit 14B south of Sheep Creek were mostly unavailable from that corridor, and a high percentage of moose vulnerable to hunters were immigrants from Subunit 16A.

Key Words: Moose, *Alces alces*, Susitna Valley, radiotelemetry, habitat, movements, aerial survey, population identity, Southcentral Alaska, subunits, annual range, Willow Mountain Critical Habitat, Kashwitna Corridor Forest, migration.

CONTENTS

BACKGROUND

Prior to statehood (i.e., 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 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 system, and increased railroad traffic in the region may greatly detract from the potential of the area to support moose.

Although development and associated activities may tend to reduce the moose population in the Susitna Valley, resource users have demanded increased allocations to satisfy consumptive and nonconsumptive uses. Accordingly, this conflict has 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 the resource to potential users.

Because the Wildlife Conservation Division personnel lack necessary information about moose populations in the lower Susitna Valley to accurately assess the ultimate impacts from these increasing resource demands, they are unable to dispute or condone specific demands or provide recommendations to regulate and minimize negative impacts on moose populations or habitat. Additionally, these personnel must be knowledgeable about behavior of moose subpopulations to mitigate unavoidable negative impacts to them or their habitat.

Because major decisions on land use and resource allocation in the lower Susitna Valley are being made, the existing database should be consolidted for the moose populations there and studies initiated to augment that database so that activities impacting moose and their habitat may be promptly recognized, evaluated, and minimized and/or mitigated. Habitats and environmental conditions of the lower Susitna Valley vary greatly. Because many resource use conflicts require site-specific knowledge, numerous interrelated substudies must be conducted to adequately understand movement patterns and identities of major moose subpopulations throughout the area. Initial substudies will be conducted in areas where immediate conflicts exist.

When I evaluated conflicts in resource use for the entire lower Susitna Valley, it was apparent that research efforts should begin in Subunits 14A and 14B in the western foothills of the Talkeetna Mountains for the following reasons: (1) this area possesses the largest, densest postrutting aggregation of moose in the region and, perhaps, the state; (2) it is the nucleus of development activities and resource use; (3) it provides recreation and resources to over half of Alaska's human population; (4) it has unique problems involving railroad and highway systems; and (5) recent information obtained from Susitna River hydroelectric environmental studies and a habitat suitability assessment project has pointed out a lack of basic knowledge about moose in the area.

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) an outdated 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 sporadically monitored 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, and (8) a study of extensive moose mortality in a severe winter (1970-71) for which there is no final report.

Recent studies designed to assess the impact of a proposed hydroelectric project on moose have provided substantial amounts of data on populations in areas adjacent to the Susitna River downstream from Devil Canyon (Arneson 1981; Modafferi 1982, 1983, 1984, 1988b). Circumstantial evidence and cursory examination of these studies suggested that traditional sex-age composition counts conducted in widely spaced alpine areas of Subunits 14A and 14B were biased, excluding samples from large segments of hunted moose subpopulations. These data also suggested that moose killed during late-winter hunting seasons in Subunit 14B originated in Subunit 16A and those killed during hunting seasons in Subunit 16A were included in composition surveys for Subunits 14A and 14B.

I believe that moose subpopulations in Subunit 16A remain largely unsurveyed because they occur in forested habitats and could only be surveyed during winter when they occur in riparian habitats common to both Subunits 14B and 16A. Traditional composition surveys that have remained relatively insensitive to large annual changes in moose mortality rates indicated assumptions about movements and identities of moose subpopulations in Subunits 14A and 14B (i.e., western foothills of the Talkeetna Mountains) are incorrect.

A recent joint study conducted by Divisions of Wildlife Conservation and Habitat (ADF&G files) and designed to evaluate methods for assessing moose population status and habitat suitability was begun to identify important moose wintering areas and to document moose-snowfall relationships in a large portion of the lower Susitna River Valley. Previous progress reports for lower Susitna Valley moose population identity and movement studies have been published (Modafferi 1987, 1988a, 1990).

OBJECTIVES

Primary

To identify and delineate major moose subpopulations in the lower Susitna River Valley.

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

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

Peripheral

To identify habitats and land areas that are important for maintaining the integrity moose subpopulations in the lower Susitna Valley.

To locate winter range and calving areas used by lower Susitna Valley moose subpopulations.

To identify moose subpopulations that sustain "accidental" mortalities on highway and railroad right-of-ways and hunting mortalities during open seasons.

To determine moose natality rates and timing of calf and adult mortalities.

STUDY AREA

The study area is located in the lower Susitna Valley in Southcentral Alaska (Fig. 1). The roughly 50,000-km^2 area (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) 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 vary from about 16 C in July to -13 C in January; maximum and minimum temperatures of 25 C and -35 C, respectively, 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 of the area. Maximum depth of snow on the ground in winter can vary 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 the 1200-m level. Vegetation in the area is diverse, typically varying with elevation: 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 follows:(1) floodplains 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. Fall-winter postrutting area surveys were conducted above timberline in the higher elevation and alpine tundra habitats, roughly between elevations of 600 and 1200 m.

METHODS

Individual moose were captured and marked with ear tags and radio-transmitting neck collars. Each ear tag featured a discrete numeral, and each neck collar featured a discrete radio-transmitted frequency and a highly visible number.

Moose were typically immobilized with 4-6 mg carfentanil (Wildnil, Wildlife Laboratories, Ft. Collins, Co.) dissolved in 2-3 cc H_2O and administered with Palmer Cap-Chur equipment by personnel aboard a hovering Bell 206B or Hughes 500D helicopter. While immobilized, moose were marked with ear tags and neck collars and aged by visual inspection of wear on incisor teeth. Antler size and conformation were considered when assessing age of males. Moose were assigned to the following age categories: calves, yearlings, 2- to 5-year-olds, 6- to 12-year-olds, and >12-year-olds. Sex of marked moose and their association with young of the year were noted. Immobilized moose were revived with an intramuscular injection of 90 mg naloxone hydrochloride (Naloxone, Wildlife Laboratories, Ft. Collins, Co.) per mg of carfentanil administered.

Forty-four moose were captured and marked in the Talkeetna Mountain alpine habitat survey areas (Fig. 3) between 23 December 1985 and 4 February 1986. Marking procedures were initiated after 18 November 1985, when aerial surveys indicated peak numbers of moose were present in alpine habitats (Modafferi 1987). Distribution of sampling effort between subareas roughly paralleled moose distribution observed during aerial surveys. On 14 December 1987 and 21 December 1988, 6 and 2 moose, respectively, were captured and radio-marked to replace those that had shed transmitting collars or died.

On 28 January 1987, 7 moose were captured and marked in lowland portions of forest habitat between Little Willow Creek and the Kashwitna River (Fig. 3, Area H). Sampling efforts roughly paralleled distribution of moose observed on a survey conducted between Willow Creek and the Kashwitna River on 7 January 1987 (Modafferi 1988a). This area is included within the Kashwitna Corridor Forest, where the State of Alaska, Department of Natural Resources, Division of Forestry, initiated a forest management program in 1988 by providing access and conducting sales to make timber available for commercial harvests. On 9 February 1989, 5 moose were captured and marked near timber sale sites between Willow and Iron Creeks in the southern portion of the Kashwitna Corridor Forest.

During February and March 1988, 6 moose were captured and marked in the Coal Creek area (Fig. 3, Area I), where personal-use cutting of firewood had been permitted by the DNR, Division of Forestry. Captured moose frequented this area to feed on buds, catkins, and twigs that had been trimmed off birch trees cut for firewood.

During this reporting period, 7 additional moose were captured and radio-marked at 5 different sites near the Parks Highway between the Little Susitna River and Sheep Creek. On 16 April 1990, 6 moose were captured, radio-marked, and released at sites where hay had been provided as supplemental food for moose stressed by an exceptionally deep snowpack. These capture sites were located near the Deshka Landing, Long Lake, Capitol Speedway, and Caswell Creek, where 1, 2, 1, and 2 moose, respectively, were captured. On 19 April 1990, 1 moose caught in a snare trap was tranquilized, radio-marked, and released at the Houston landfill.

In 1988 and 1989 parallel moose population identity and movement studies were initiated in other areas of the lower Susitna River

Valley (Modafferi 1990: Appendix B). In March 1987, 23 moose were captured and radio-marked along the Alexander Creek floodplain (Fig. 3, Area J). Thirteen of these marked moose with operational radio-transmitters were periodically radiolocated during this reporting period. In February 1988 and 1989, 21 and 6 moose, respectively, were captured and radio-marked in the Lake Creek-Skwentna area (Fig. 3, Area K). Twenty-three of these marked moose with operational radio-transmitters were periodically radiolocated during this reporting period.

Moose captured and radio-marked during previous studies along the Susitna River floodplain (Arneson 1980; Modafferi 1982, 1983, 1984, 1988b) ranged within the lower Susitna Valley study area. Information gathered from these radio-marked moose was incorporated into the database. Seventeen of these marked moose with operational radio transmitters were radiolocated during the reporting period.

Survey flights in Cessna 180 or 185 and Piper PA-18 aircraft equipped with 2-element "H" or 3-element yagi antennas (Telonics, Mesa, AZ) were conducted at 2- to 4-week intervals to radiolocate moose. Moose location points (audio-visual or audio) were noted on USGS topographic maps (1:63,360) and later transferred to translucent overlays of those maps for computer digitization and geoprocessing. A maximum of about 200, 85, 58, 42, 27, and 15 point locations were recorded through 14 February 1990 for radio-marked moose in the Susitna River floodplain, Susitna River Montana Creek, Talkeetna Mountain, northern Kashwitna Corridor, Coal Creek, and southern Kashwitna Corridor areas, respectively.

During this reporting period, transmitters on some individuals marked along the Susitna River in March 1981 and February 1982 exhibited weak signals, infrequent signals, and/or no signals. These transmitters were presumed to be weakening and expiring from battery failure.

Moose distribution, abundance, and herd composition were assessed by aerial surveys conducted at different times and locations within the study area. Each winter between October 1985 and April 1989, aerial surveys were periodically conducted to determine timing, magnitude, and duration of moose use of alpine habitats in the western foothills of the Talkeetna Mountains. Surveys were initiated and periodically conducted as weather permitted and snowcover sufficient to observe moose. Numbers of antlered yearlings, antlered adults, nonantlered adults, and calves were counted on each survey. Survey data were totaled for 7 discrete alpine habitat moose postrutting subareas (Fig. 4, Areas A-G) separated by lower-elevation river drainages.

Additional information on herd size, composition, and distribution for moose in the lower Susitna River Valley was obtained from stratified random censuses (Gasaway et al. 1986) conducted 5-8 December 1987 in Subunit 14B (Fig. 4, Area K) and

19-23 November 1988 in Subunit 14A (Fig. 2) and a modified census (ADF&G files) conducted 13-15 November 1989 in Subunit 14B. Other information on moose herd composition, distribution, and densities was obtained from aerial surveys related to forest management in the Susitna Regional Forest in Subunit 16A (Fig. 2), the Kashwitna Corridor Forest in Subunit 14B (Fig. 4, Area H) and the Matanuska Valley Moose Range and ski resort development in the Hatcher Pass area of Subunit 14A.

Data on moose killed by collisions with trains and highway vehicles were collected to evaluate the impact of those mortalities on moose populations in the lower Susitna River Valley. The Alaska Railroad and Department of Public Safety recorded and provided the ADF&G with data on locations and dates for all moose killed in their respective rights-of-way. Beginning in the fall of 1987, recipients of salvaged moose were required to provide the lower jaw and information on the sex, method, date, and location of kill to the ADF&G.

To assess moose winter mortality in Moose and Kroto Creek floodplains in Subunit 16A (Fig. 4, Areas I and J, respectively) were surveyed for moose carcasses on 18 March 1987, 20 April 1988, and 3 April 1989. Similar surveys were conducted 5 March 1984 and periodically between 29 November 1984 and 16 April 1985 during previous studies (Modafferi 1988b). On 11 January 1988, I visited areas where moose concentrated in forested habitats in the Kashwitna Corridor Forest (Fig. 4, Hc and He) to determine food sources moose had utilized.

Snowpack data for Wasilla, Willow, Talkeetna, Skwentna, and Chulitna River Lodge 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. Tabular data for daily measurements of depth of snow on the ground were condensed to "maximum snowpack depth" values for monthly periods equivalent to 1-10, 11-20, and 21-31 calendar days. "Maximum snowpack depth" values equalled the greatest depth of snow recorded on the ground during each monthly period. Willow and Talkeetna snowpack data were used as an index to snowpack depth in alpine habitat postrutting survey areas.

This progress report primarily contains movement data collected from moose captured and radio-marked between 23 December 1985 through 14 February 1990 in 7 alpine habitat postrutting areas in the western foothills of the Talkeetna Mountains (Fig. 5), where the ADF&G conducts sex-age composition surveys of moose herds in Subunits 14A and 14B. Movements of radio-marked moose are related to alpine habitat postrutting areas, the Willow Mountain Critical Habitat Area, and adjacent state and borough lands in the Kashwitna Corridor Forest area designated for timber harvest (Fig. 6). Relevant data and findings from previous studies (1980-85) of moose movements in the lower Susitna Valley are included.

RESULTS

Annual Ranges for Groups of Moose ("Subpopulations") and Representative Individuals

Bald Mountain Postrutting Area:

Except for the extraordinary movements of one 2-year-old male, the 322 point locations for 11 radio-marked moose from Bald Mountain postrutting area indicated short seasonal migrations and small annual ranges bounded by Willow Creek and the Parks Highway (Fig. 7). Most marked moose utilized lowlands between the Little Susitna River and the Parks Highway for winter range. In this area, moose wintered among abandoned homesteads, rural and suburban residential developments, and agricultural fields. Moose browse was provided by second-growth vegetation that had colonized the area after natural vegetation was disturbed or removed for development. This winter range area traditionally receives a shallow snowpack. In the spring, moose moved to higher elevations and forest habitats slightly below timberline on south and southeast facing slopes of Bald Mountain. In late June and early July, marked moose moved above timberline, remaining there until late August or early September, when they returned to forest habitats below timberline. Male moose appeared to precede females in the spring-summer movement above timberline. Marked moose remained in forest habitats below timberline during the rut. In late October (i.e., after the rut) moose returned to alpine habitat postrutting ranges, remaining there until they migrated to lowland winter ranges. Time of year, magnitude (number of moose involved), and extent (distance of movement) of movements between postrutting and winter ranges were associated with timing of winter snowfall and snowpack depth (Modafferi 1990). A major portion of the moose that wintered in the Palmer-Wasilla area were winter migrants from the Bald Mountain postrutting area. Aerial survey data indicate that movement patterns described for moose on the Bald Mountain postrutting area probably involved about 500-700 moose. Figure 8 illustrates a representative annual range for a radio-marked moose (No. 291F) from the Bald Mountain postrutting area to the Palmer-Wasilla wintering area.

Moss Mountain Postrutting Area:

Limited data available from 38 point locations for 2 radio-marked moose from the Moss Mountain postrutting area indicated their migratory patterns were similar to those from the Bald Mountain postrutting area (Fig. 9). These data indicated that moose migrated south, wintering in the Palmer-Wasilla area with moose from Bald Mountain. Movement patterns exhibited by radio-marked moose from Moss Mountain were probably representative of 75-150 moose. Figure 10 illustrates the annual range for 1 radio-marked moose (No. 38F) that moved from the Moss Mountain postrutting area to the Palmer-Wasilla area for the winter.

Willow Mountain Postrutting Area:

Data from 680 point locations for 19 radio-marked moose from the Willow Mountain postrutting area indicated several types of winter migrations, movement patterns similar to moose from Bald and Moss Mountains postrutting areas, and substantially different migrations to calving areas (Fig. 11). Eight moose migrated south in the winter to Subunit 14A. Five of these moose migrated about 40 km and wintered in the Palmer-Wasilla area with moose from Bald and Moss Mountain postrutting areas. During the winter, several marked moose ranged farther south (nearer to Knik Arm) than moose from Bald or Moss Mountains. Several marked moose remained at high elevations near timberline or in alpine postrutting areas on Willow Mountain throughout the winter. Others wintered in forest habitats at lower elevations west of the postrutting area. Few marked moose made long westerly winter migrations to lowland areas near the Parks Highway and Alaska Railroad rights-of-way (road-rail corridor). Several female marked moose migrated 20-30 km west and crossed the Susitna River into Subunit 16A prior to calving. These moose remained in Subunit 16A for varying lengths of time through the summer.

Other general seasonal migratory patterns for these moose were similar to those for moose from Bald Mountain. Movement patterns exhibited by marked moose were probably representative for about 500-750 moose. Figures 12, 13, and 14 illustrate representative annual ranges for moose that were nonmigratory (No. 17M), migrated to a winter range in the Palmer-Wasilla area (No. 793F), and migrated to a calving area in Subunit 16A (No. 601F), respectively.

Witna Mountain Postrutting Area:

Data from 89 point locations for 3 radio-marked moose from the Witna Mountain postrutting area indicated they migrated west during the winter toward the road-rail corridors (Fig. 15). These data also indicated moose migrated west of the Susitna River prior to calving. Generally, migrations of marked moose were east-west oriented. No marked moose made extensive migrations to the south during the winter. Movement patterns represented of about 100-150 moose. Figure 16 illustrates an annual range for 1 moose (No. 551F) that extended from the road-rail corridor during the winter to the Susitna River area in Subunit 16A prior to calving.

Brownie Mountain Postrutting Area:

Data from 333 point locations for 7 radio-marked moose from the Brownie Mountain postrutting area exhibited spring movement patterns that were similar to those from more southerly postrutting areas and winter movement patterns that differed greatly from other subpopulations (Fig. 17). In contrast to moose from the Bald, Moss, Willow, and Witna Mountain postrutting areas, marked moose from the Brownie Mountain postrutting area wintered at higher elevations in riparian areas and along side-slopes of valleys of the north and main forks of the Kashwitna River. Moose did not migrate south or west to lowland winter ranges, and the only major westerly movement to lower elevations was by 1 female during the calving period. Moose remained relatively isolated from moose from other postrutting areas throughout the year. Movement patterns represented about 150-250 moose. Figure 18 illustrates the annual range for 1 moose (No. 49F) that did not migrate to lower elevations during winter.

Wolverine Mountain Postrutting Area:

Data from 176 point locations for 6 radio-marked moose from the Wolverine Mountain postrutting area indicated somewhat different migratory patterns than those exhibited by moose from postrutting areas farther south (Fig. 19). Marked moose utilized upland riparian or lowland winter ranges. A radio-marked male migrated north of the Sheep River, a distance over 35 km, and remained there during the winter, spring, and summer periods. Prior to calving, a marked female migrated across the Susitna River into Subunit 16A. Movement patterns for these moose probably represented 150-250. Figure 20 illustrates the annual range for 1 moose (No. 51F) that migrated to lower elevations in winter.

Sunshine Mountain Postrutting Area:

Data from 119 point locations for 3 radio-marked moose from the Sunshine Mountain postrutting area (Fig. 21) and movement data from 4 radio-marked moose in other studies (Modafferi 1988b) indicated that during the winter moose may remain near alpine postrutting areas or migrate west to lower elevations. Peak numbers of moose occurred about a month later than in the other postrutting areas studied (Modafferi 1990). Several marked female moose migrated across the Susitna River prior to calving (Modafferi 1988b). One of these moose traditionally remained west of the Susitna River until September or October. Movement patterns represented about 75-100 moose. Figure 22 illustrates the annual range for 1 moose (No. 11F) that wintered at lower elevations along the road-rail system corridor.

Susitna River Area No. 1 Winter Range, Devil Canyon to Talkeetna:

Data provided from 1,070 point locations for 12 radio-marked moose from the Susitna River floodplain in the winter indicated relatively compact annual ranges (Fig. 23), although a few females exhibited extraordinary movements during or after the calving period. Marked females vacated floodplain wintering areas after the winter, but they commonly returned to floodplain islands prior to calving (Modafferi 1988b). After calving female moose returned to higher elevations on the valley's side slopes. Figure 24 illustrates a relatively compact and characteristic annual range (No. 63F).

Susitna River Area No. 2 Winter Range, Talkeetna to Montana Creek:

Data provided from 825 point locations for 9 radio-marked moose from the Susitna River floodplain in the winter indicated that most were winter migrants from the west and some were winter or spring migrants from the east (Fig. 25). These data support the contention that moose north of Sheep Creek exhibit a tendency to migrate to lowlands along the Susitna River floodplain and along the roadrail corridor in the winter. Some radio-marked moose had migrated east-west distances over 30 km to winter on the Susitna River floodplain. These data also illustrate that migrant moose from the west were drawn from a larger north-south area than those from the east. Migrant moose from the west originated from as far south as Lockwood Lake and as far north as Little Peters Hills; whereas, moose from the east were migrants from postrutting areas between Sheep Creek and Montana Creek. Figure 26 illustrates the annual range for 1 moose (No. 82F) from the winter capture site that migrated from north of the Petersville Road near Kroto Creek in Subunit 16A to the road-rail corridor in Subunit 14B.

Susitna River Area No. 3 Winter Range, Montana Creek to the Yentna River:

Data provided by 2,579 point locations from 25 radio-marked moose in winter on the Susitna River floodplain between Montana Creek and the Yentna River indicated that most are migrants from the west (Fig. 27). Figure 27 also shows that few moose from the Willow and Bald Mountain postrutting areas (i.e., few point locations between the Kashwitna River and the Little Susitna River) migrate west to winter on the Susitna River floodplain. Some radio-marked moose migrated from distances over 35 km to winter on this section of the Susitna River floodplain. Point locations east of the Susitna River and south of Willow Creek are mostly winter locations, representing radio-marked moose that migrated from Subunit 16A to winter ranges in Subunit 14A. Point locations east of the Susitna River and north of the Kashwitna River are from 1 migrant male from the Wolverine Mountain area that occasionally wintered on the Susitna River floodplain. Some radio-marked moose occurred on the Susitna River floodplain throughout the year. Figure 28 illustrates the annual range for 1 moose (No. 59F) that migrated from the interior of Subunit 16A to the road-rail corridor in Subunit 14B.

Susitna River Area No. 4 Winter Range, Yentna River to Cook Inlet:

Data provided by 674 point locations for 11 radio-marked moose between the Yentna River and Cook Inlet indicated that most wintering along this section of the Susitna River floodplain were migrants from the west (Fig. 29). Some radio-marked moose migrated from about 50 km to winter on this section of the Susitna River floodplain. Only one moose marked in this area was a winter migrant from Subunit 14A; during other seasonal periods this individual never occurred more than 5 km east of the floodplain. Figure 30 illustrates the annual range for 1 moose (No. 93F) that migrated from the Beluga Lake area to the Susitna River floodplain for the winter.

Susitna River Area No. 5 Winter Range:

Data provided by 444 point locations for 8 radio-marked moose from this abandoned homestead site west of Montana Creek indicated that those utilizing the area were all migrants from Subunit 16A (Fig. 31). All moose captured at this site eventually wintered on the Susitna River floodplain in Subunit 16A or along the road-rail corridor in Subunit 14B or migrated to winter ranges farther east in Subunit 14B. These data illustrate that moose from Subunit 16A migrate through this site enroute to more permanent winter ranges farther east. No moose captured at this site were winter migrants from Subunit 14B. Figure 32 illustrates the annual range for 1 moose (No. 812F) that migrated from the Amber Lake area in Subunit 16A the road-rail corridor in Subunit 14B for the winter.

Annual Differences in Moose Movements and Use of Fall Postrutting and Winter Ranges

The duration of use of alpine postrutting areas, including the Willow Mountain critical habitat, has varied among years. In the "typical" pattern observed in 1986-87, 1987-88, and 1988-89; moose occupied these areas in the fall (28 October-25 November) (Figs. 33, 34,and 35), moving to upland or lowland ranges in the winter (20 January-20 March) (Figs. 36, 37, and 38); however, during the mild winter of 1985-86, many remained all winter near where they had been captured (23 December-7 January) (Fig. 39) (20 January-20 March)(Fig. 40).

During the 1989-90 winter that was characterized by very heavy snowfall and extremely deep snowpacks, many marked moose had vacated alpine postrutting areas by the fall and were enroute to lowland or upland winter ranges (Fig. 41). Early departures from fall postrutting ranges coincided with early snowfall and deep snowpacks. During the 1990 winter period, many marked moose occurred at locations different from those they had utilized in previous winters (Fig. 42). Although many marked moose tended to move in their traditional migratory direction, they continued to travel farther in that direction as snowfall and snowpack depths continued to increase. In most cases, these extended migrations resulted in moose moving to progressively lower elevations. However, lower elevations were not always associated with shallow snowpack depths and higher elevations were not always associated with deeper snowpacks. As in other years, some marked moose (particularly individuals from Brownie Mountain) migrated to and remained at higher elevations throughout the winter. Severe winter conditions may explain atypical movements and range extensions recorded for radio-marked moose in 1990.

Monthly Changes in Moose Distribution and Habitat Use

Data presented for the following monthly periods include all point locations obtained for each radio-marked moose from 1 May 1986 to 14 February 1990 (i.e., data for each month include all point locations collected during 1986, 1987, 1988, and 1989). Since data from several years are combined and moose movements are influenced by weather conditions, these data may represent "average", rather than "typical", patterns for moose movements and habitat use.

October:

Many radio-marked moose had not returned to alpine postrutting areas where they had been captured and marked (Fig. 43). Many marked moose were still in forest habitats below timberline where the rut had occurred. Also many radio-marked moose were in the Willow Mountain Critical Habitat (WMCH) and in the Kashwitna Corridor Forest (KCF).

November:

Most marked moose had returned to alpine habitat postrutting areas (Fig. 44). Many exceptions to this movement occurred in the fall of 1989, when moose vacated alpine postrutting areas early (see Fig. 41). Generally, greater numbers of radio-marked moose were located at higher elevations in alpine postrutting areas in November than in October. In an average winter, most moose traditionally remained in postrutting areas until late November or early December.

December:

Occurrence of radio-marked moose in the Palmer-Wasilla area increased (Fig. 45). These moose were migrants from the Bald, Moss, and Willow Mountain postrutting areas. Point location data illustrated that marked moose had not vacated the Sunshine Mountain postrutting area; rather, some marked moose from the Wolverine, Brownie, Witna and Willow Mountain postrutting areas had initiated winter migrations and were beginning to appear at lower elevations below timberline in the WMCH and KCF.

January:

Data indicated many radio-marked moose were on winter ranges in the Palmer-Wasilla area, the upper Kashwitna River drainage, the KCF, and along the road-rail corridor (Fig. 46). These data indicated that most marked moose had vacated the Bald Mountain postrutting area by January, but those in the Sunshine Mountain and Brownie Mountain postrutting areas remained. Some marked moose still remained in the WMCH, but many had passed through this area and were located in the KCF. One radio-marked male moose migrated from the Sunshine Mountain postrutting area to north of Sheep River.

February and March:

Most radio-marked moose were located on lower-elevation winter ranges (Figs. 47 and 48). Bald, Moss, and Wolverine Mountain postrutting areas were void of radio-marked moose by February (Fig 47), and the Sunshine Mountain postrutting area was vacant in March (Fig. 48). By February, all marked moose from the Bald and Moss Mountain postrutting areas and some from Willow Mountain were located on lowland winter ranges in the Palmer-Wasilla area. Few marked moose occurred along the road-rail corridor between the Kashwitna and Little Susitna Rivers, but many marked moose were present in the road-rail corridor north of the Kashwitna River. Marked moose from the Brownie Mountain postrutting area were located at higher-elevation winter ranges in the upper Kashwitna River drainage. Marked moose were also located on winter ranges in the upper Sheep Creek and Sheep River drainages.

April:

Winter ranges in the upper Kashwitna River, the Palmer-Wasilla area, and along the road-rail corridor were vacant of marked moose (Fig. 49). Moose initiated migrations to spring ranges before April. The April point location data illustrated notable concentrations of marked moose in forest habitats immediately below timberline near the Bald, Willow, and Brownie Mountain postrutting areas. Many were located in forest habitats of the KCF. Fewer marked moose occurred in the WMCH in April than in February. Some marked female moose were located across the Susitna River enroute to calving areas in Subunit 16A.

May and June:

Data for May (Fig. 50) and June (Fig. 51) indicated that most radio-marked moose were concentrated in forest habitats immediately below timberline. Those that wintered in the upper Kashwitna River had moved back downstream. Females had migrated to forest habitats below timberline or west of the Susitna River floodplain in Subunit 16A to prepare for calving. Few marked moose were located above timberline in alpine habitat postrutting areas during May and June. Many were in the KCF and lesser numbers were concentrated in parts of the WMCH.

July:

Point location data indicated a major movement of radio-marked moose near or above the timberline ecotone and into alpine habitat postrutting areas (Fig. 52). Smaller numbers remained at lower elevations well below timberline, and some marked females remained at calving areas near the road-rail corridor between the Kashwitna River and Sheep Creek or west of the Susitna River in Subunit 16A. Many marked moose that migrated to timberline ecotone habitat were located within the WMCH. Most marked moose north of the North Fork Kashwitna River remained below timberline in the KCF.

August:

Point location data indicated many radio-marked moose remained concentrated in the timberline ecotone habitat on the periphery of all alpine habitat postrutting areas (Fig. 53). Most marked moose in the Willow Mountain area were located in or near the WMCH. Several females remained near calving areas west of the Susitna River in Subunit 16A. Many marked moose had moved from alpine areas and lower elevations to intermediate elevations on steeper west facing slopes near the western boundary of the KCF. One radio-marked female moose remained in the upper Sheep Creek drainage.

September:

Many radio-marked moose returned to forest habitats slightly below timberline or lower elevations; some occurred above timberline, and 2 marked females remained near calving areas west of the Susitna River in Subunit 16A (Fig. 54). Large numbers of radio-marked moose were concentrated in the WMCH between its western boundary and timberline. Many more radio-marked moose had moved to lower elevations in the western part of the KCF than had moved in August. Point locations west of the Yentna River and north of Beluga Mountain in Subunit 16B resulted from an exceptional movement (100 km) by a two-year-old male from Bald Mountain that was subsequently located and killed by a hunter near Hiline Lake. Another marked male from Subunit 14B also moved extensively from north of Sheep River to the North Fork Kashwitna River.

Annual Ranges For Moose That Migrated Across Subunit Boundaries

Study Area:

Radio-marked moose from most capture sites made significant seasonal migrations to and from postrutting ranges, calving ranges, and/or winter ranges. During these movements, moose frequently traversed subunit boundaries. Migrations across subunit boundaries were more common for moose from some capture sites than for others.

Bald Mountain Postrutting Area:

The only boundary crossing recorded for radio-marked moose from the Bald Mountain postrutting area was by a two-year-old male (No. 35M) that had moved from Bald Mountain in Subunit 14A to near Hiline Lake in Subunit 16B, where it was killed by a hunter (Fig. 55). This movement may not have been a true migration; rather, it may have been colonizing a new area.

Moss Mountain Postrutting Area:

Radio-marked moose did not cross Subunit boundaries; however, 1 marked moose made an extensive migration south to winter in the Palmer-Wasilla area (see Fig. 10).

Willow Mountain Postrutting Area:

It was not uncommon for marked moose in Subunit 14B to migrate to Subunit 14A for the winter (see Fig. 11). Eight of 17 marked moose monitored during the winter followed this migratory pattern; three of those wintered just south of Willow Creek, and the remaining five wintered near the Palmer-Wasilla area. The latter migrations measured between 30 and 50 km. Two radio-marked females (Nos. 601F and 261F) migrated across the Susitna River into Subunit 16A prior to calving (see Fig. 14 and Fig. 56).

Witna Mountain Postrutting Area:

One of 2 marked moose (No. 551F) in Subunit 14B migrated across the Susitna River into Subunit 16A prior to the calving period (see Fig. 16).

Brownie Mountain Postrutting Area:

Generally, marked moose remained at higher elevations within the drainages of the North Fork and Main Fork of the Kashwitna River throughout the year (see Fig. 17). However, 1 radio-marked female (No. 54F) from this area was located on the Susitna River floodplain in Subunit 16A during the calving period (Fig. 57).

Wolverine Mountain Postrutting Area:

Radio-marked moose generally moved to lower elevations within Subunit 14B during the winter period. One radio-marked female (No. 46F) was located west of the Susitna River in Subunit 16A during the calving period (Fig. 58).

Sunshine Mountain Postrutting Area:

None of the 3 radio-marked moose traversed Subunit boundaries; however, 4 females that had been radio-marked the previous winter on the Susitna River floodplain (Arneson 1981) and subsequently located in the Sunshine Mountain area during the postrutting period migrated across the Susitna River into Subunit 16A during the calving period. One of these moose (No. 22F) traditionally did not return to the Sunshine Mountain postrutting area in Subunit 14B until late September or early October, after hunting season opened (Fig. 59).

Susitna River Area No. 1 Winter Range:

Marked moose in Subunit 13E generally exhibited compact annual ranges that allowed little opportunity for traversing subunit boundaries. However, extraordinary movements involving traversing boundaries into Subunit 16A and 14B were recorded for 1 marked female (No. 74F) in the spring-summer period (Fig. 60).

Susitna River Area No. 2 Winter Range:

Marked moose originated from Subunits 16A and 14B. Several moose from Subunit 14B remained in Subunit 16A for varying periods of time from spring through early fall. Most radio-marked moose from this capture site were found in the road-rail corridor of Subunit 14B in the winter. All of these marked moose migrated west of the Susitna River into Subunit 16A in spring. Point locations for 1 male (No. 65M) illustrated this movement pattern (Fig. 61).

Susitna River Area No. 3 Winter Range:

Most marked moose spent the nonwinter months in Subunit 16A. During the winter many from this capture site were frequently located along near the road-rail corridor in Subunit 14B (see Fig. 27). One marked male (No. 27M) migrated into Subunit 14B in the spring (Fig. 63). Some individuals radio-marked at this site (i.e., No. 100F) migrated farther east in winter, eventually wintering in Subunit 14A south of the Little Susitna River (Fig. 64) or north of the Kashwitna River (i.e., No. 62F). In the spring the latter marked moose returned to Subunit 16A. None of the moose marked at this capture site migrated directly east after winter into Subunits 14A or 14B between the Kashwitna River and the Little Susinta River (see Fig. 27).

Susitna River Area No. 4 Winter Range:

All but one radio-marked moose migrated west and remained there after the winter (i.e., No. 44M) (Fig. 65). Although several of these marked moose occurred in Subunit 14A in winter for varying periods of time, only one ranged about 8 km into Subunit 14A during the remainder of the year. Few marked moose in this area traversed subunit boundaries.

Susitna River Area No. 5 Winter Range:

All marked moose remained in Subunit 16A during the spring and summer. Most moose captured at this site eventually migrated into Subunit 14B along the road-rail corridor (i.e., as No. 61F) (Fig. 66) during the winter; one migrated farther east (No. 18F) (Fig. 67).

DISCUSSION

Migrations and Annual Range Size and Shape

Traditional migrations of individual moose should be adaptive and have survival value (LeResche 1974). To be adaptive, migrations must increase the reproductive potential of individual moose. To have survival value, movements must provide moose with a beneficial change in their environment that may involve forage quality and quantity; desirability of snow conditions; relief from predators, insects, or conspecifics; or opportunities for breeding. These changes should ultimately be linked to conservation of energy. Because moose are long lived and their movements can become traditional (LeResche 1974) and learned by their offspring (Pulliainen 1974), the historical background of populations and landscapes may have to be studied to help explain the survival value of specific contemporary movement patterns for individuals or subpopulations.

Individual radio-marked adult moose from the same site in the lower Susitna Valley commonly exhibited similar ("group or subpopulation specific") seasonal movement patterns. Groups of radio-marked adult moose from different sites in the lower Susitna Valley frequently exhibited different ("site specific") seasonal movement patterns. Group specific similarities and site specific differences in movement patterns and annual ranges of moose documented in my study are consistent with findings from other studies in Alaska (LeResche 1972) and elsewhere (Sweanor and Sandegren 1987, Addison et al. 1980).

LeResche (1974) indicated that short migrations and small home ranges were more characteristic of moose inhabiting areas with little variation in topographic relief; he reasoned that to be adaptive, migrations between seasonal ranges must provide moose with favorable environmental changes. He further believed that in extensive low-relief areas of homogeneous habitats, reasonable migrations would not provide the necessary favorable environmental changes to warrant migratory behavior. In support of this contention, Cederlund and Okarma (1988) found that nonmigratory moose occurred in flat areas where habitat types were evenly spaced.

The size and shape of annual ranges for individuals and groups are largely influenced by snowfall and the resulting distance moose must migrate to winter ranges (Phillips et al. 1973 and Addison et al. 1980). Snowfall and snowpack depth may be the underlying and overiding habitat component influencing timing, occurrence, and magnitude of moose migrations and the size and shape of annual ranges; however, the patterns of these effects can be quite varied. Moose from some postrutting areas in the Talkeetna Mountains have made migrations that were longer in years with deeper snow; moose in the Susitna River Area No. 1 moved very little in areas with extremely deep snowpack; and those from the Susitna River Area Nos. 2, 3, and 5 have made extensive movements in response to moderate snowpack depths. Perhaps, deep snowpacks can inhibit movements in one area (i.e., where the energy required to find more amenable conditions is great) and stimulate movements in another (i.e., one where snowpacks depths are moderate and proximity of more desireable habitat makes migration worthwhile). Similarly, different moose from the same area (e.g., Willow Mountain) may demonstrate a variety of behaviors (migratory or nonmigratory) to deal with snowpack. Cederlund and Okarma (1988) found nonmigratory moose in an area where snow cover occasionally exceeded 50 cm, but it did not impede their movements or affect food availability. Bald Mountain moose maintained small annual ranges by migrating to the nearby lowland areas of shallow snow near Palmer and Wasilla, while Brownie Mountain moose accomplished the same objective by moving to relatively shallow snow areas at higher elevations.

In addition to snowfall, the size and shape of annual ranges of female moose can be influenced by spring migrations to calving areas (LeResche 1974). Movement to calving areas was the second-most important factor in determining annual range size for females. Many female moose from the Susitna River Area No. 1 made short movements directed to specific areas prior to parturition (Modafferi 1984). Several female moose from Willow, Wolverine, and Sunshine Mountains made extensive migrations (over 20 km) west of the Susitna River prior to calving that significantly affected conformation to their annual ranges. Females from Willow Mountain that made westerly migrations in the spring did not make extensive southerly migrations in the winter. Female moose may migrate to specific areas prior to parturition to avoid predators (Edwards 1983), to obtain nutritious forage (LeResche and Davis 1973), or to locate a particular habitat type (Leptich and Gilbert 1989).

Winter and Spring Migrations and Calf Recruitment

Sweanor and Sandegren (1987) found that calf recruitment rates were similar for some groups of migratory and nonmigratory moose and that recruitment rates were highest for migrants and nonmigrants that wintered in areas where snowpacks were less, despite locally higher densities and severely browsed forests. These findings led Sweanor and Sandegren (1987) to speculate that other factors (e.g., snow conditions) were more important than browsing damage in limiting calf recruitment. Summer and winter ranges were important factors affecting productivity of female moose (Edwards and Ritcey 1956, Pimlott 1959). In view of these findings, moose from Willow Mountain that migrate to the Palmer-Wasilla area for the winter (i.e., snowpack depths are typically shallow) may have higher calf recruitment rates than those moose from Willow Mountain that forgo this extensive migration and winter locally where snowpacks are deeper.

If snowfall and snowpack depth are dominant factors affecting calf recruitment, regardless of the migration distance (within reason) required to reach such areas, then snow conditions should be a primary factor for selecting locations for winter range habitat enhancement. Because highly productive winter ranges in areas with shallow snowpacks may not be duplicated by enhancing habitats in areas where snowpacks are deeper, high-quality winter range with shallow snowpacks (e.g., the Palmer-Wasilla area), is irreplaceable. These findings emphasize the importance of maintaining, conserving, and protecting moose wintering ranges at locations that traditionally receive shallow snowpacks.

If long migrations to an area during a season important for recruitment or survival indicate relatively high habitat quality, then moose migratory patterns may be useful for identifying important winter ranges. Similarly long migrations during other seasons may be indicative of some special habitat quality; for example, female moose from Willow, Wolverine, and Sunshine Mountain postrutting areas that migrate across the Susitna River into Subunit 16A for calving may encounter high-quality habitats and experience higher rates of calf recruitment than females that forgo extensive spring migrations and calve locally in Subunit 14B.

Basic Seasonal Movement Patterns and Habitat Use for Moose in the Western Foothills of the Talkeetna Mountains

Moose begin to aggregate in alpine habitat postrutting areas in the western foothills of the Talkeetna Mountains in mid-October (Modafferi 1990). Numbers of moose in alpine postrutting areas typically attain peak levels between late October and early December. Snowfall and snowpack depth can affect moose movements (Sandegren et al. 1985, Sandegren and Sweanor 1987) and the timing, duration and magnitude of moose use of alpine postrutting areas (Modafferi 1990). Early heavy snowfalls can affect peak moose levels by causing some moose to vacate alpine postrutting areas before others arrive. In an average winter, fall-winter moose migrations from postrutting areas are initiated in late November or early December, and most moose are located on winter ranges by mid- to late January. In a mild winter having light snowfall, some moose do not arrive on winter ranges until February or March and others may not migrate (Modafferi 1988b, 1990).

My data indicated that many moose from the Willow Mountain postrutting area and most moose between there and Bald Mountain migrated south to lowland winter ranges in the Palmer-Wasilla area. Moose from the North Fork Kashwitna and Kashwitna Rivers remained at high elevations in those drainages throughout the winter. Large numbers of moose from the latter area did not appear to move west to lower elevations during winter as contended (ADF&G files). Moose north of the North Fork tended to move westerly toward lower elevations in winter. The tendency and distance that moose migrated west appeared to increase from Bald Mountain north. Most moose in Subunit 14B north of Sheep Creek probably migrate west to lowlands in the road-rail corridor or along the Susitna River floodplain or north to floodplains of the Sheep River-Talkeetna River.

During the winter, many moose along the road-rail corridor from Willow Creek to Talkeetna are migrants from Subunit 16A (Modafferi 1988b). Probably, few moose in the road-rail corridor between Willow Creek and the Kashwitna River are from Subunit 14B. Numbers of migrant moose from Subunit 16A in the road-rail corridor appear to be increasingly "diluted" with moose from the Kashwitna River north in Subunit 14B.

Moose along the road-rail corridor in the Palmer-Wasilla area were from Bald and Moss Mountains in Subunit 14A, Willow Mountain in Subunit 14B, and from across the Susitna River in Subunit 16A. Some moose from the Point Mackenzie area (Subunit 14A) may move north and also winter in the Palmer-Wasilla area or along the road-rail corridor (AD&G files). If snowfall and snowpack depth continue to increase excessively throughout the winter, moose will continue to move in their traditional direction of migration. This may result in extended moose movements to lower elevations outside their traditional annual range. In this manner, severe winter conditions can cause large numbers of moose to concentrate in lowland wintering areas along the road-rail corridor and in Palmer-Wasilla area. Regardless of snow conditions and winter severity, some moose do not migrate, remaining in or near alpine postrutting areas during the winter.

In an average winter, most moose have initiated migrations from winter ranges by April. Between the time moose leave winter ranges and parturition, concentrations of moose occur in forest habitats on south or southwest facing slopes immediately below timberline. Moose occurrence in these habitats is protracted following a mild winter when they leave winter ranges earlier.

By early May antler growth has been initiated in males and most females are migrating to or are at calving areas. Some female moose calve in the same subalpine forest habitats occupied during April. Many other females typically move to lowland areas near wet, open black spruce- (Picea mariana) muskeg habitats during calving (Modafferi 1988b). Some female moose in postrutting areas between Willow and Sunshine Mountains in Subunit 14B migrate across the Susitna River into Subunit 16A and calve in wet, black spruce-muskeg habitats. Females become sedentary near parturition, and they remain near calving areas through June.

In July some females were located near parturition sites, but more males than females were located in open shrub habitats at or above timberline near alpine postrutting areas. In the June-July period female moose occasionally exhibited extraordinary movements (Modafferi 1988b).

In August, many moose that were in lowland forest habitats were closer to the timberline ecotone and more moose began appearring near or above timberline on west or southwest facing slopes.

Some females remained near lowland calving areas throughout August.

By early September significantly fewer moose occurred above timberline in postrutting areas, and many had moved to forest habitats at slightly lower elevations. The hunting season opens during September, and it has been hypothesized that moose vacate alpine areas to avoid activities of hunters (ADF&G files). Observations of radio-marked moose in the lower Susitna River Valley where few hunters occur indicated movement into forest habitats during late August and early September (ADF&G files). I believe they move there for reasons other than to avoid hunters. Prior to the rut, male moose may move extensively during September. The rut probably peaks between late September and early October. I rarely observed moose engaged in rutting behavior during moose surveys in alpine habitats in Talkeetna Mountains from early to mid-October through the winter (Modafferi 1990). I believe that most moose in Subunit 14B rut in forest habitats. Following the rut, moose began to concentrate in the alpine habitat postrutting areas, where they were captured and radio-marked.

Occurrence in the Willow Mountain Critical Habitat and the Kashwitna Corridor Forest

Willow Mountain Critical Habitat (WMCH) is recognized as an important moose postrutting concentration area (ADF&G files). Data from radio-marked moose indicated that significant concentrations also occur in WMCH and the adjacent KCF during other seasons.

Significant numbers of marked moose occurred in the WMCH, the KCF, and other subalpine habitats of Subunit 14B in April; i.e., subsequent to winter range and before migrations to calving areas in May. Moose continued to concentrate in or near timberline ecotone habitats during July and August. During September, moose concentrations occurred below timberline in the WMCH and at lower elevations in forest habitats in the KCF. In October moose began to gather in postrutting concentration areas at higher elevations in the northern KCF and alpine areas of the WMCH. In November and December moose occurrence in postrutting concentration areas and alpine portions of WMCH was greatest. By late December, along with increased snowfall and wintery conditions, moose initiated migrations to lower elevation winter ranges. This shift between postrutting concentration areas and winter ranges continued through early winter. In the mild winter of 1985-86, large numbers of marked moose remained in alpine habitat postrutting areas and did not migrate, and the WMCH (i.e., a moose alpine postrutting area) apparently functioned as a winter range.

Movements Across Subunit Boundaries

Subunits are the basic geographical unit for moose management in the lower Susitna River Valley. Data on moose population size, demography, productivity, and mortality are collected within subunits. Analyses of these data provide area management biologists with information necessary to assess the status of moose populations within the subunit, formulate and propose regulatory changes, and comment on regulatory proposals. A basic assumption is that the subunit is a closed system, implying that all data obtained within it is representative of the moose population (i.e., moose are always within the same subunits).

Moose in the lower Susitna Valley commonly and traditionally cross subunit boundaries during different seasonal migrations. In the winter significant numbers of moose migrate from subunit 16A to Subunits 14A and 14B. Many of these moose winter in the Palmer-Wasilla area, along the Knik Goose Bay Road, and in the road-rail corridor between Talkeetna and Wasilla. A single male moose provided evidence that moose cross from the Alexander Creek area in Subunit 16B to Point Mackenzie in Subunit 14A. Small numbers of moose from Sunshine Mountain area in Subunit 14B crossed into Subunit 16A during the winter. Marked moose from north of Talkeetna in Subunit 13E migrated into Subunit 14B during the winter and into Subunit 16A in the spring and summer (Modafferi 1988b).

In the spring significant numbers of female moose from Subunit 14B migrated into subunit 16A. Some moose involved in this migration did not return to Subunit 14B until late September after moose hunting season had opened.

I suspect that boundary crossings were considerably less common for moose from the Bald Mountain postrutting area, because acceptable winter range and calving habitat occurred nearby within the boundaries of Subunit 14A; however, one 2-year-old male moved from Bald Mountain in Subunit 14A to the Hiline Lake area in Subunit 16B. This male may have been establishing a new annual range, rather than making a migration with the intent to return.

Because moose in the lower Susitna Valley migrate across subunit boundaries during the fall and winter, moose censuses and composition surveys for Subunits 14A 14B, or 16A must be conducted before moose begin winter migrations to accurately evaluate effects of fall hunts. Because timing of winter migrations varies vary greatly (Modafferi 1990) and is related to snowfall and snowpack depth (Addison et. al., Sandegren et al. 1987, and Modafferi 1990), area wildlife managers must initiate and complete moose surveys so they are initiated at the proper times.

Area wildlife managers must be cautious when allocating moose mortality data recorded in Subunits 13E, 14A, 14B, 16A, and 16B to specific subunits. Moose mortalities from winter hunts and collisions with trains and vehicles in the road-rail corridor, which can be significant in some years, must not be allocated solely to Subunits 14A or 14B (i.e., where the mortalities occurred) moose subpopulations. Likewise, mitigation for moose mortalities from these sources should not be targeted solely for Subunits 14A or 14B. Knowledge about identity and migratory patterns of moose subpopulations will assist area wildlife managers in making acceptable decisions for allocating mortality and targeting mitigation among the correct moose subpopulations.

Moose from Subunits 16A, 16E, 14B, and 14A utilized winter range in the Palmer-Wasilla area. Positive or negative impacts to this winter range will affect moose from many subunits. Because of traditionally shallow snowpacks in the Palmer-Wasilla wintering area, habitat enhancement at another location cannot substitute for loss of this winter range. Because moose cross subunit boundaries for calving, surveys of calves and females during parturition are not a recommended method of obtaining information on production that is to be integrated with herd composition data obtained from fall moose surveys in alpine habitat postrutting areas.

Movements and Late Winter Hunts in Subunit 14B

In the recent past, moose in remote alpine habitat postrutting areas in the western foothills of Talkeetna Mountains (Subunit 14B) were considered inaccessible to hunters during fall hunting seasons (ADF&G files). Additionally, it was contended that in the winter these moose subpopulations migrated to lowland areas along the road-rail corridor where they could be accessed and harvested by hunters (ADF&G files). This rationale helped justify late-winter moose hunting seasons along the road-rail corridor as a means of controlling levels of "subpopulations" that remained at high elevations in the fall and were inaccessible to hunters. These contentions, however, are not entirely valid. I found that moose from the Brownie Mountain postrutting area would not be vulnerable to hunters during the winter moose hunts in lowlands near the road-rail corridor. Radio-marked moose from Brownie Mountain postrutting area seldom left higher elevations of the North Fork Kashwitna River and the main fork Kashwitna River drainages and were rarely located in lowlands near the road-rail corridor that were accessible to hunters in winter. I found that many moose from the Willow Mountain postrutting area migrated south into Subunit 14A in the winter where late-winter moose hunts were not implemented; most other moose moved slightly west to lower-elevation areas inaccessible to hunters from the road-rail corridor. These data indicated that few moose from Subunit 14B south of Little Willow Creek would be vulnerable in winter to hunter harvests from along the road-rail corridor in Subunit 14B. Moose from Wolverine Mountain migrated west in winter, but they terminated movements before reaching points accessible from the road-rail corridor. I found that moose from Witna Mountain and other postrutting areas north of Sheep Creek migrated into lowland areas accessible by the road-rail corridor. Some moose from these areas may remain in foothill areas, which are not accessible by the road-rail corridor. Although field data were not collected for moose north of the South Fork Montana Creek, I suspect that large numbers of moose from this area make winter migrations west to the road-rail corridor or north to floodplains of Sheep and Talkeetna Rivers to avoid excessively deep snowpacks in alpine postrutting areas.

Previous moose studies documented significant winter moose migrations from Subunit 16A toward the Susitna River and the road-rail corridor in Subunits 14B and 14A between Talkeetna and Cook Inlet (Modafferi 1988b). These west-to-east migrations appeared to involve significant numbers of moose from Subunit 16A, regardless of winter severity. Moose from Subunit 16A terminated these migrations on the Susitna River floodplain along the road-rail system or farther east in Subunit 14B. This major west-to-east winter migration leaves significant numbers of moose from Subunit 16A in the road-rail corridor between Wasilla and Talkeetna in the winter. Because extreme snow conditions appear to influence the magnitude of moose migrations in Subunit 14B more than in Subunit 16A, in mild winters a smaller proportion of moose in the road-rail corridor are from remote portions of Subunit 14B (vs. Subunit 16A) (Modafferi 1988b and 1990). The proportion of Subunit 14B moose (vs. Subunit 16A moose) vulnerable to hunter harvest in the road-rail corridor in late winter probably increases with winter severity. These data indicated that only during severe winters and only north of Sheep Creek would late winter moose hunts along the road-rail corridor be a viable management option to promote the harvest of moose from remote northeastern parts of Subunit 14B.

ACKNOWLEDGMENTS

I thank D. McAllister, Alaska Department of Fish and Game, for logistic assistance, help with "radio-tracking" surveys, assistance drafting figures and who along with B. Taylor, Alaska Department of Fish and Game, assisted in the capture, handling and radio-marking of moose. K. Schneider, Alaska Department of Fish and Game, is acknowledged for providing support and helpful suggestions throughout this study, reviewing drafts of this report, and for willingly providing assistance in administration procedures. C. Grauvogel, Area Management Biologist, Alaska Department of Fish and Game, is acknowledged for "area" support, comments on all aspects of the study, and for sharing his vast experiences and knowledge about moose. B. Wiederkehr, Wiederkehr Air Inc., Palmer, L. Rogers, Southcentral Air Inc., Kenai, and C. Soloy, Soloy Helicopters, Wasilla, deserve special thanks for safely piloting super cub, 185 and helicopter aircraft, respectively, utilized in this study. Becky Strauch, Alaska Department of Fish and Game, is acknowledged for updating and maintaining the computerized data file for radio-marked moose, for providing compilations of data on marked moose and for

producing the computer generated Figures included in this report. In spite of her very busy work schedule, Ms. Strauch, always managed to find time to provide computer generated products that I requested.

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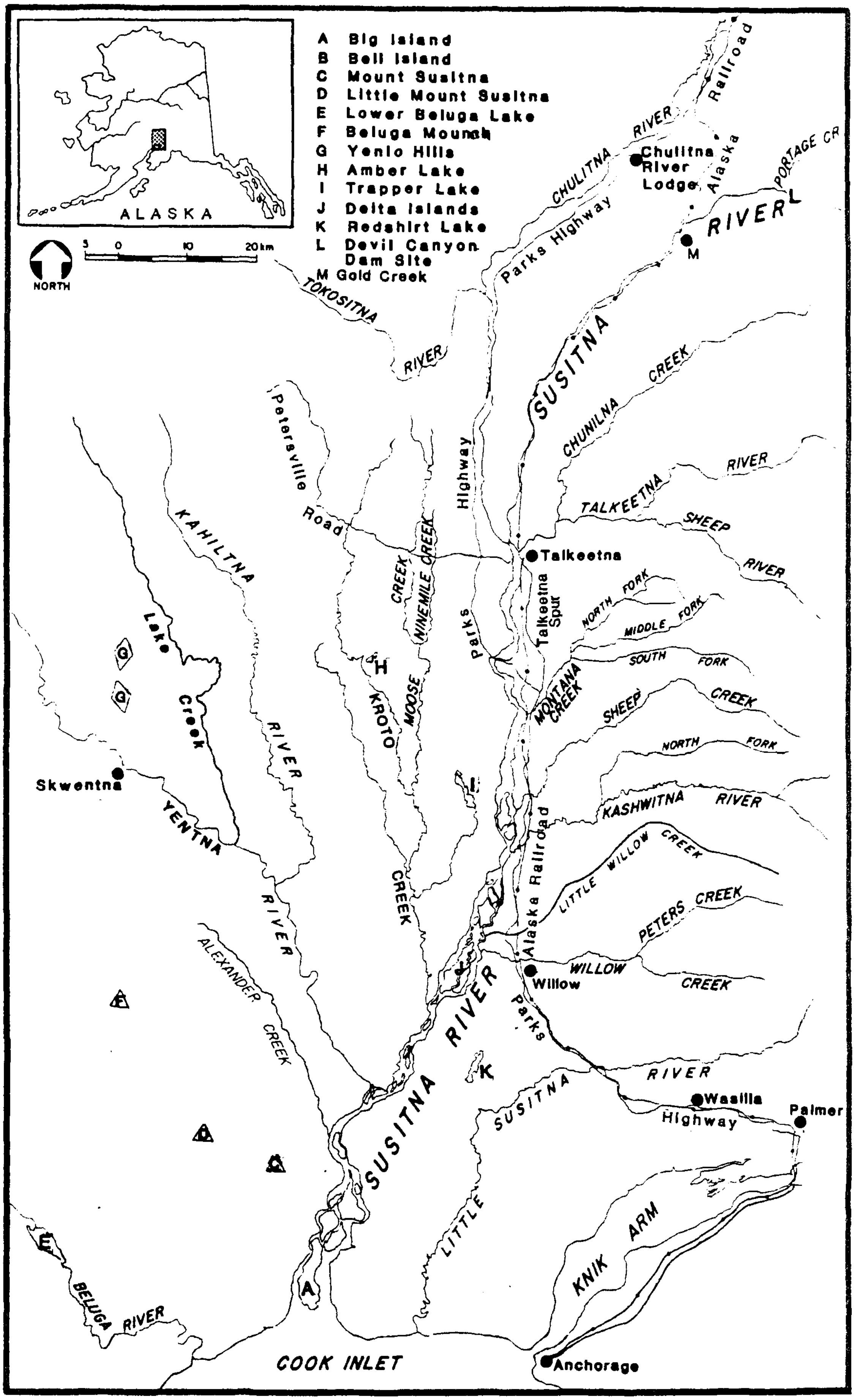

Figure 1. Map showing location of the study area in Alaska with names listed for rivers, lakes and other prominent landscape features.

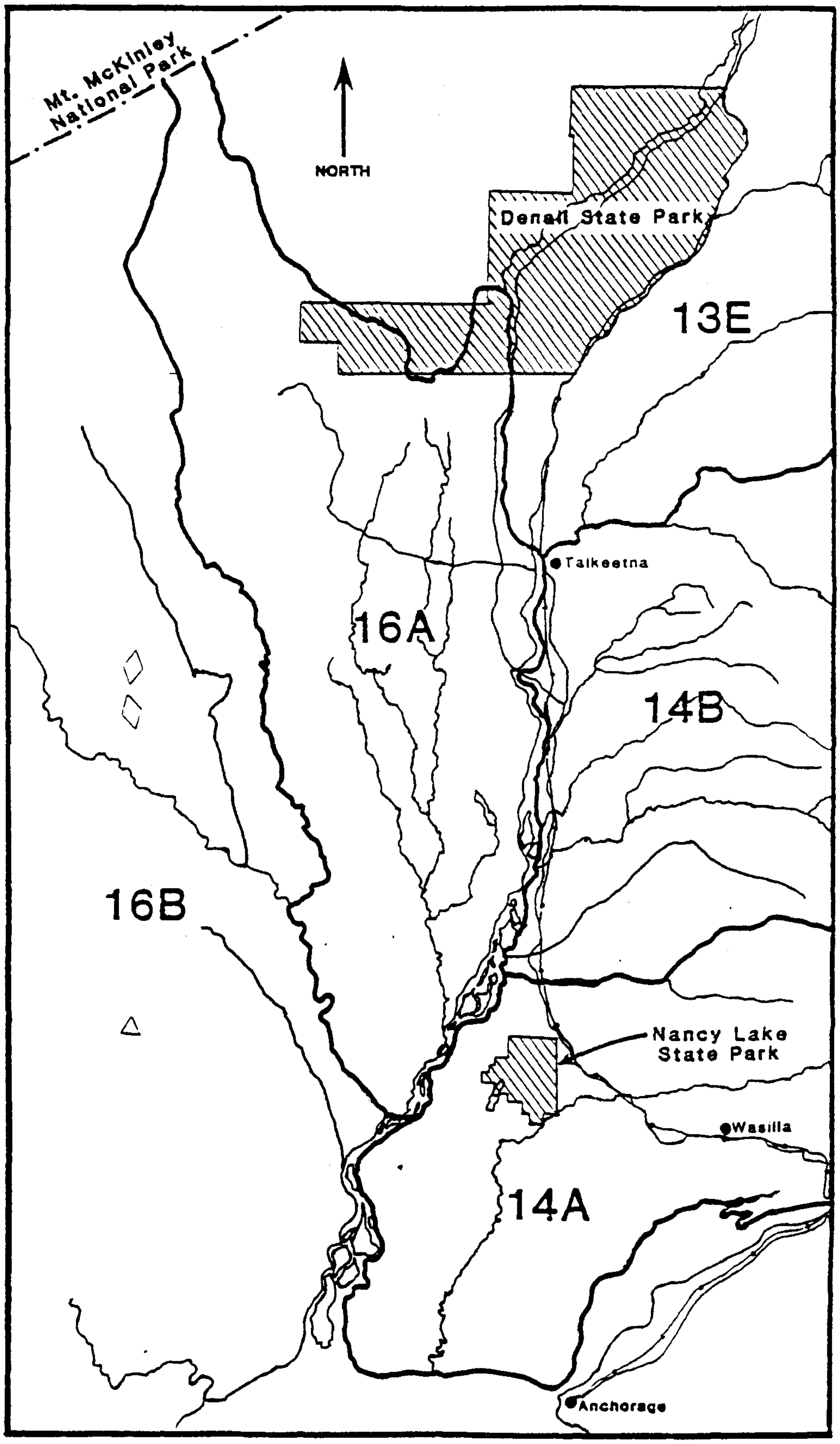

Fig. 2. Location of Game Management Subunits (13E, 14A, 14B, 16A and 16B) and state and national parks in the study area.

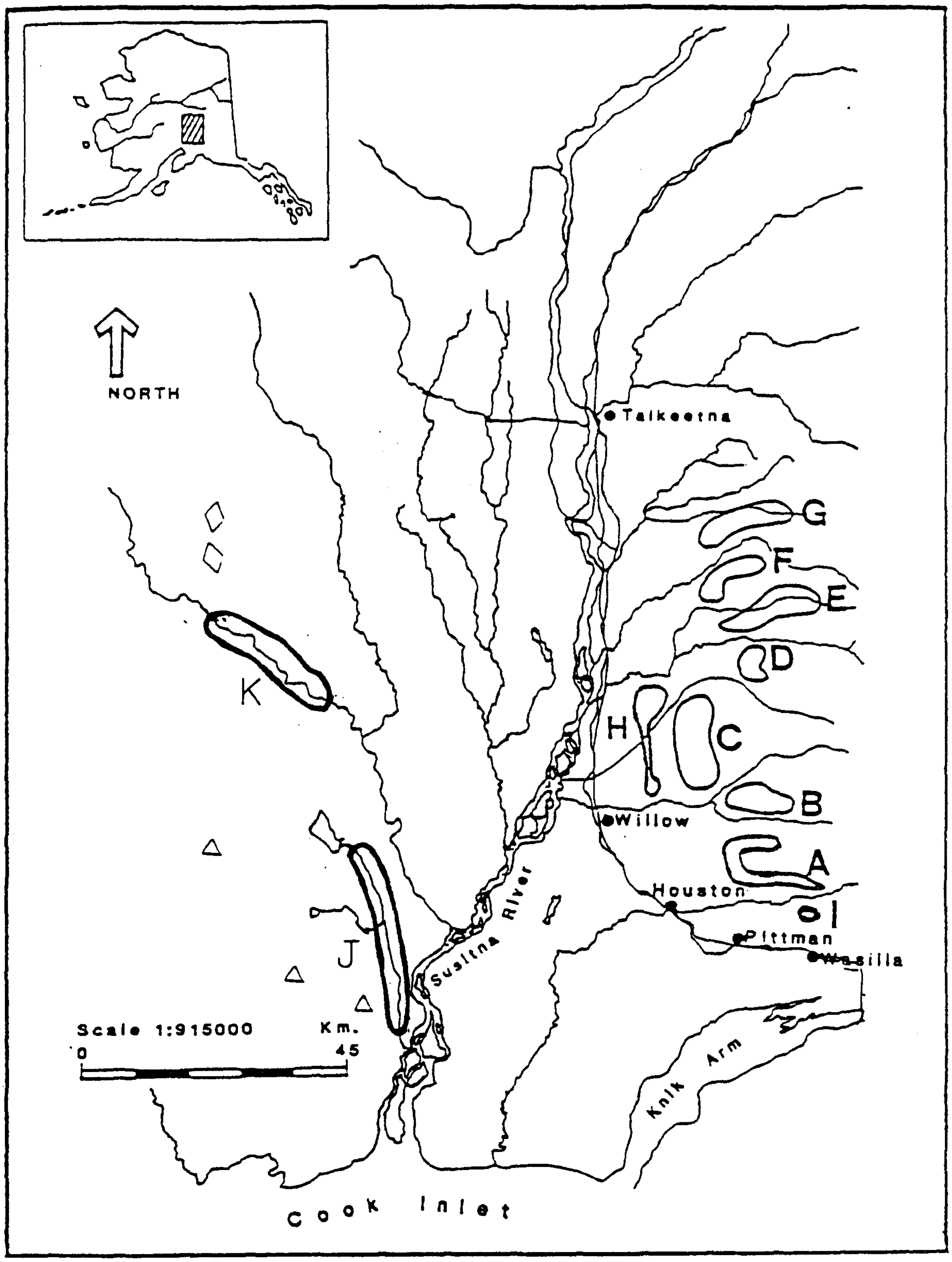

Fig. 3. Locations of Talkeetna Mountains alpine habitat moose postrut areas (A-G), Kashwitna Corridor Forest (H), Coal Creek timber cut area (I), Alexander Creek (J) and the Lake Creek/Skwentna area (K) where moose were captured and radio-marked. A = Bald Mountain, B = Moss Mountain, C = Willow Mountain,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

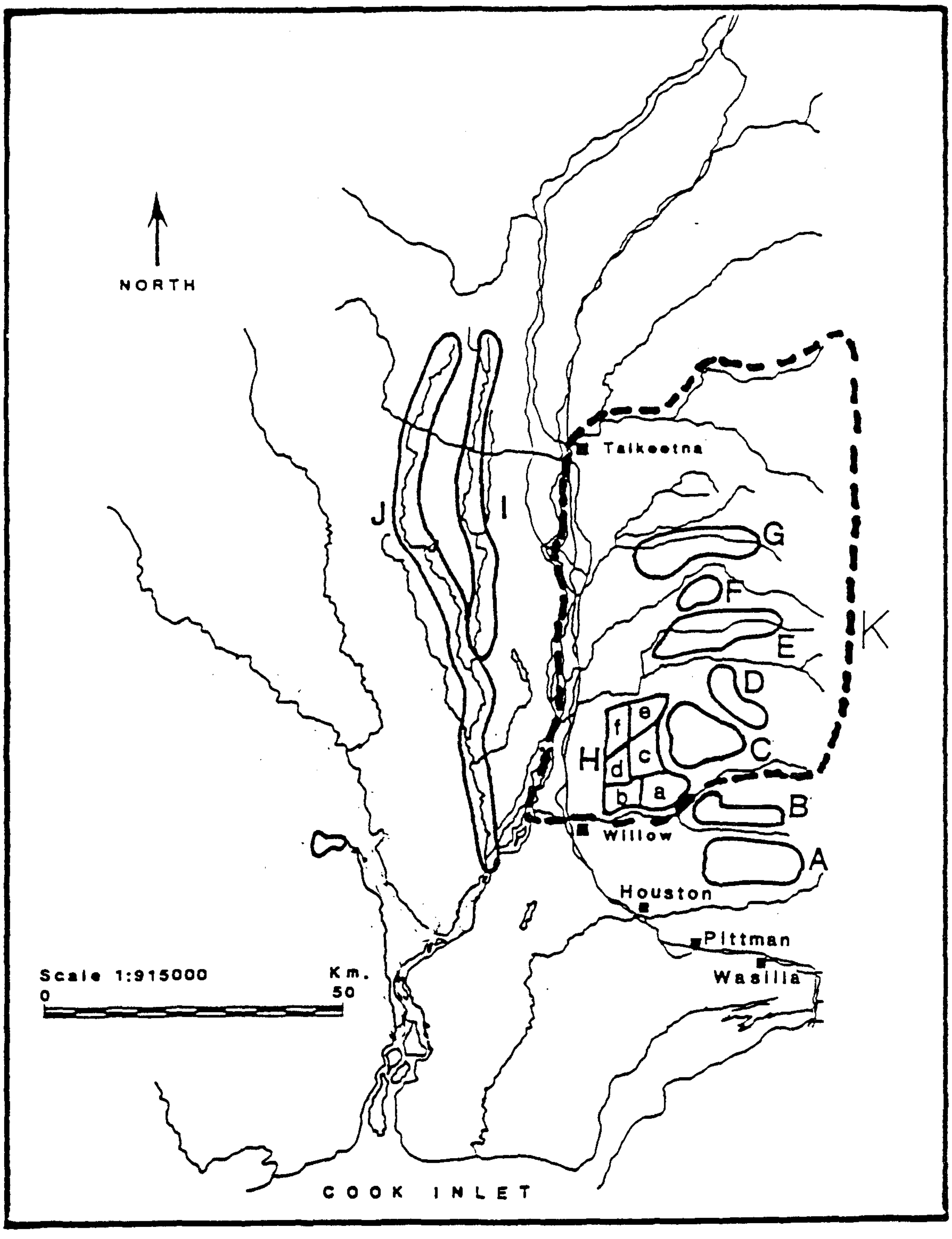

Fig. 4. Locations of Talkeetna Mountains alpine habitat moose postrut areas (A-G), Kashwitna Corridor Forest area (H), Moose Creek (I), Kroto Creek (J) and Game Management Subunit 14B (K) where moose surveys were conducted. A = Bald Mtn., B = Moss Mtn., C = Willow Mtn., D = Witna Mtn., E = Brownie Mtn., F = Wolverine Mtn., and G = Sunshine Mtn.

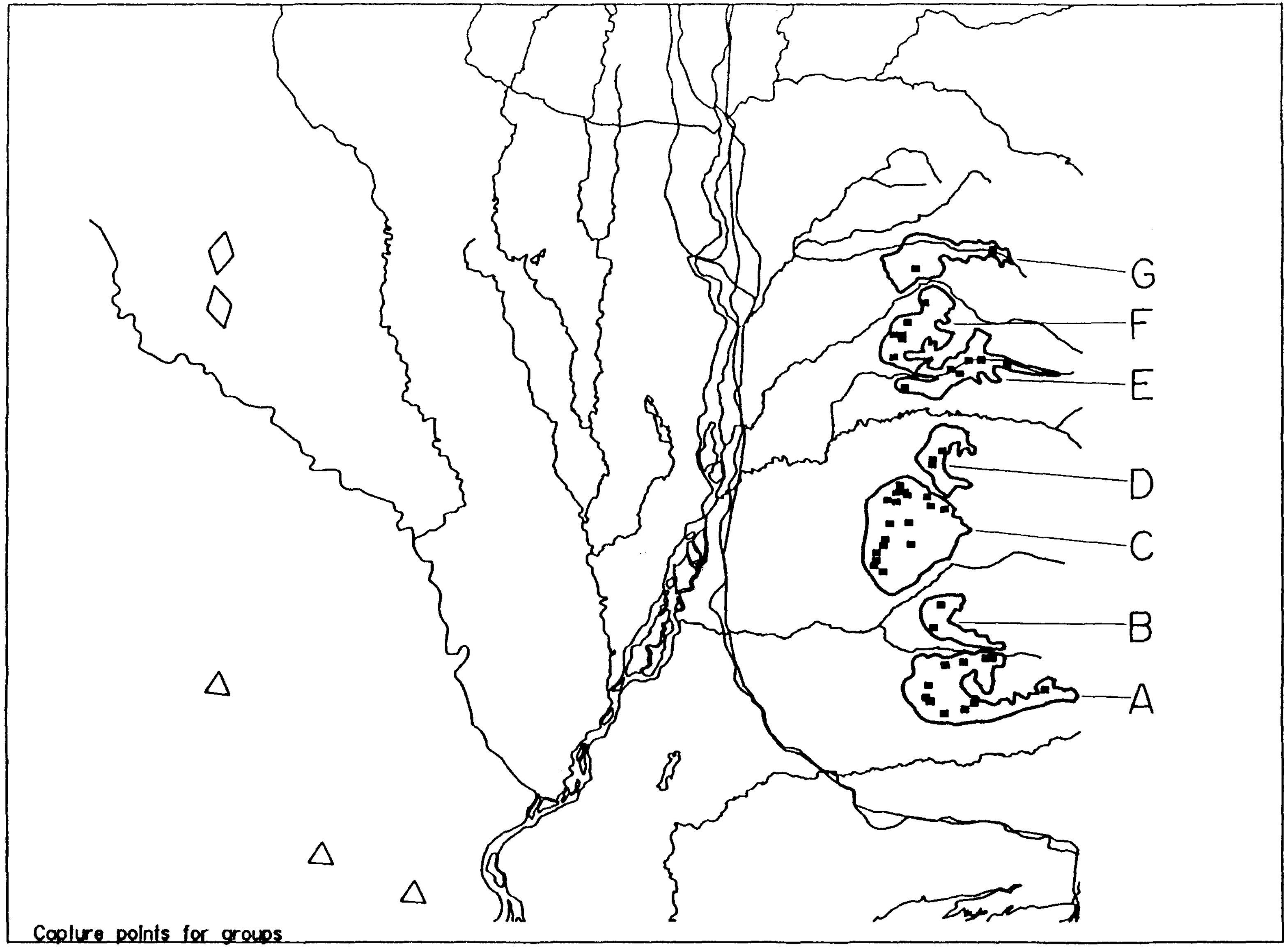

Fig. 5. Point locations where individual moose were captured and radio-marked in 7 alpine habitat postrut areas in game management Subunits 14A and B in the western foothills of the Talkeetna Mountains in southcentral Alaska. A = Bald Mtn., B = Moss Mtn., C = Willow Mtn., D = Witna Mtn., E = Brownie Mtn., F = Wolverine Mtn., and G = Sunshine Mtn.

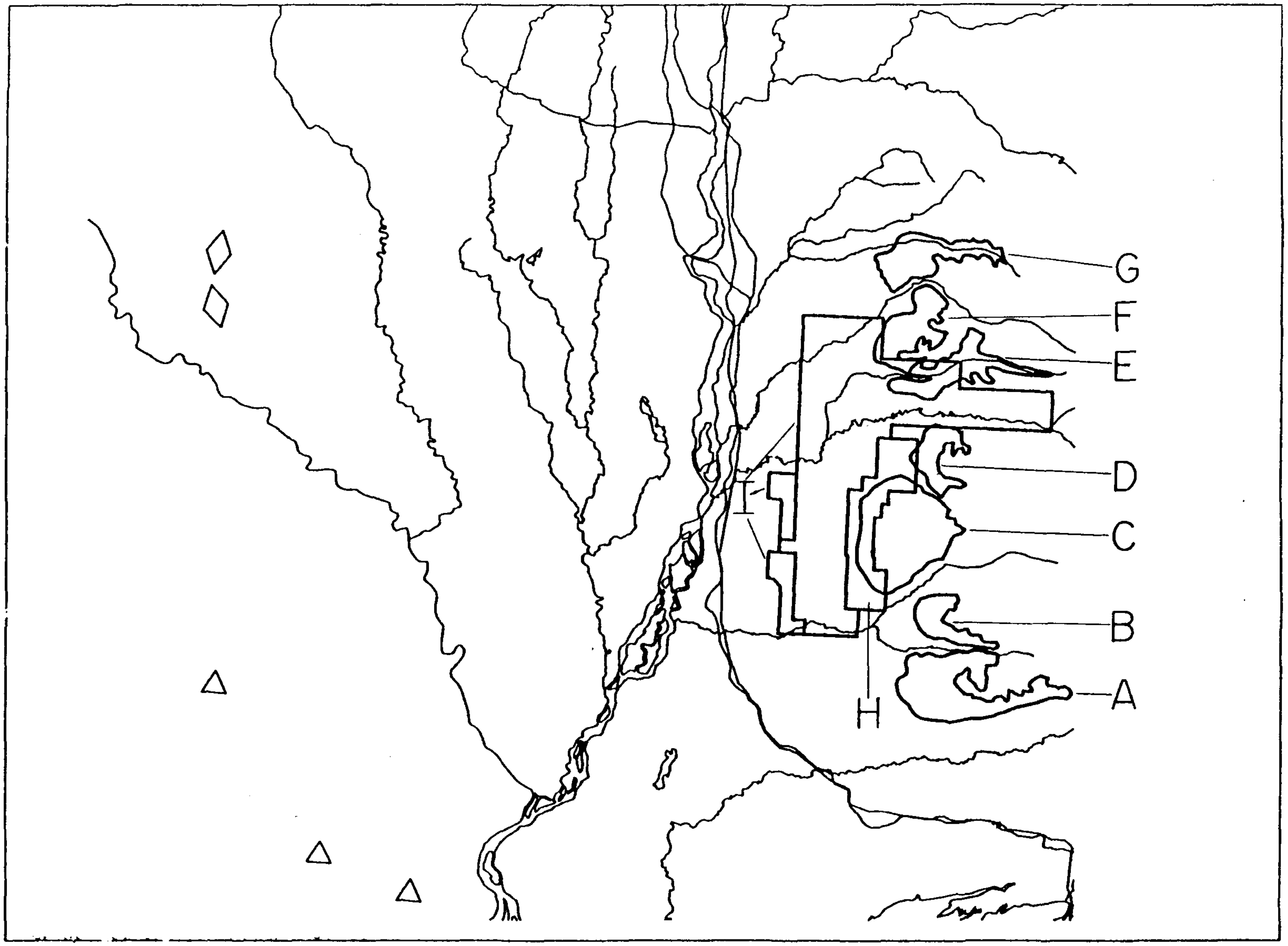

Fig. 6. Locations of Willow Mountain Critical Habitat (H) and Kashwitna Corridor Forest Lands (I) in relation to alpine habitat moose postrut areas where moose were captured and marked (A-G) in the western foothills of the Talkeetna Mountains in southcentral Alaska. A = Bald Mtn., B = Moss Mtn., C = Willow Mtn., D = Witna Mtn., E = Brownie Mtn., F = Wolverine Mtn., and G = Sunshine Mtn.

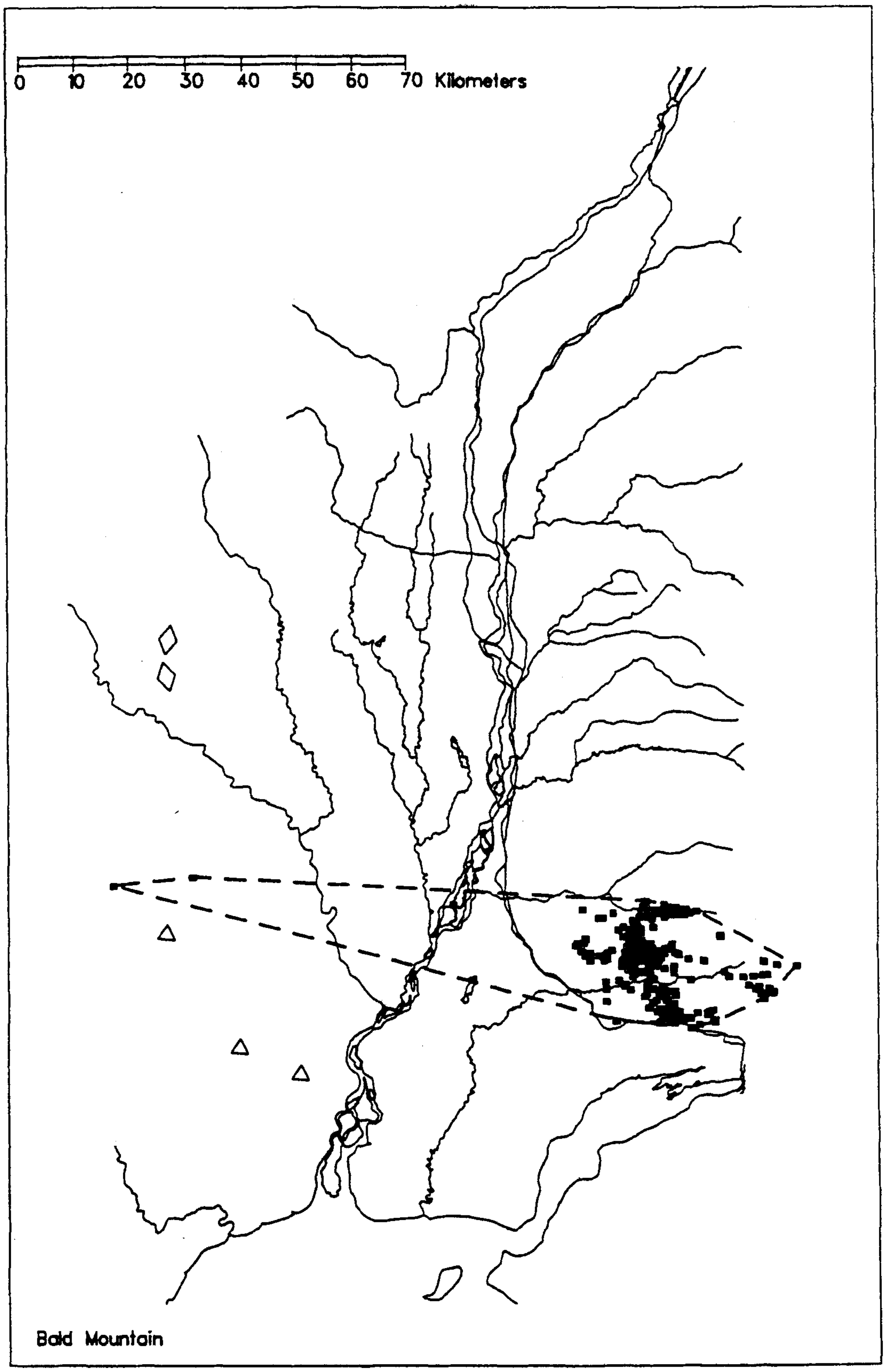

Fig. 7. Convex polygon encompassing point locations from 11 moose radio-marked on the Bald Mountain alpine habitat postrut area in the western foothills of the Talkeetna Mountains in southcentral Alaska, 1985-90.

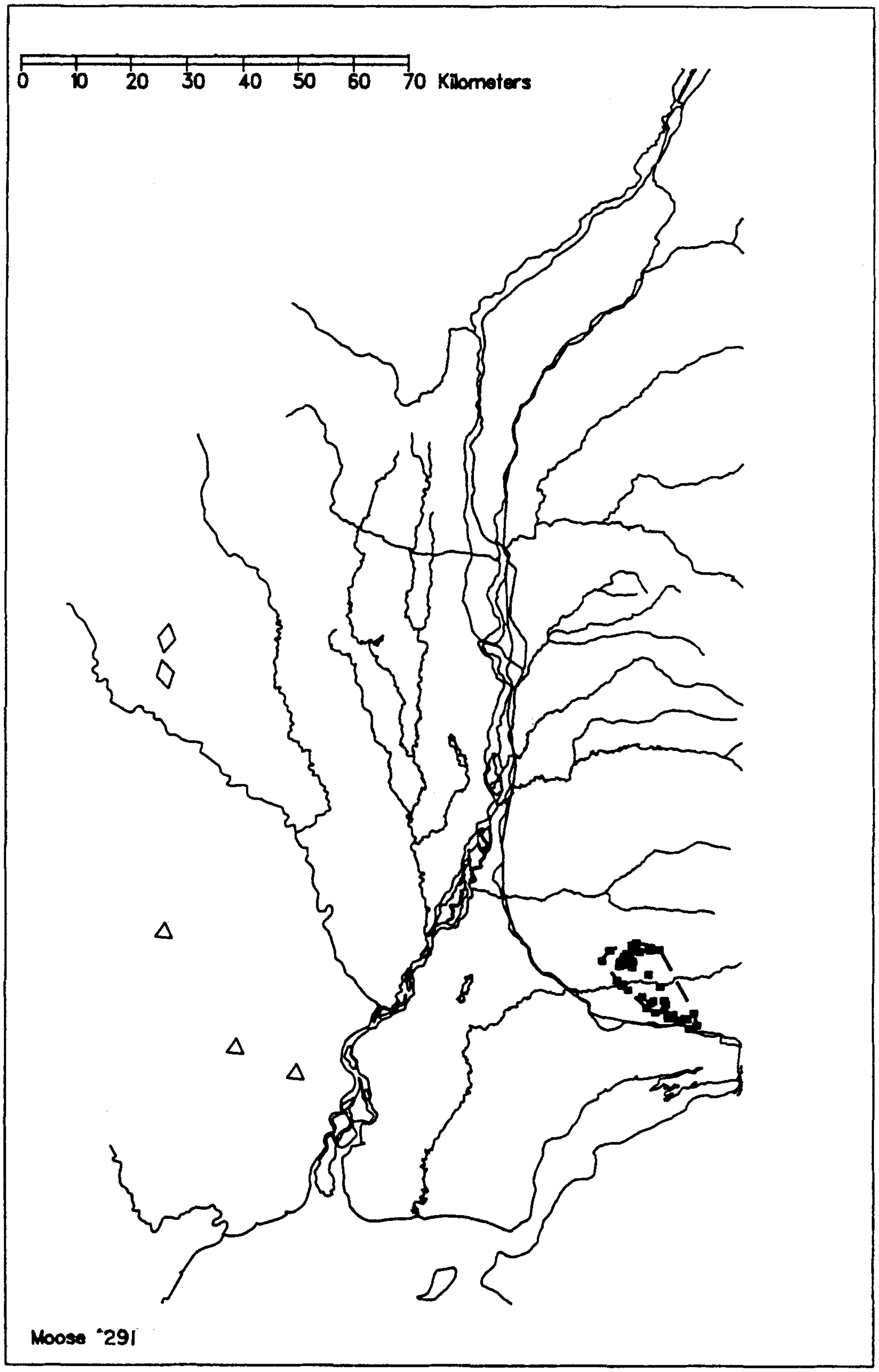

Fig. 8. Convex polygon encompassing point locations from a moose radio-marked (No. 291F) on the Bald Mountain alpine habitat postrut area in the western foothills of the Talkeetna Mountains in southcentral Alaska, 1985-90.

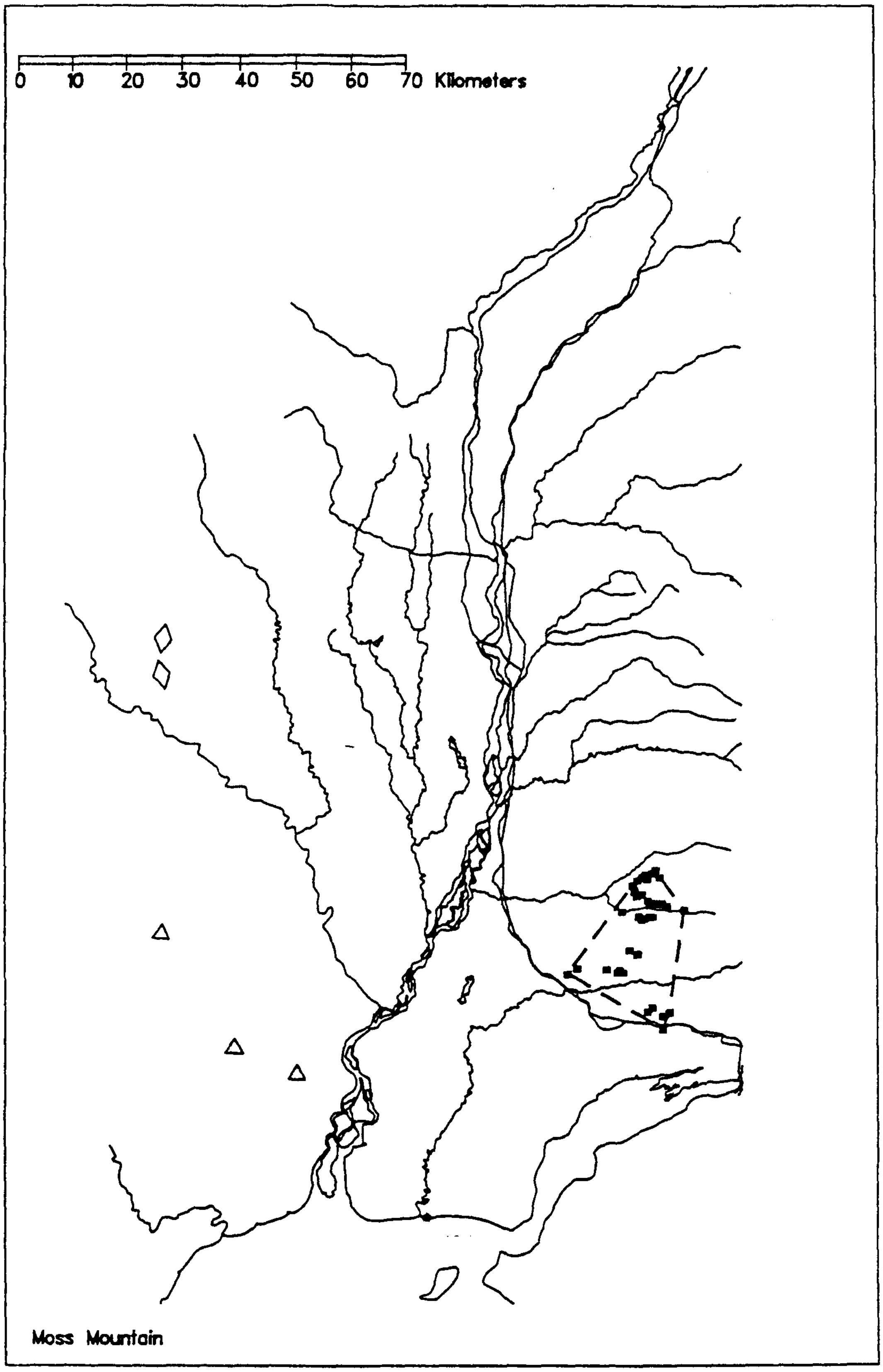

Fig. 9. Convex polygon encompassing point locations from 2 moose radio-marked on the Moss Mountain alpine habitat postrut area in the western foothills of the Talkeetna Mountains in southcentral Alaska, 1985-87.

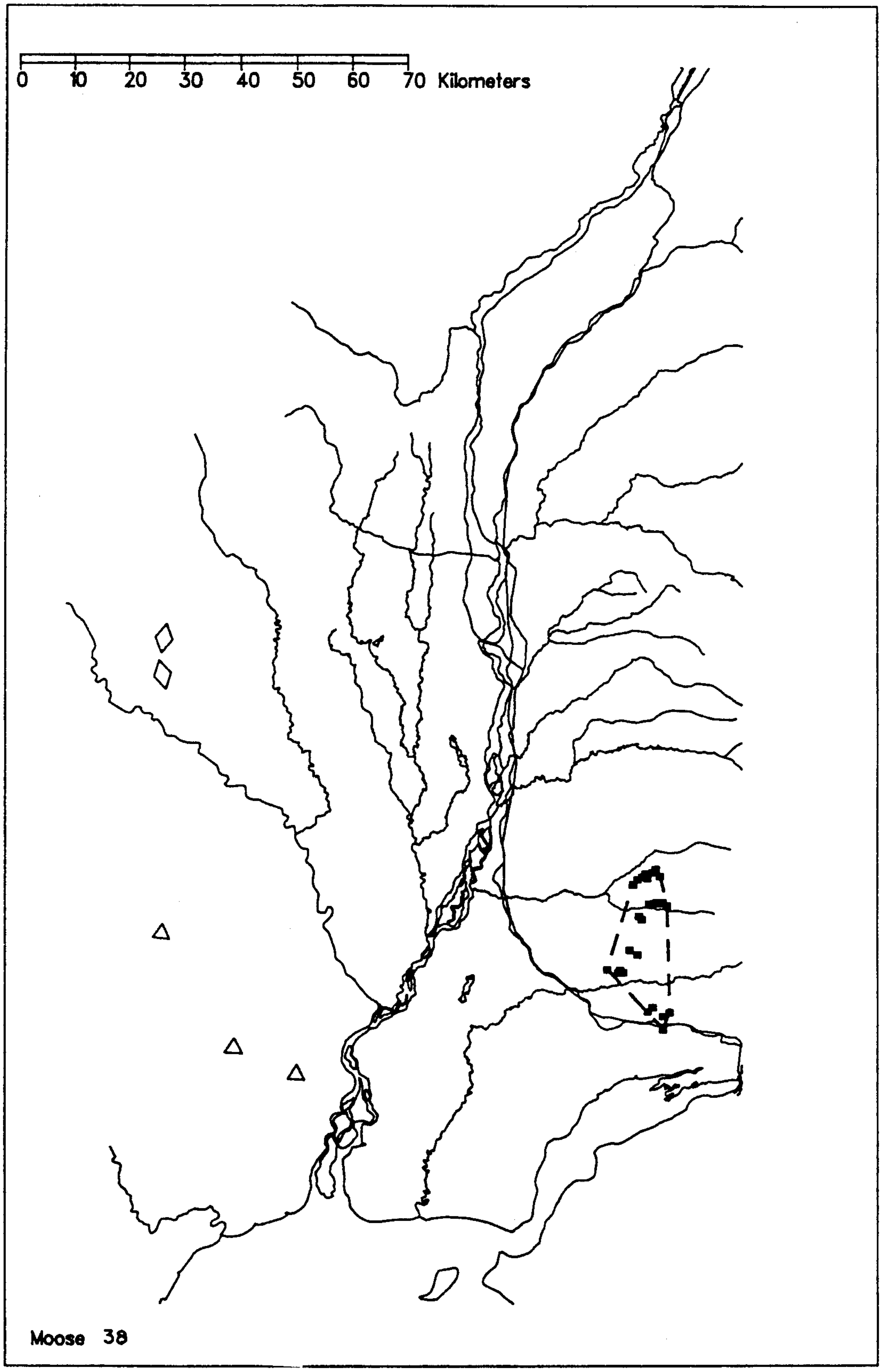

Fig. 10. Convex polygon encompassing point locations from a moose radio-marked (No. 38F) on the Moss Mountain alpine habitat postrut area in the western foothills of the Talkeetna Mountains in southcentral Alaska, 1985-87.

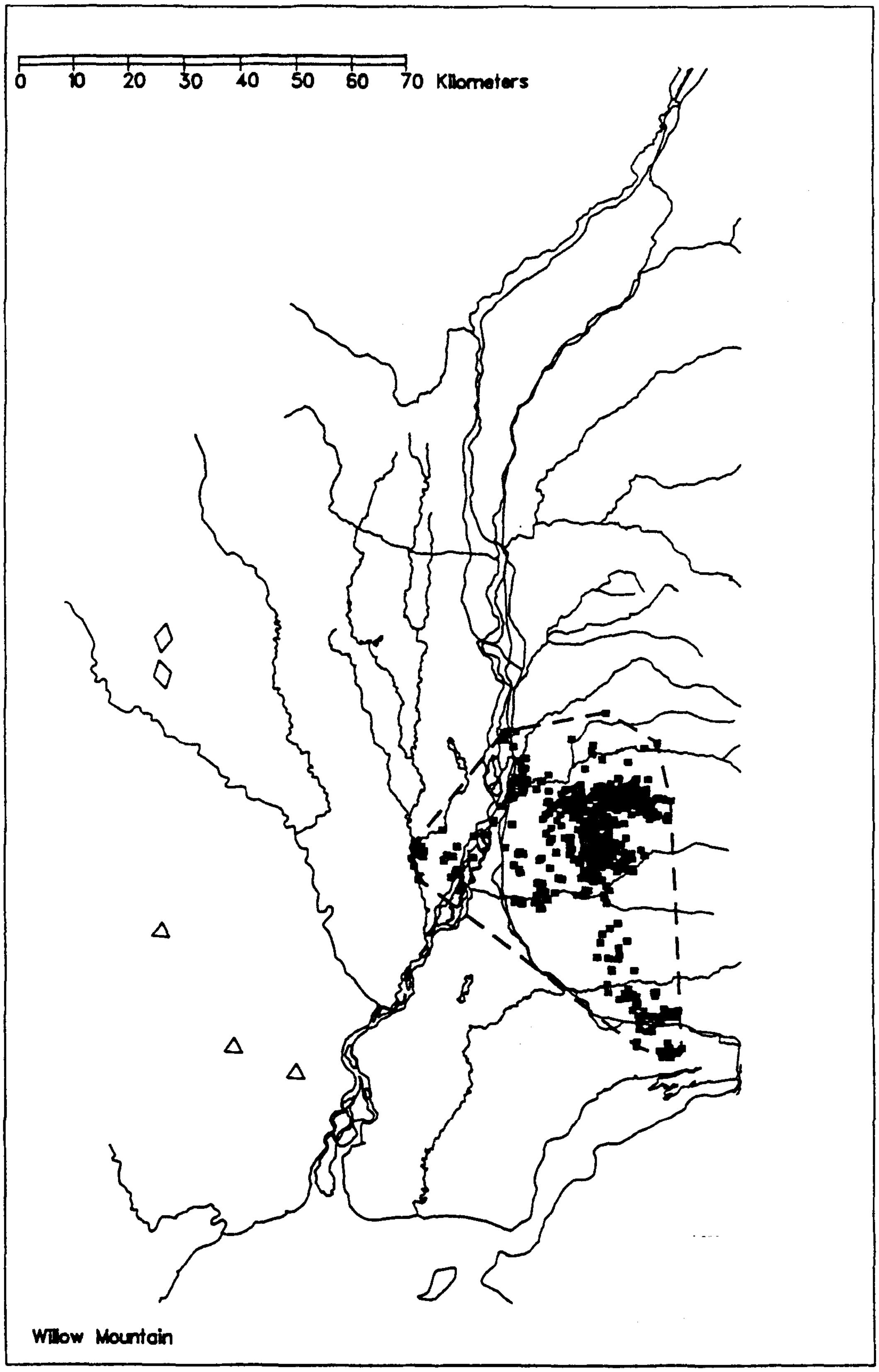

Fig. 11. Convex polygon encompassing point locations from 19 moose radio-marked on the Willow Mountain alpine habitat postrut area in the western foothills of the Talkeetna Mountains in southcentral Alaska, 1985-90.

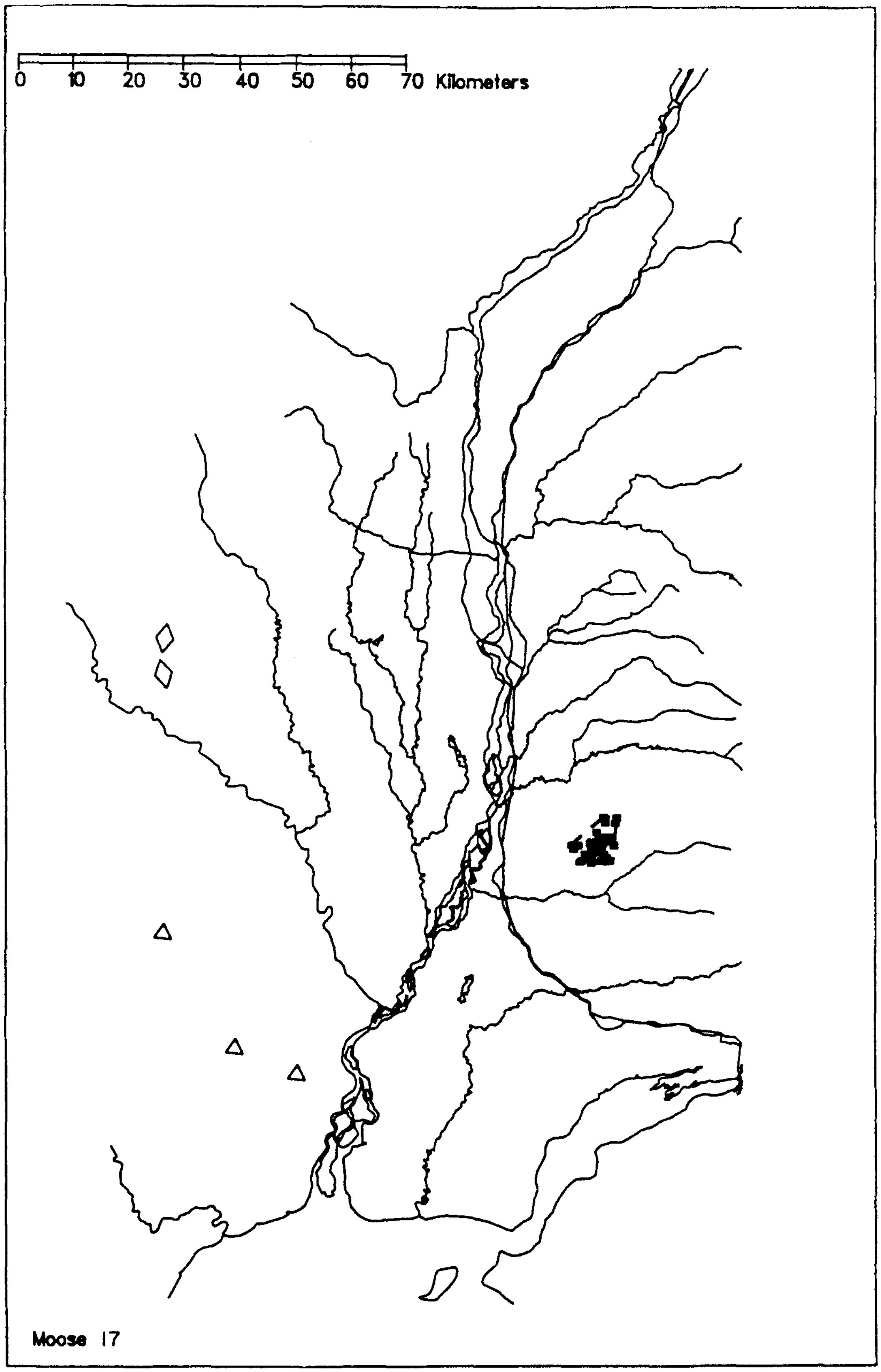

Fig. 12. Convex polygon encompassing point locations from a moose radio-marked (No. 17M) on the Willow Mountain alpine habitat postrut area in the western foothills of the Talkeetna Mountains in southcentral Alaska, 1985-89.

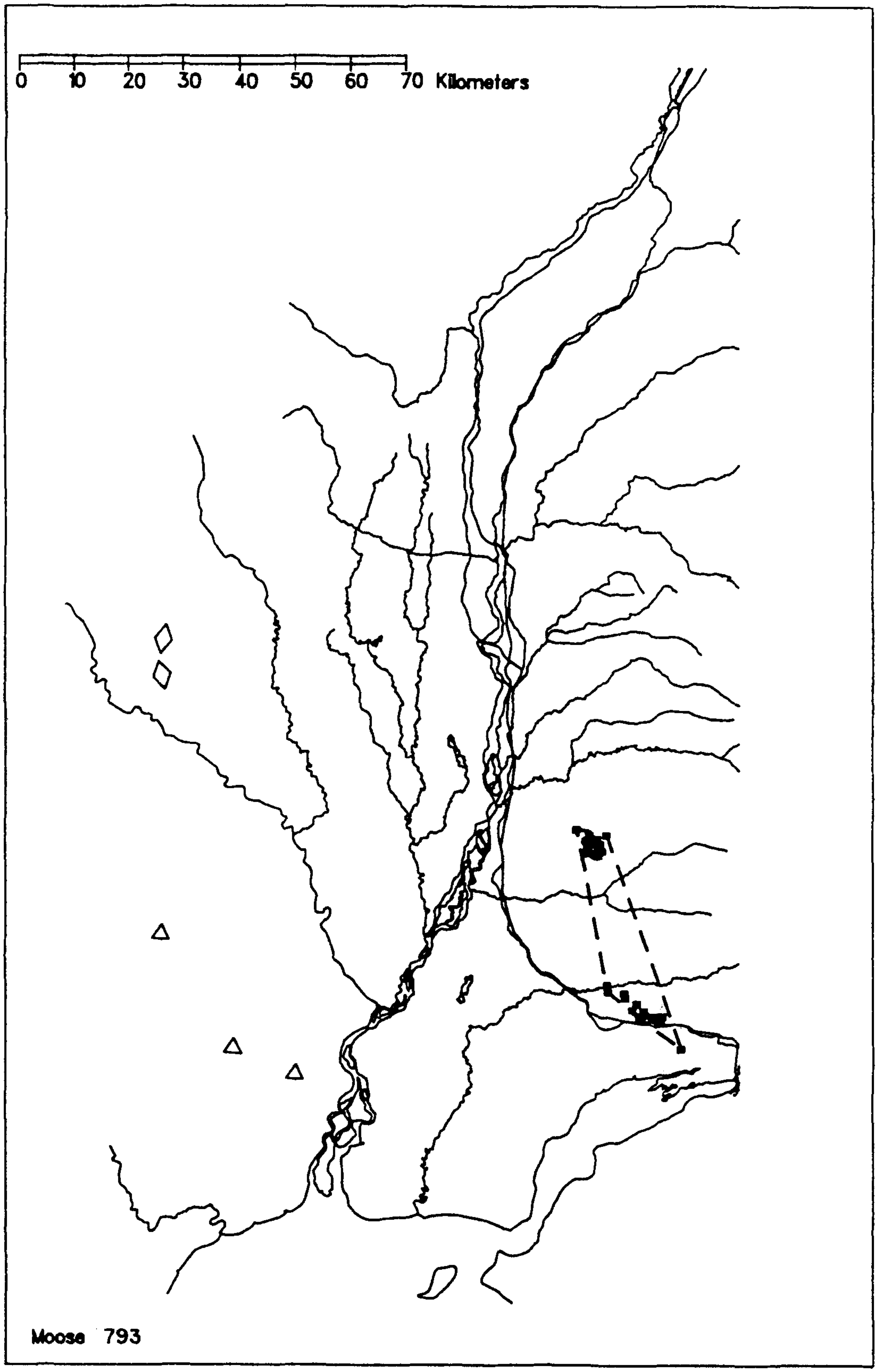

Fig. 13. Convex polygon encompassing point locations from a moose radio-marked (No. 793F) on the Willow Mountain alpine habitat postrut area in the western foothills of the Talkeetna Mountains in southcentral Alaska, 1987-90.

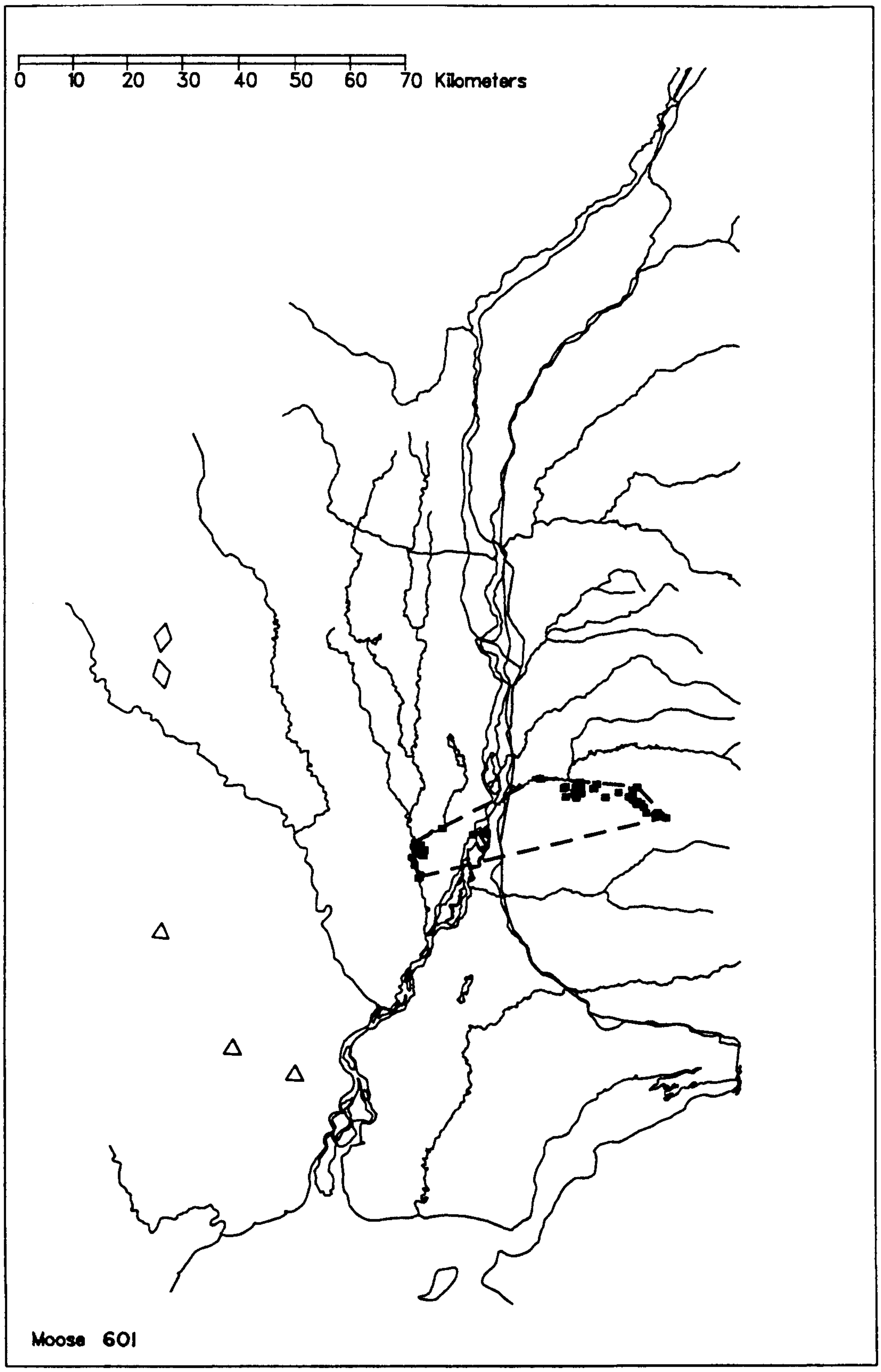

Fig. 14. Convex polygon encompassing point locations from a moose radio-marked (No. 601F) on the Willow Mountain alpine habitat postrut area in the western foothills of the Talkeetna Mountains in southcentral Alaska, 1986-90.

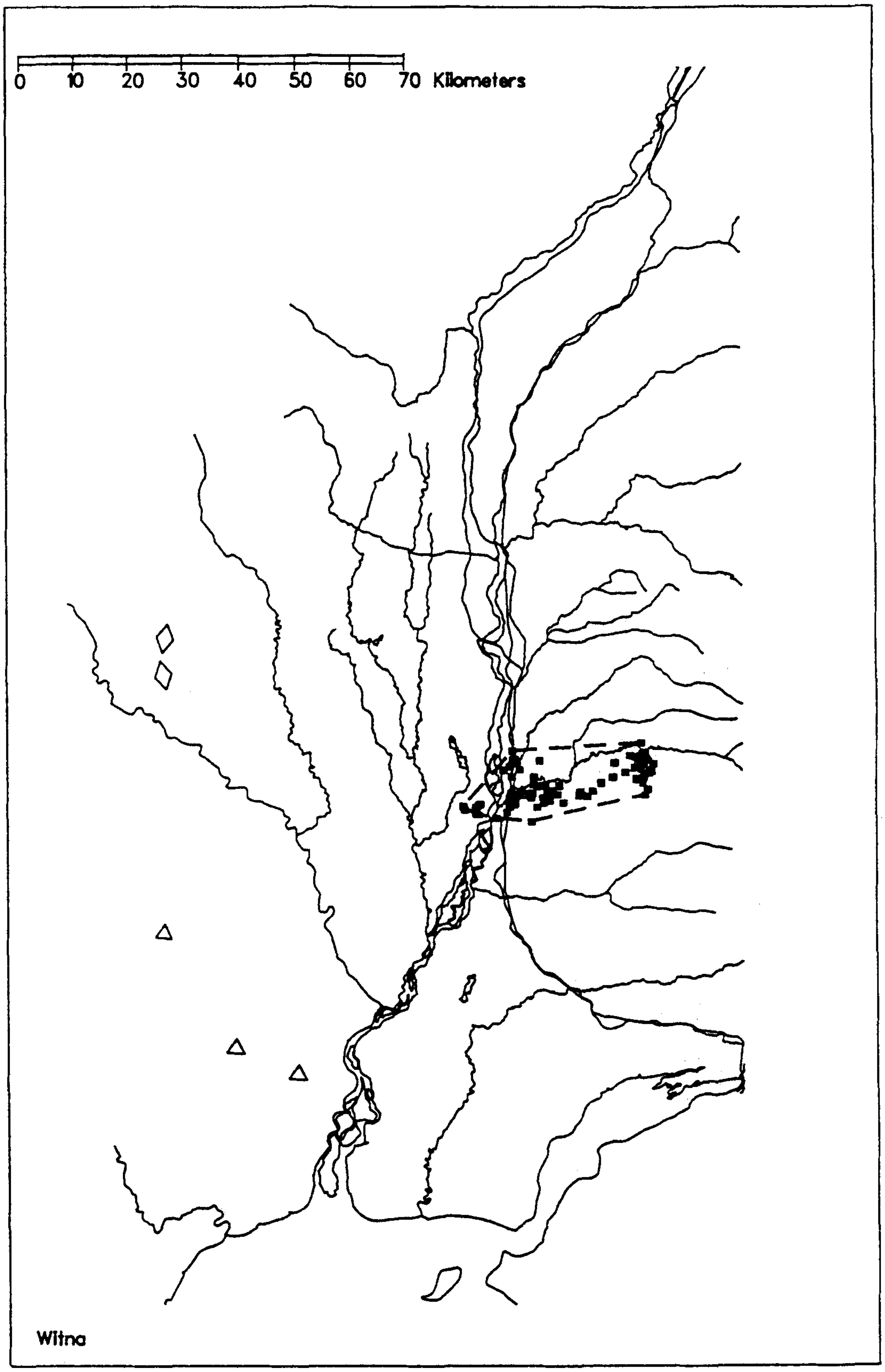

Fig. 15. Convex polygon encompassing point locations from 3 moose radio-marked on the Witna Mountain alpine habitat postrut area in the western foothills of the Talkeetna Mountains in southcentral Alaska, 1985-90.

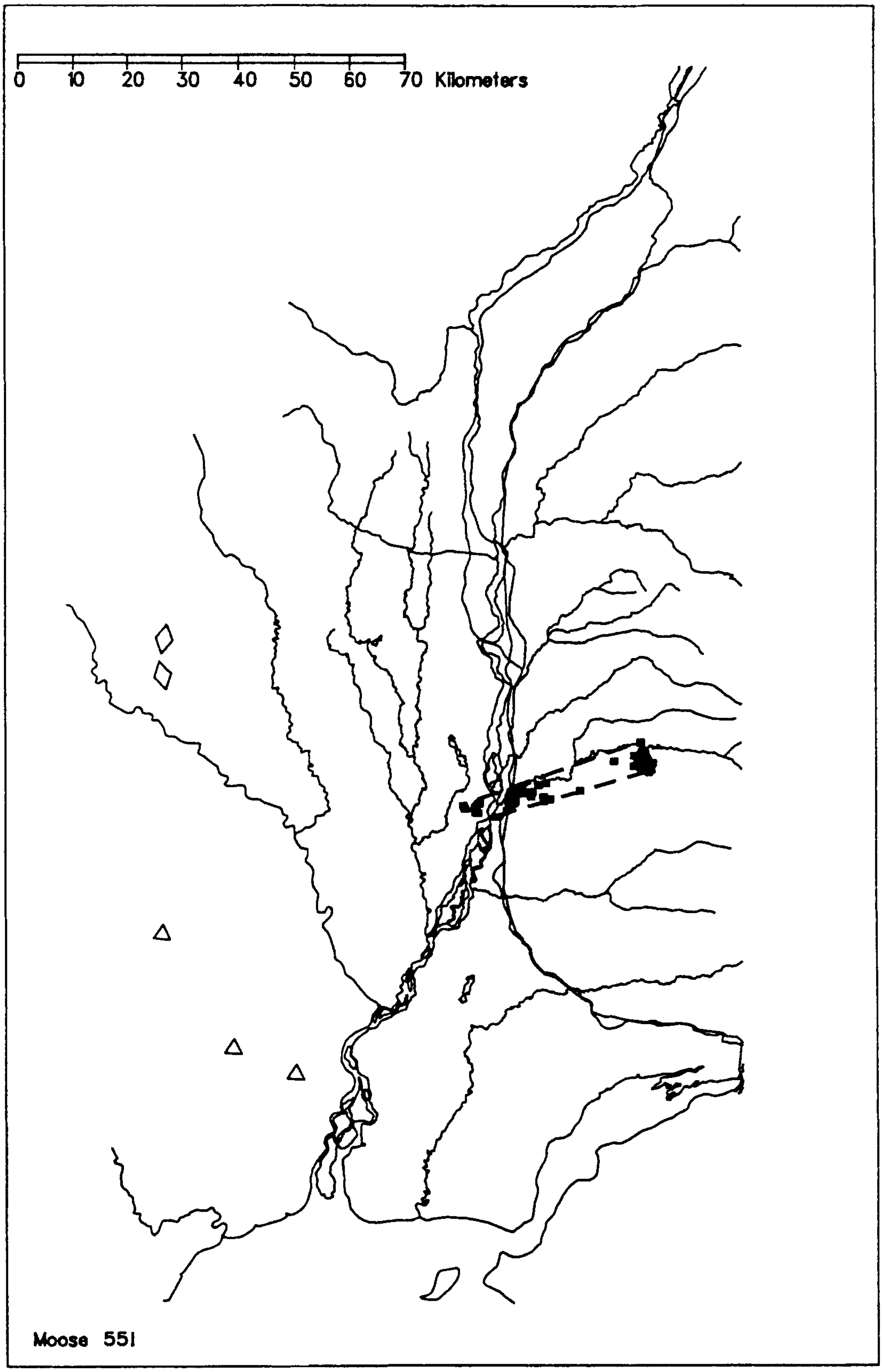

Fig. 16. Convex polygon encompassing point locations from a moose radio-marked (No. 551F) on the Witna Mountain alpine habitat postrut area in the western foothills of the Talkeetna Mountains in southcentral Alaska, 1986-90.

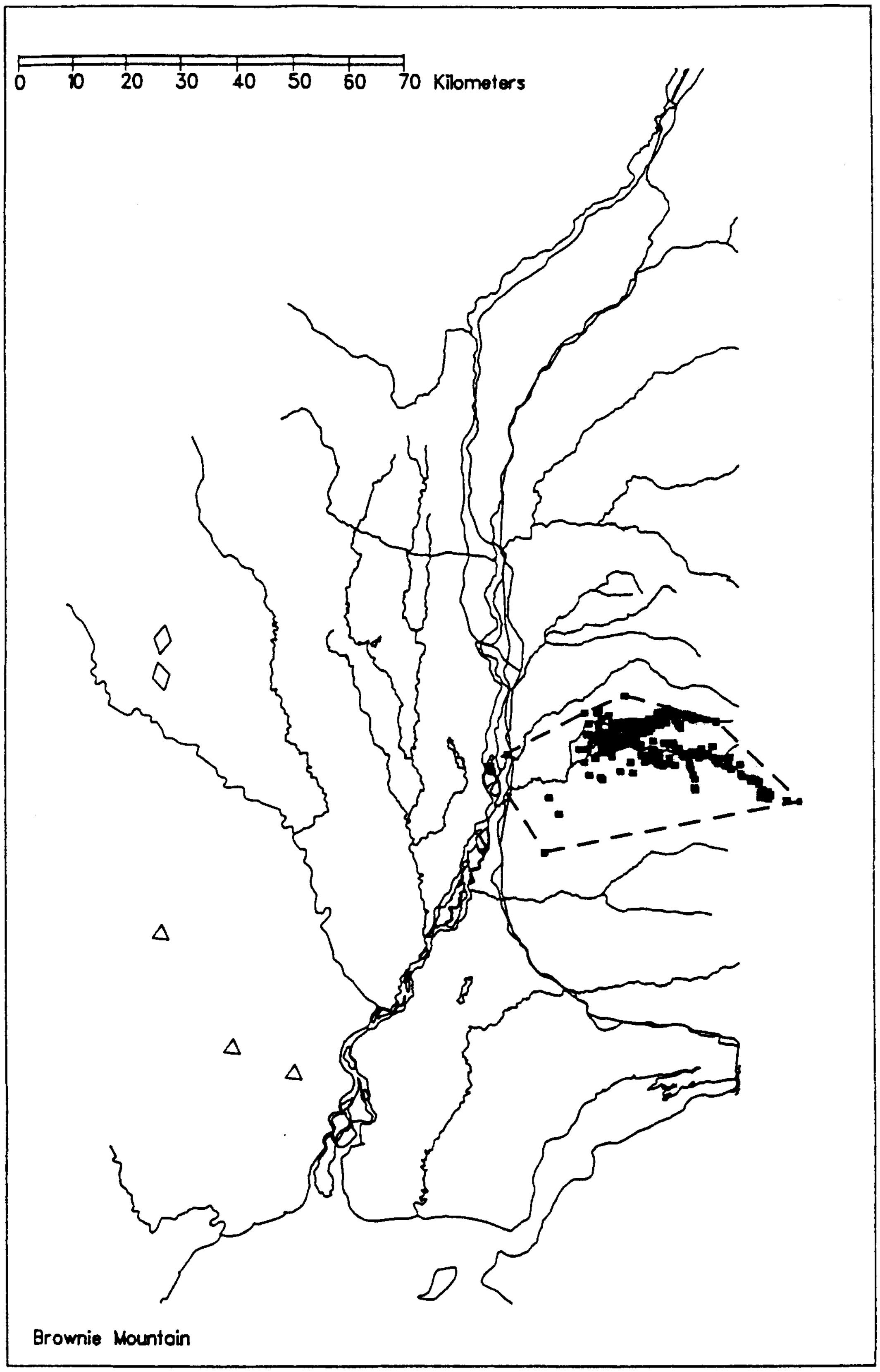

Fig. 17. Convex polygon encompassing point locations from 7 moose radio-marked on the Brownie Mountain alpine habitat postrut area in the western foothills of the Talkeetna Mountains in southcentral Alaska 1985-90.

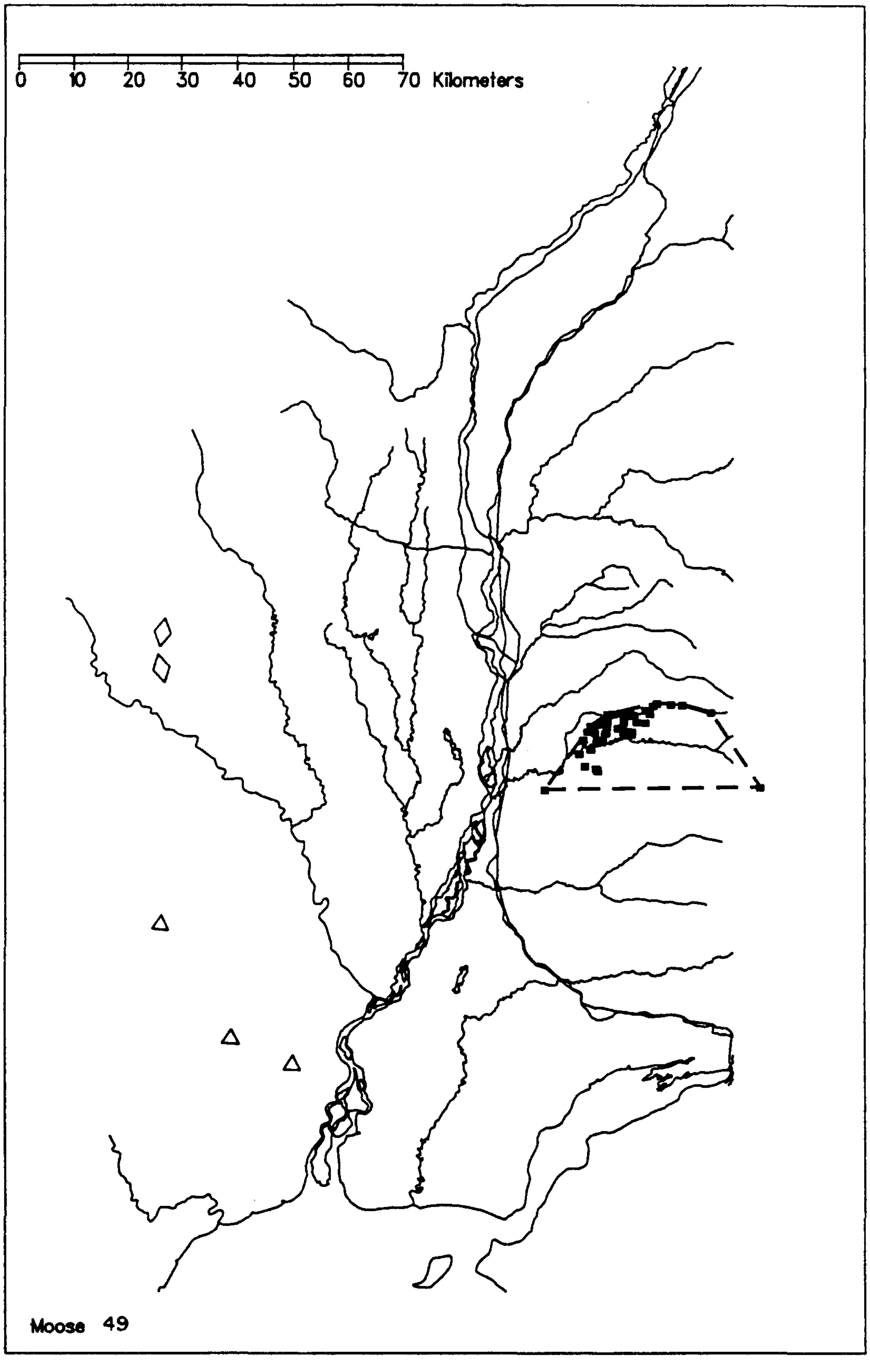

Fig. 18. Convex polygon encompassing point locations from a moose radio-marked (No. 49F) on the Brownie Mountain alpine habitat postrut area in the western foothills of the Talkeetna Mountains in southcentral Alaska, 1986-90.

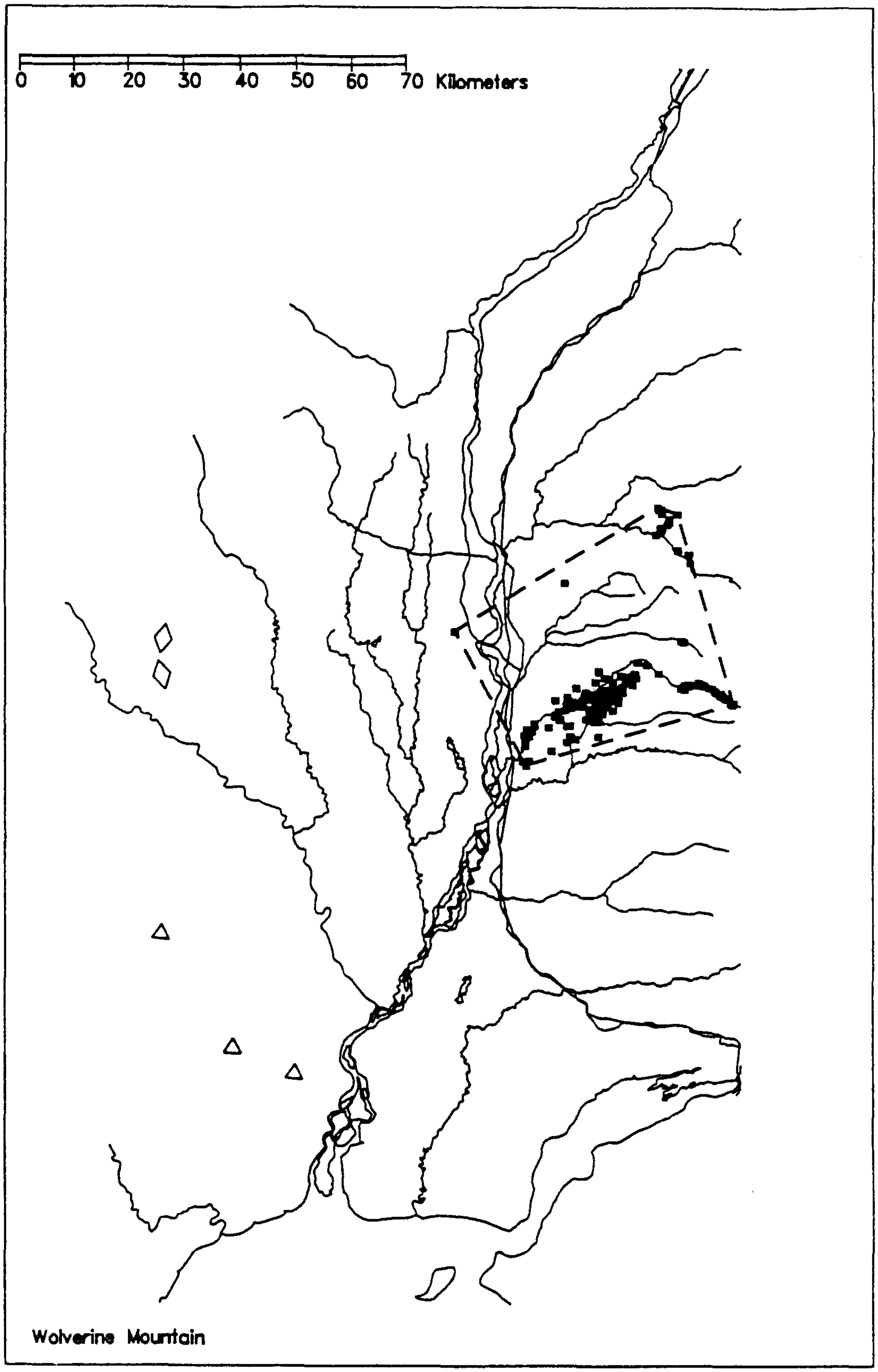

Fig. 19. Convex polygon encompassing point locations from 6 moose radio-marked on the Wolverine Mountain alpine habitat postrut area in the western foothills of the Talkeetna Mountains in southcentral Alaska, 1985-90.

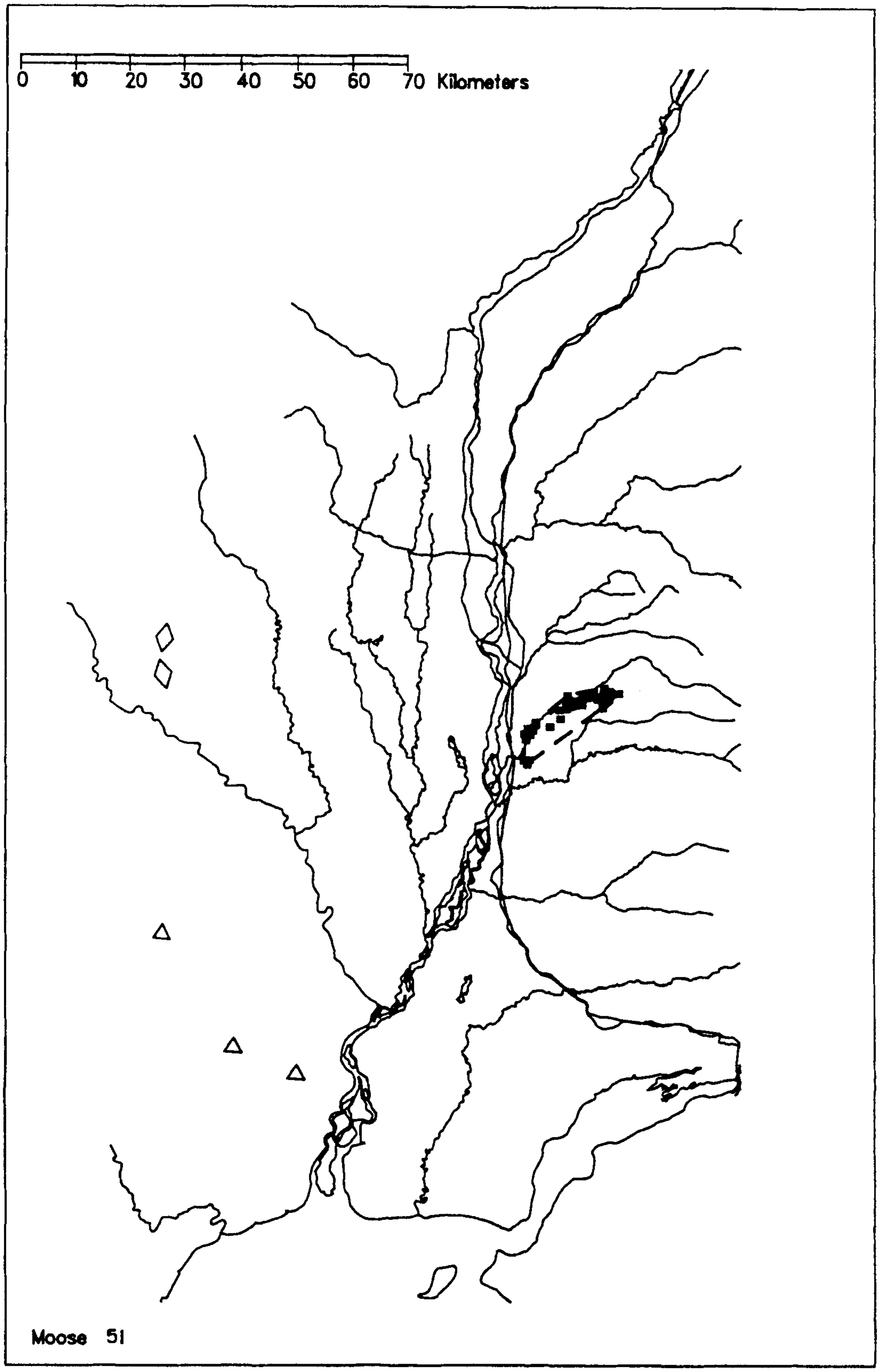

Fig. 20. Convex polygon encompassing point locations from a moose radio-marked (No. 51F) on the Wolverine Mountain alpine habitat postrut area in the western foothills of the Talkeetna Mountains in southcentral Alaska, 1986-90.

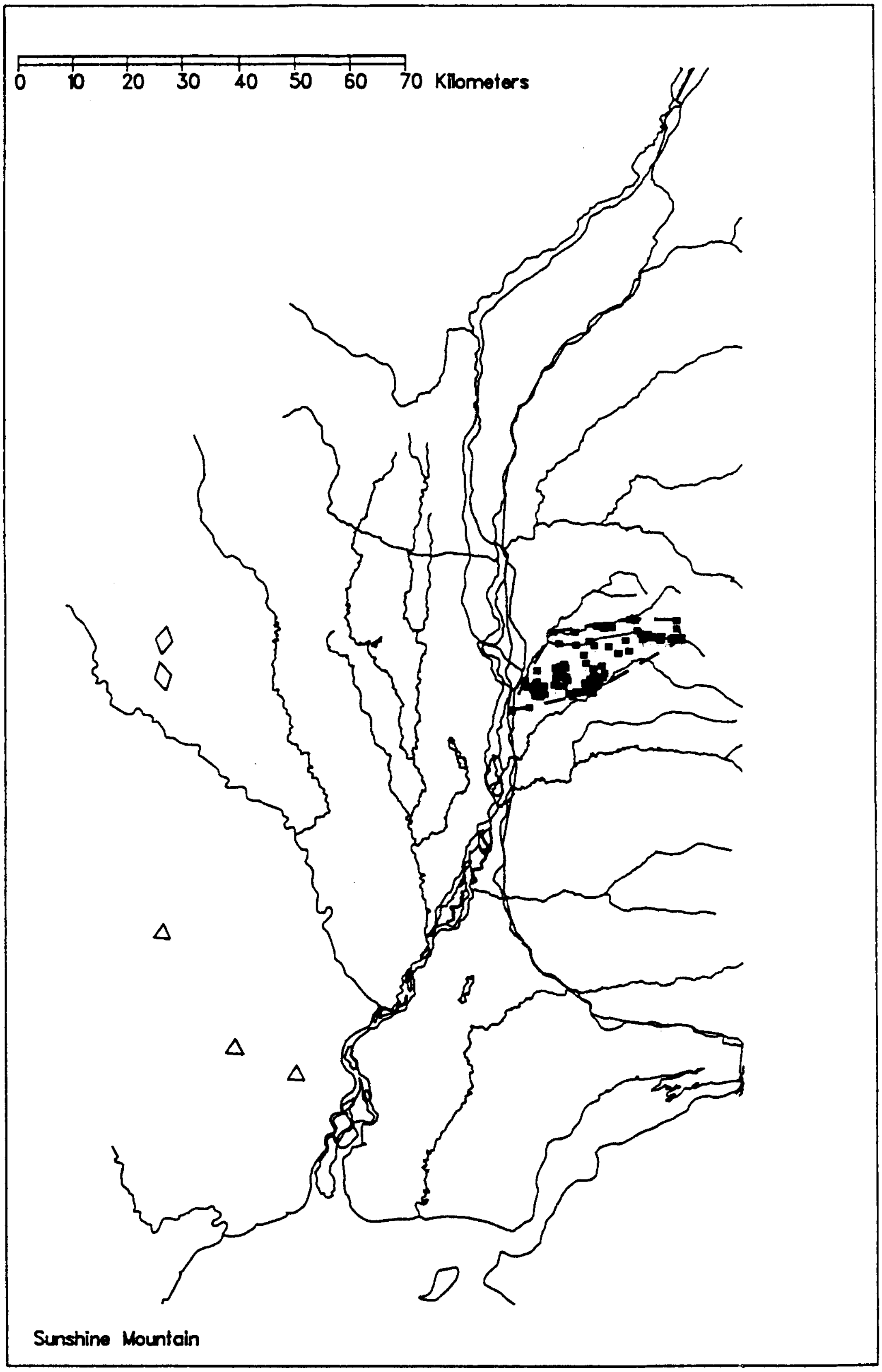

Fig. 21. Convex polygon encompassing point locations from 3 moose radio-marked on the Sunshine Mountain alpine habitat postrut area in the western foothills of the Talkeetna Mountains in southcentral Alaska, 1985-86.

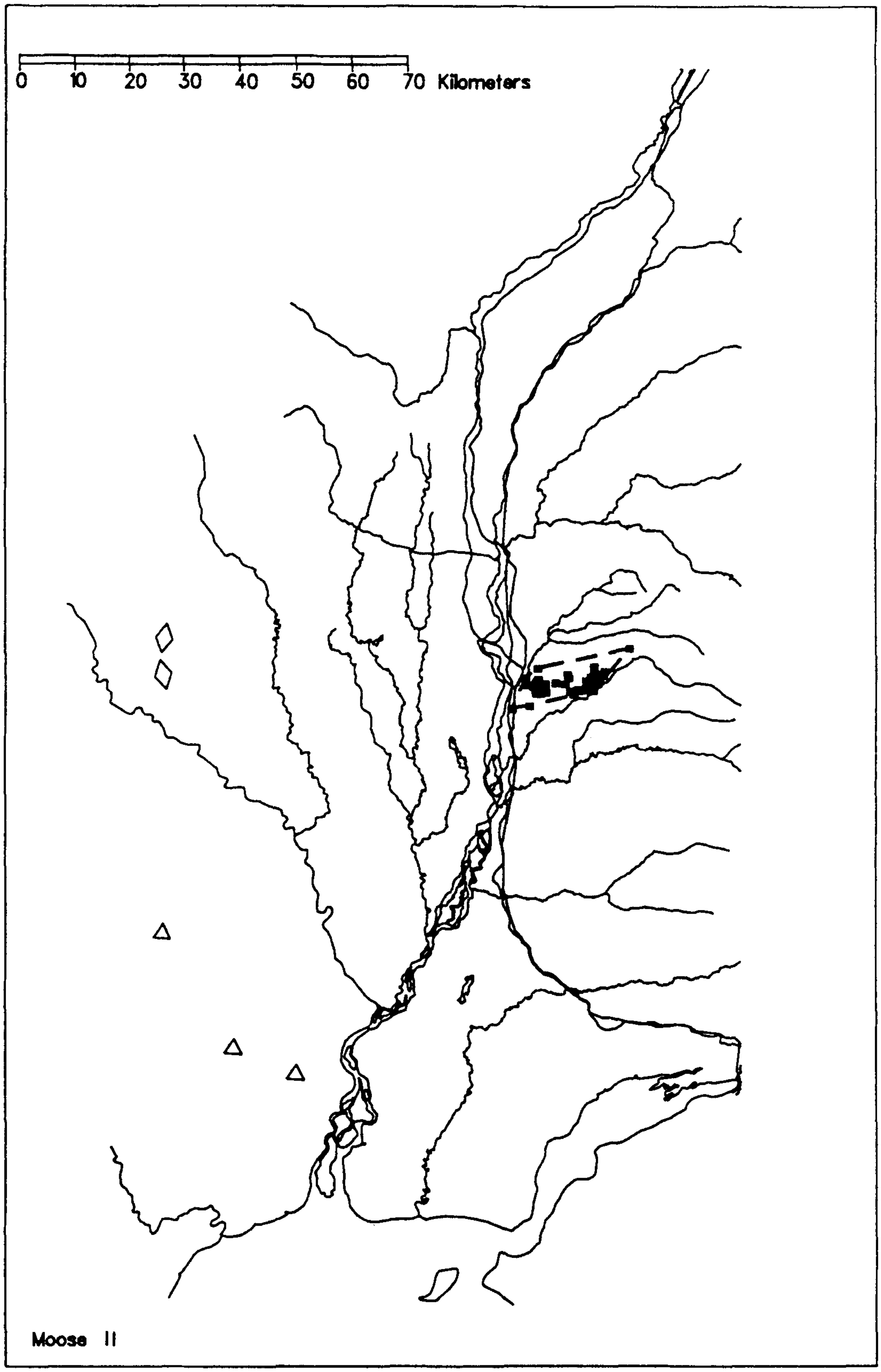

Fig. 22. Convex polygon encompassing point locations from a moose radio-marked (No. 11F) on the Sunshine Mountain alpine habitat postrut area in the western foothills of the Talkeetna Mountains in southcentral Alaska, 1986-90.

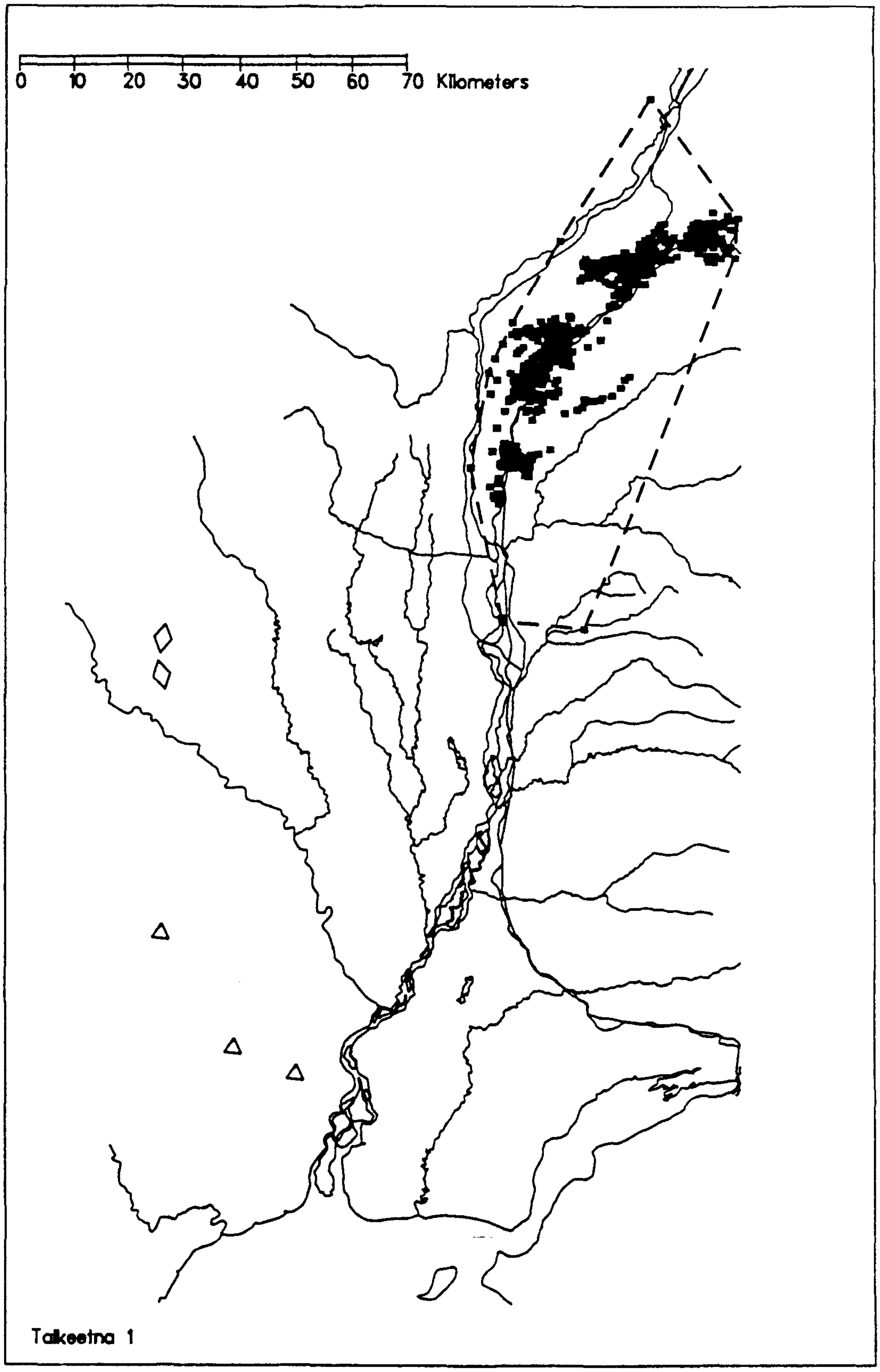

Fig. 23. Convex polygon encompassing point locations from 12 moose radio-marked in winter along the Susitna River floodplain between Talkeetna and Devil Canyon (Susitna River Area 1) in southcentral Alaska 1980-90.

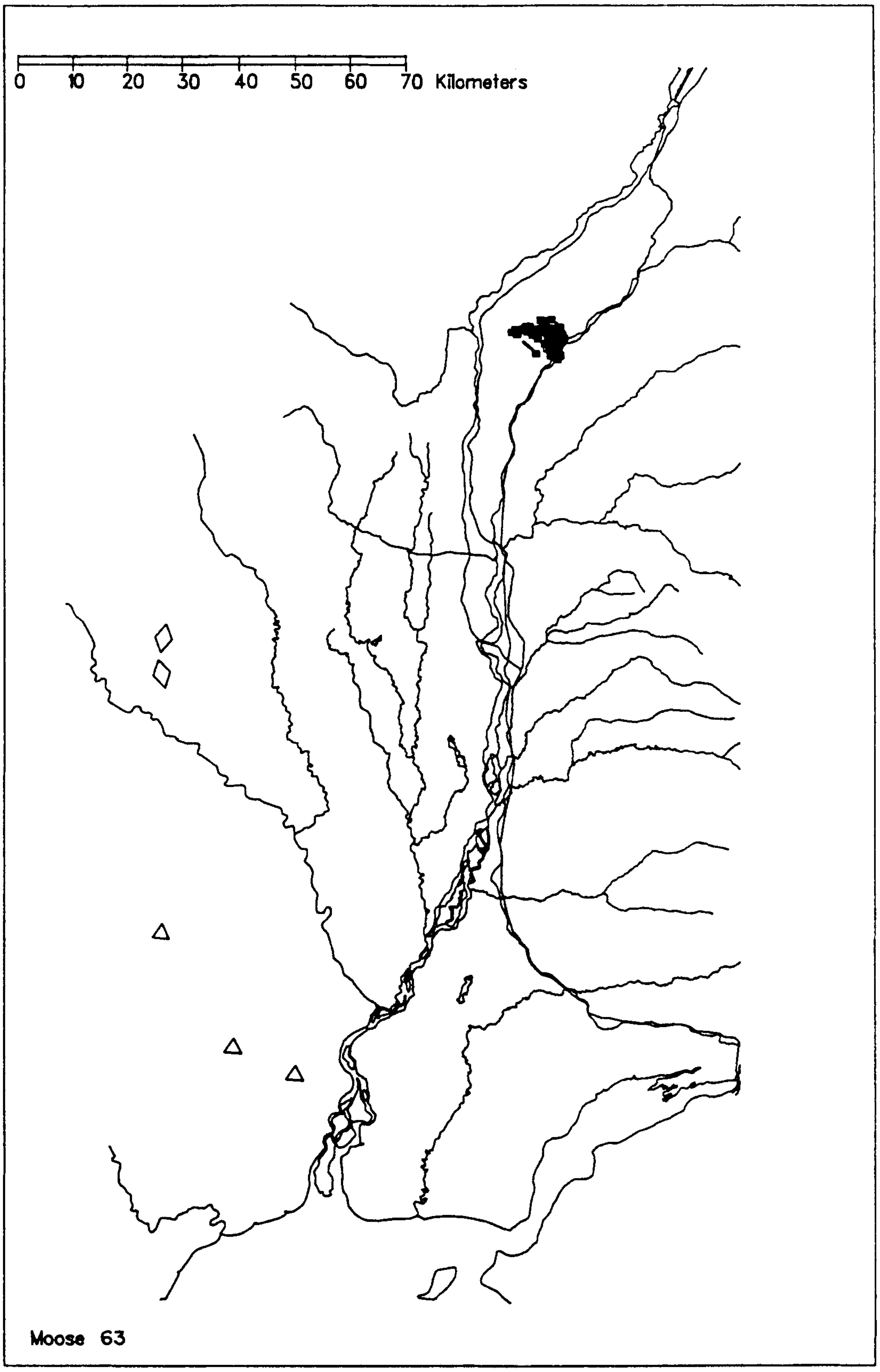

Fig. 24. Convex polygon encompassing point locations from a moose radio-marked (No. 63F) in winter along the Susitna River floodplain between Talkeetna and Devil Canyon (Susitna River Area 1) in southcentral Alaska, 1981-90.

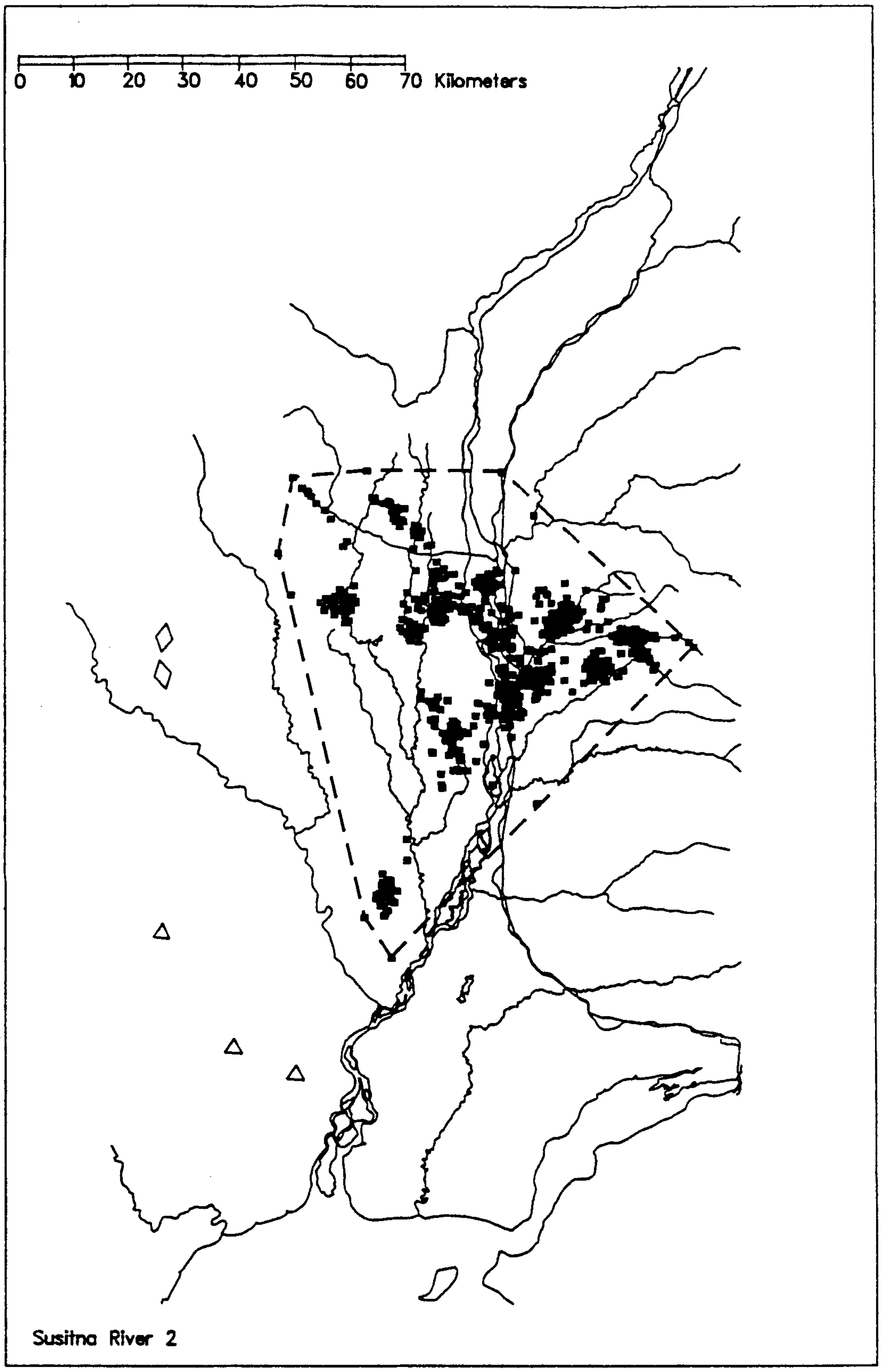

Fig. 25. Convex polygon encompassing point locations from 9 moose radio-marked in winter along the Susitna River floodplain between Talkeetna and Montana Creek (Susitna River Area 2) in southcentral Alaska, 1980-90.

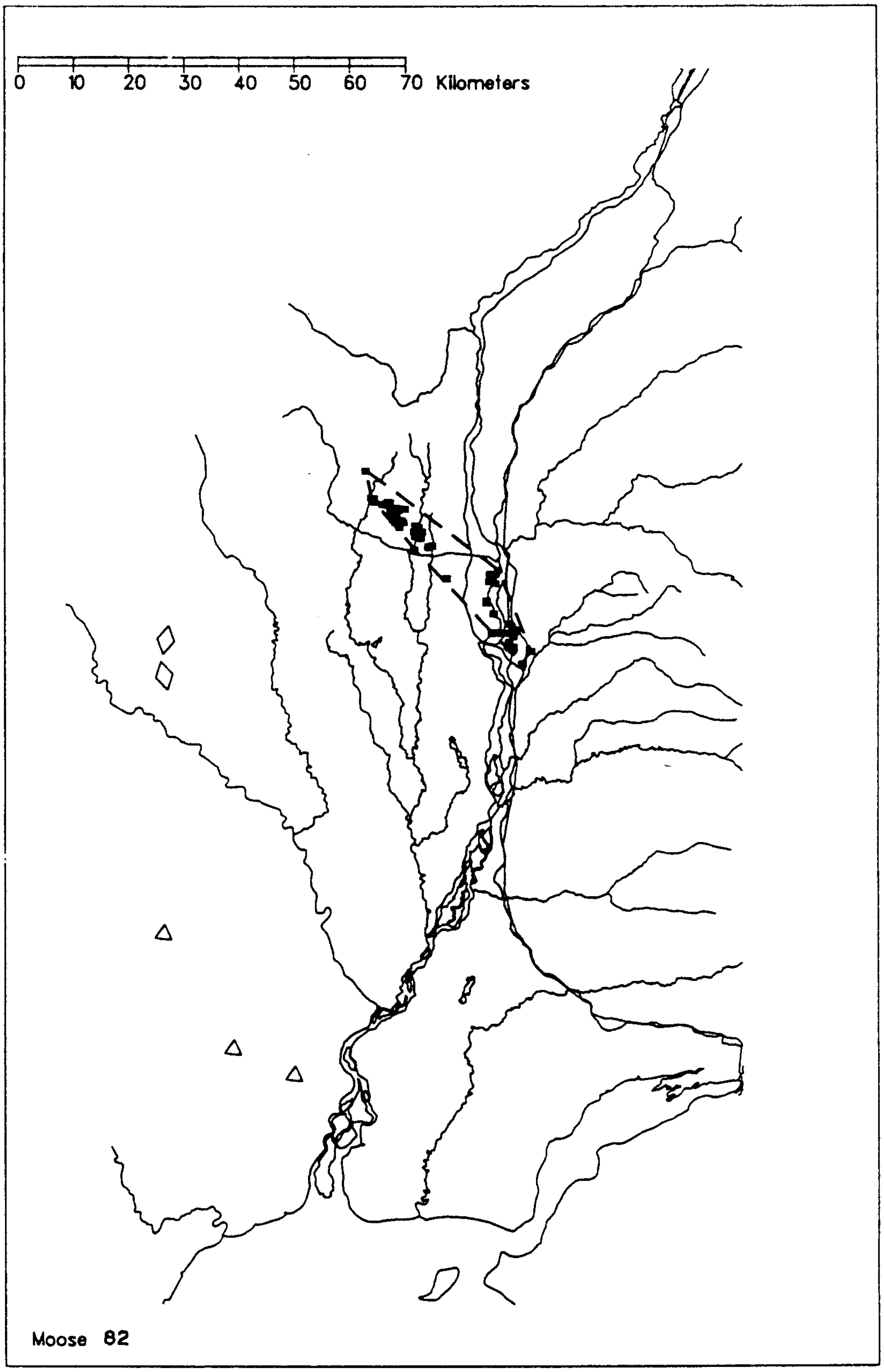

Fig. 26. Convex polygon encompassing point locations from a moose radio-marked (No. 82F) in winter along the Susitna River floodplain between Talkeetna and Montana Creek (Susitna River Area 2) in southcentral Alaska, 1981-83.

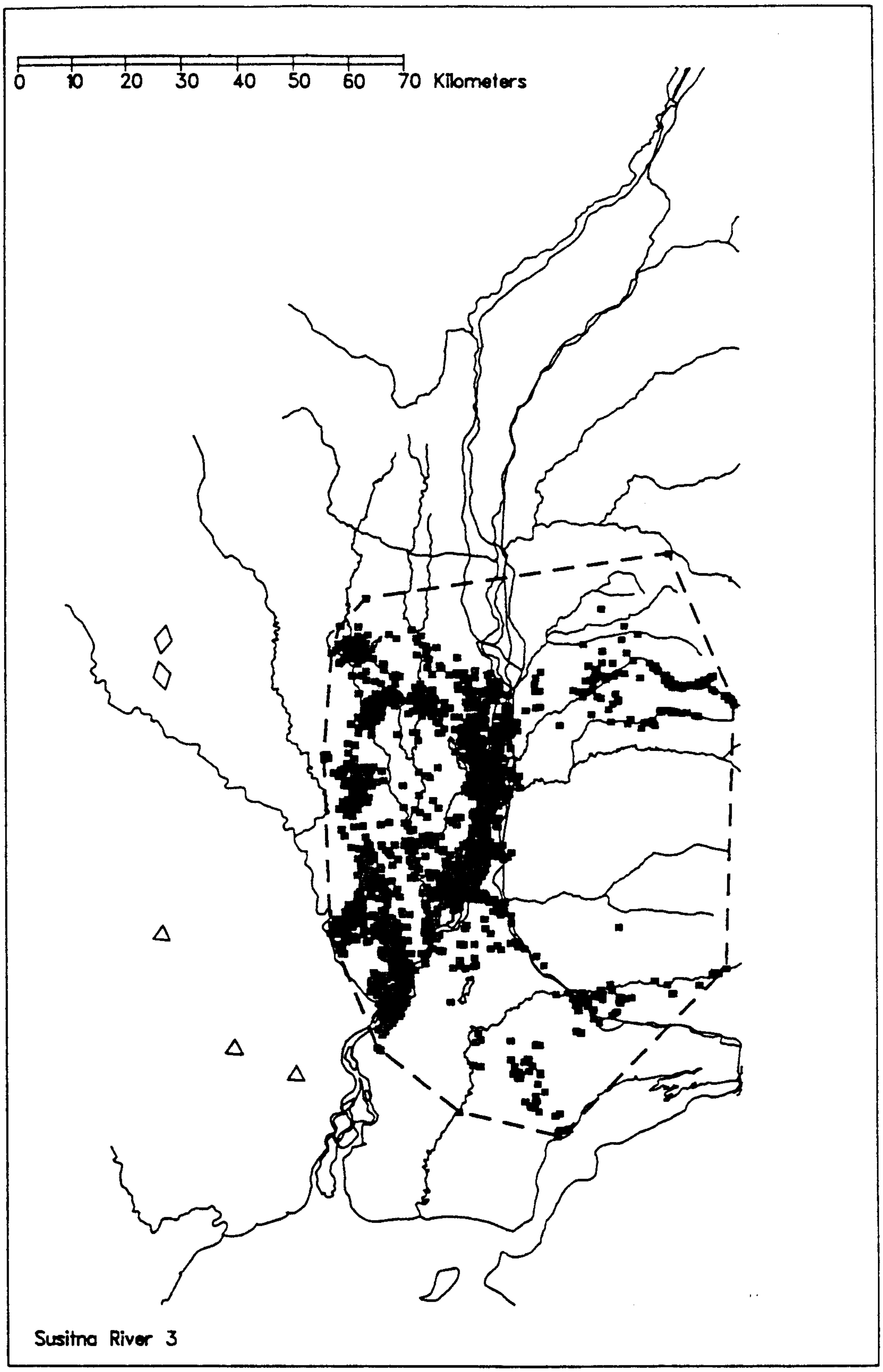

Fig. 27. Convex polygon encompassing point locations from 12 moose radio-marked I winter along the Susitna River floodplain between Montana Creek and the Yentna River, (Susitna River Area 3) in southcentral Alaska, 1980-90.

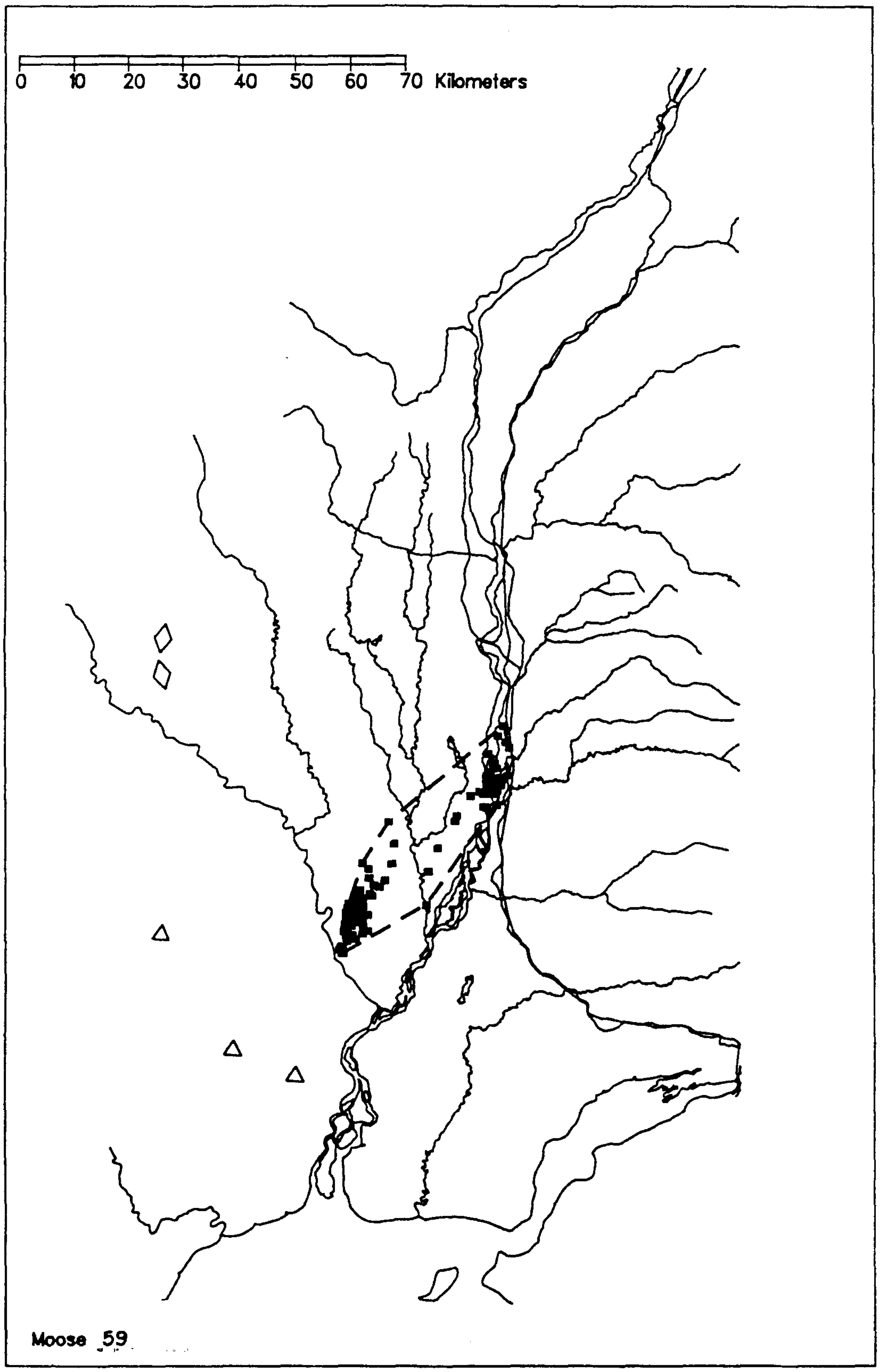

Fig. 28. Convex polygon encompassing point locations from a moose radio-marked (No. 59F) in winter along the Susitna River floodplain between Montana Creek and the Yentna River (Susitna River Area 3) in southcentral Alaska, 1981-90.

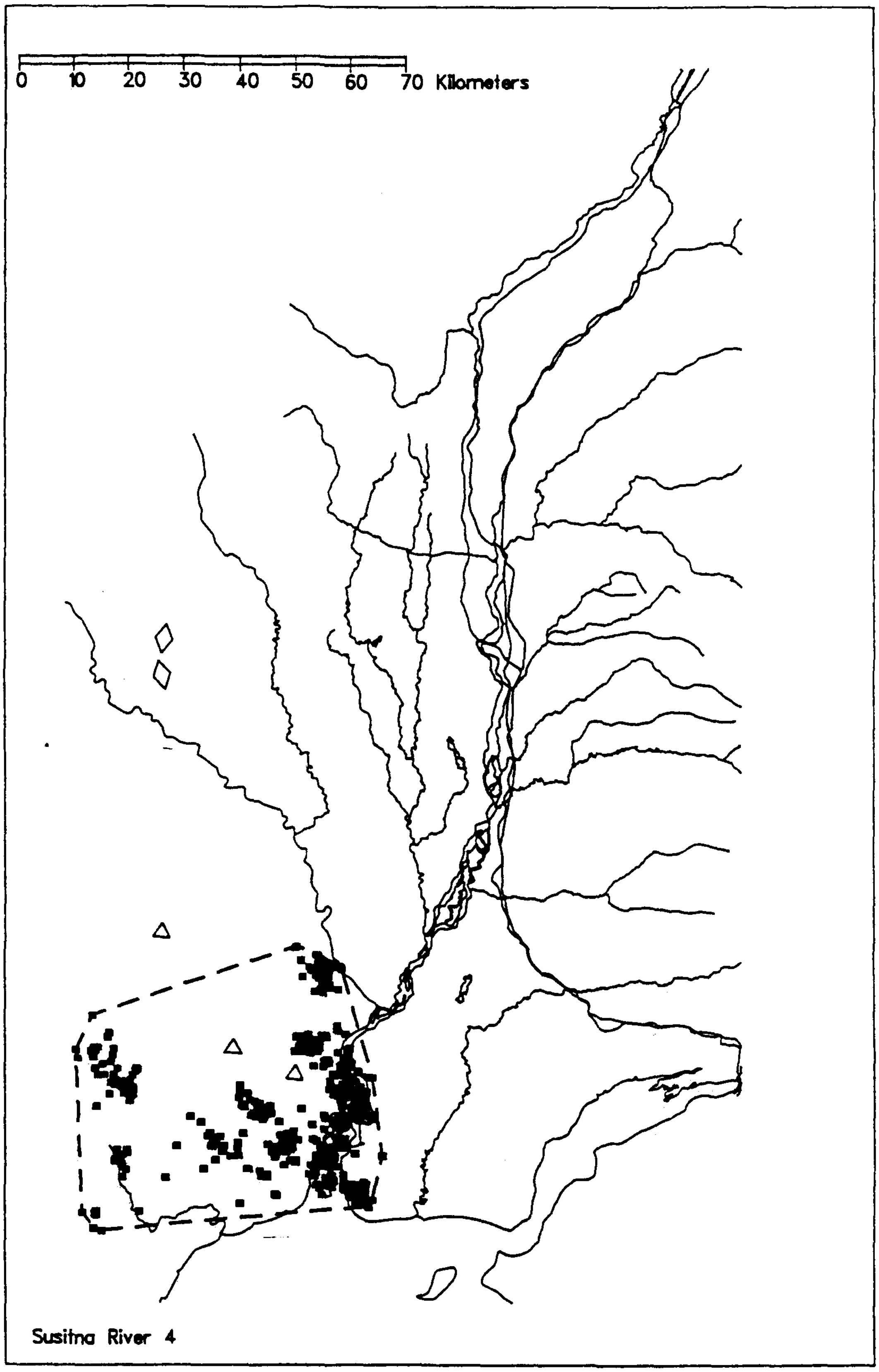

Fig. 29. Convex polygon encompassing point locations from 11 moose radio-marked in winter along the Susitna River floodplain between the Yentna River and Cook Inlet (Susitna river Area 4) in southcentral Alaska 1981-90.

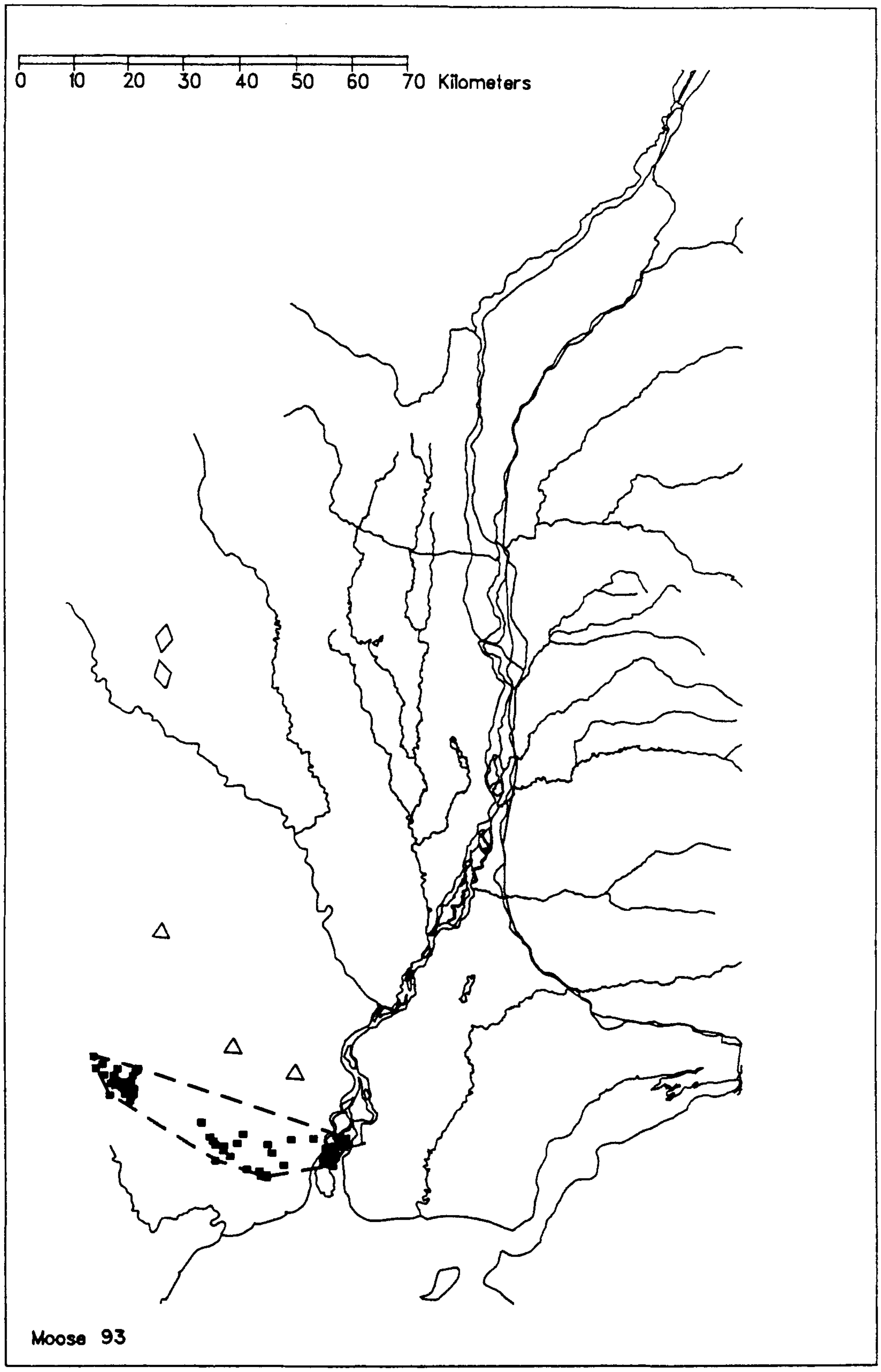

Fig. 30. Convex polygon encompassing point locations from a moose radio-marked (No. 93F) in winter along the Susitna River floodplain between the Yentna River and Cook Inlet (Susitna River Area 4) in southcentral Alaska, 1981-90.

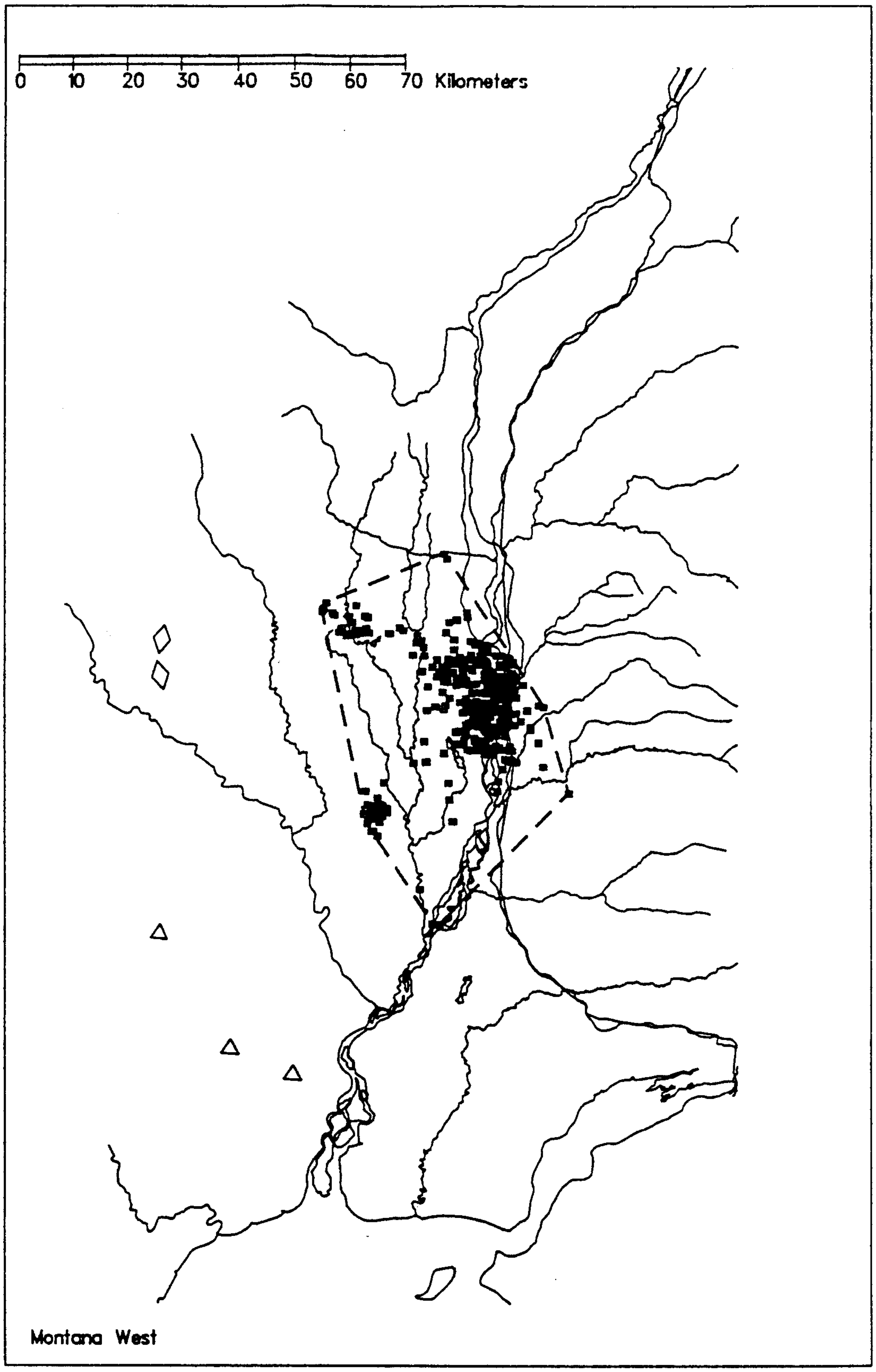

Fig. 31. Convex polygon encompassing point locations from 8 moose radio-marked i winter on an abandoned homestead site along the west bank of the Susitna River opposite Montana Creek (Susitna River Area 5) in southcentral Alaska, 1984-90.

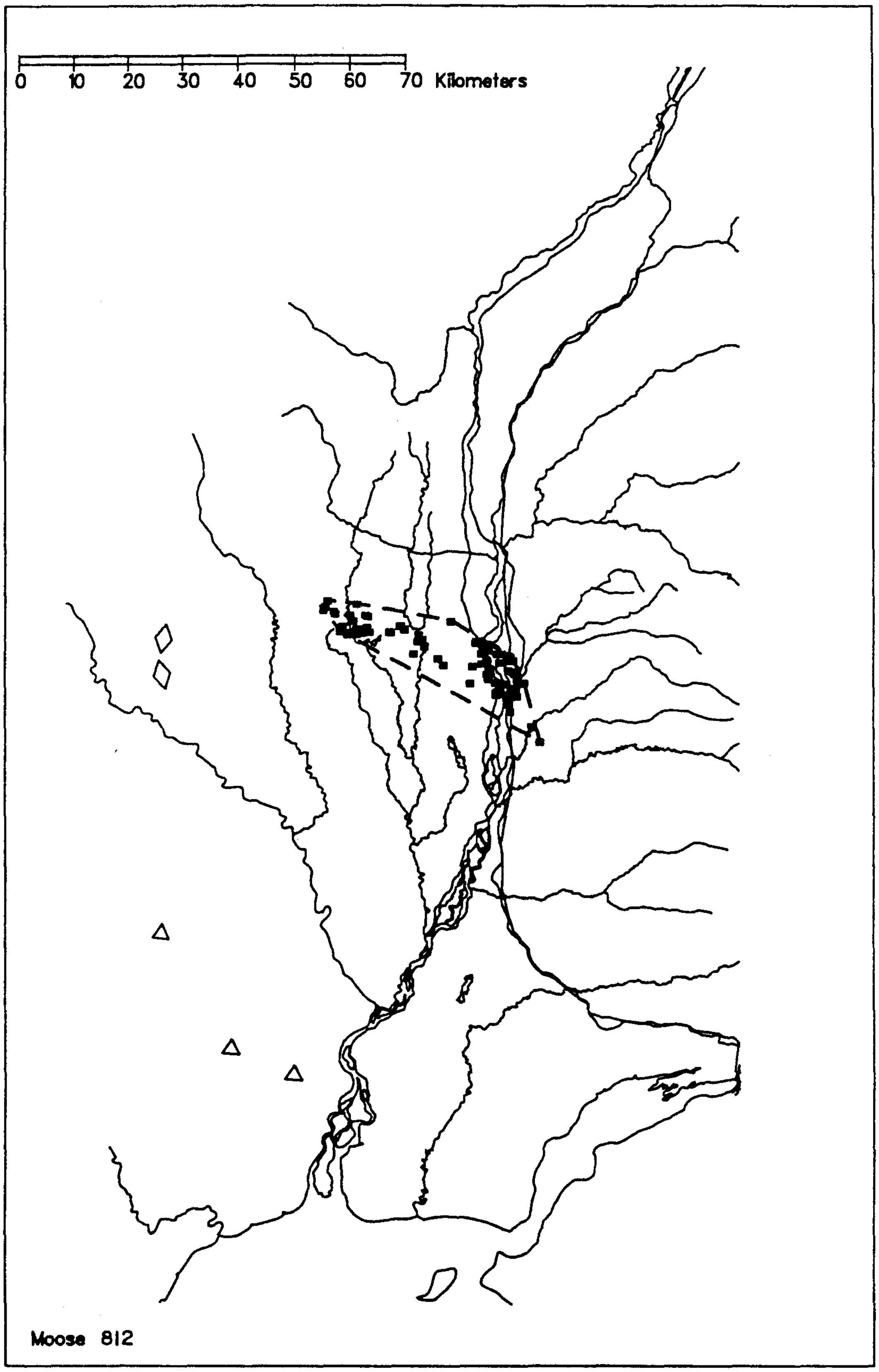

Fig. 32. Convex polygon encompassing point locations from a moose radio-marked (No. 812F) in winter on an abandoned homestead site along the west bank of the Susitna river southcentral Alaska, 1984-90.

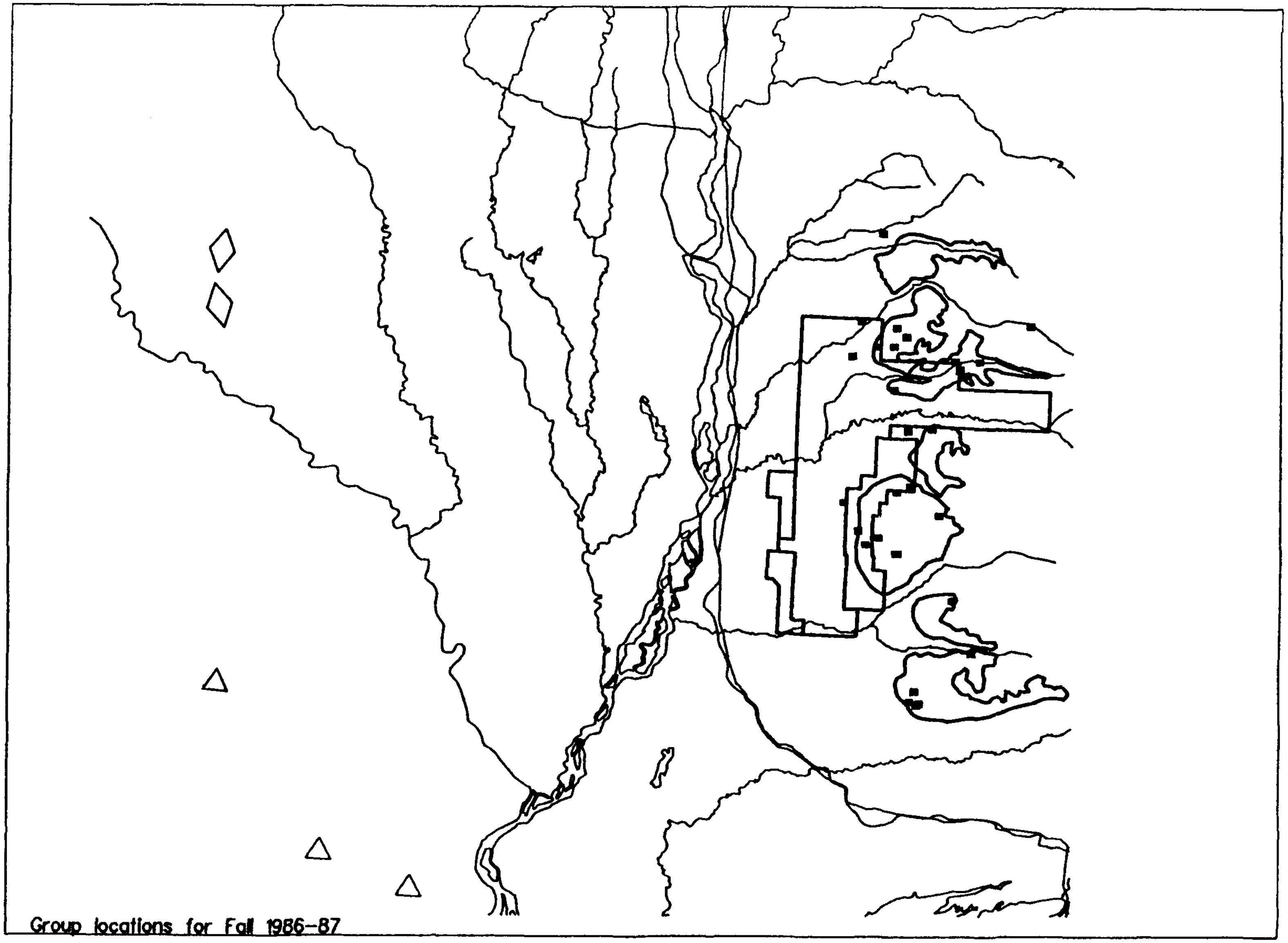

Fig. 33. Fall (28 October-25 November) point locations from moose radio-marked in alpine habitat postrut areas in the western foothills of the Talkeetna Mountains in southcentral Alaska, 1986. Alpine habitat postrut areas, Willow Mountain Critical Habitat, and the Kashwitna Corridor Forest are delineated (see Fig. 6).

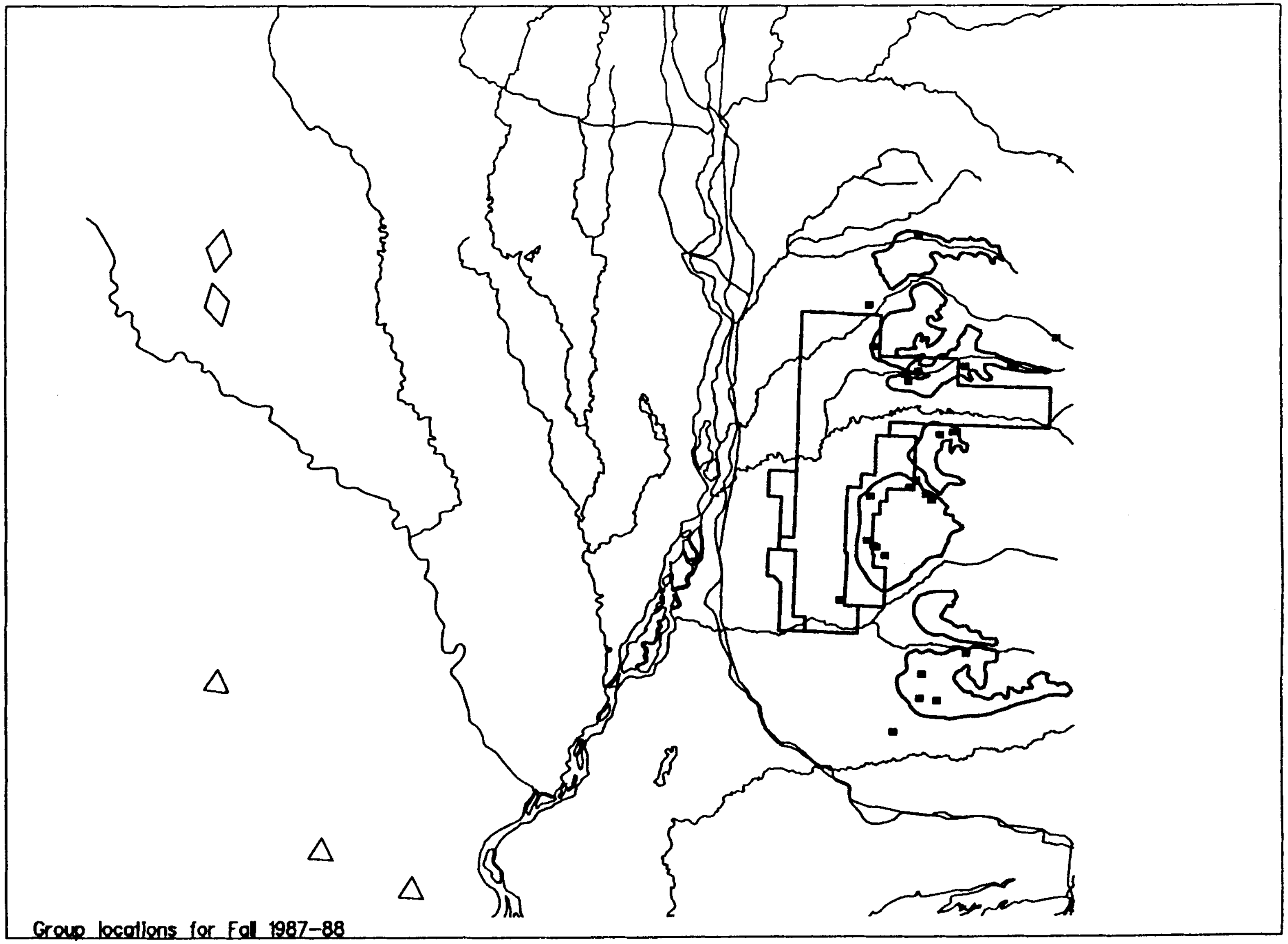

Fig. 34. Fall (28 October-25 November) point locations from moose radio-marked in alpine habitat postrut areas in the western foothills of the Talkeetna Mountains in southcentral Alaska, 1987. Alpine habitat postrut areas, Willow mountain Critical Habitat, and the Kashwitna Corridor forest are delineated (see Fig. 6).

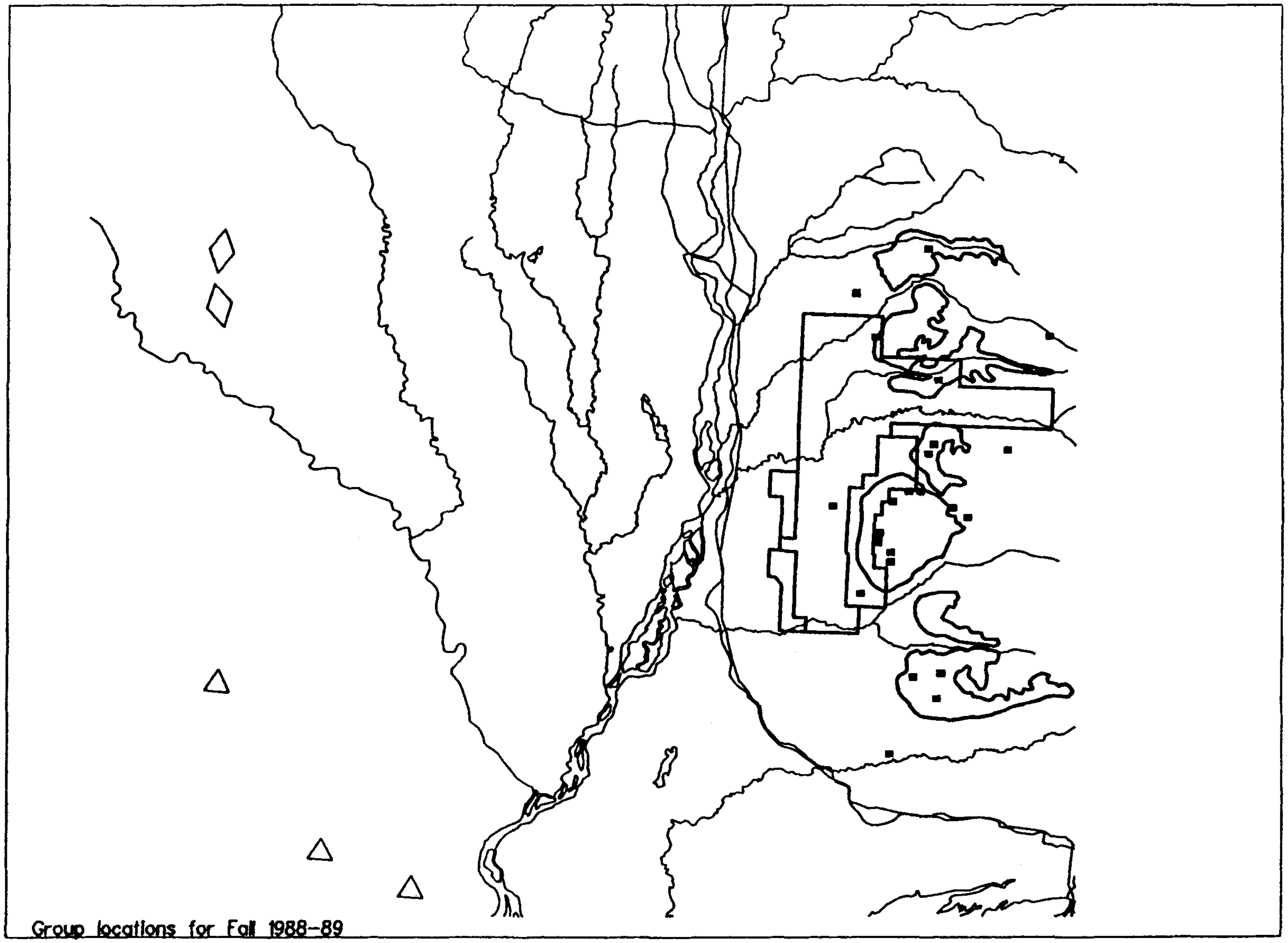

Fig. 35. Fall (28 October-25 November) point locations from moose radio-marked in alpine habitat postrut areas in the western foothills of the Talkeetna Mountains in southcentral Alaska, 1988. Alpine habitat postrut areas, Willow mountain Critical habitat, and the Kashwitna Corridor Forest are delineated (see Fig. 6).

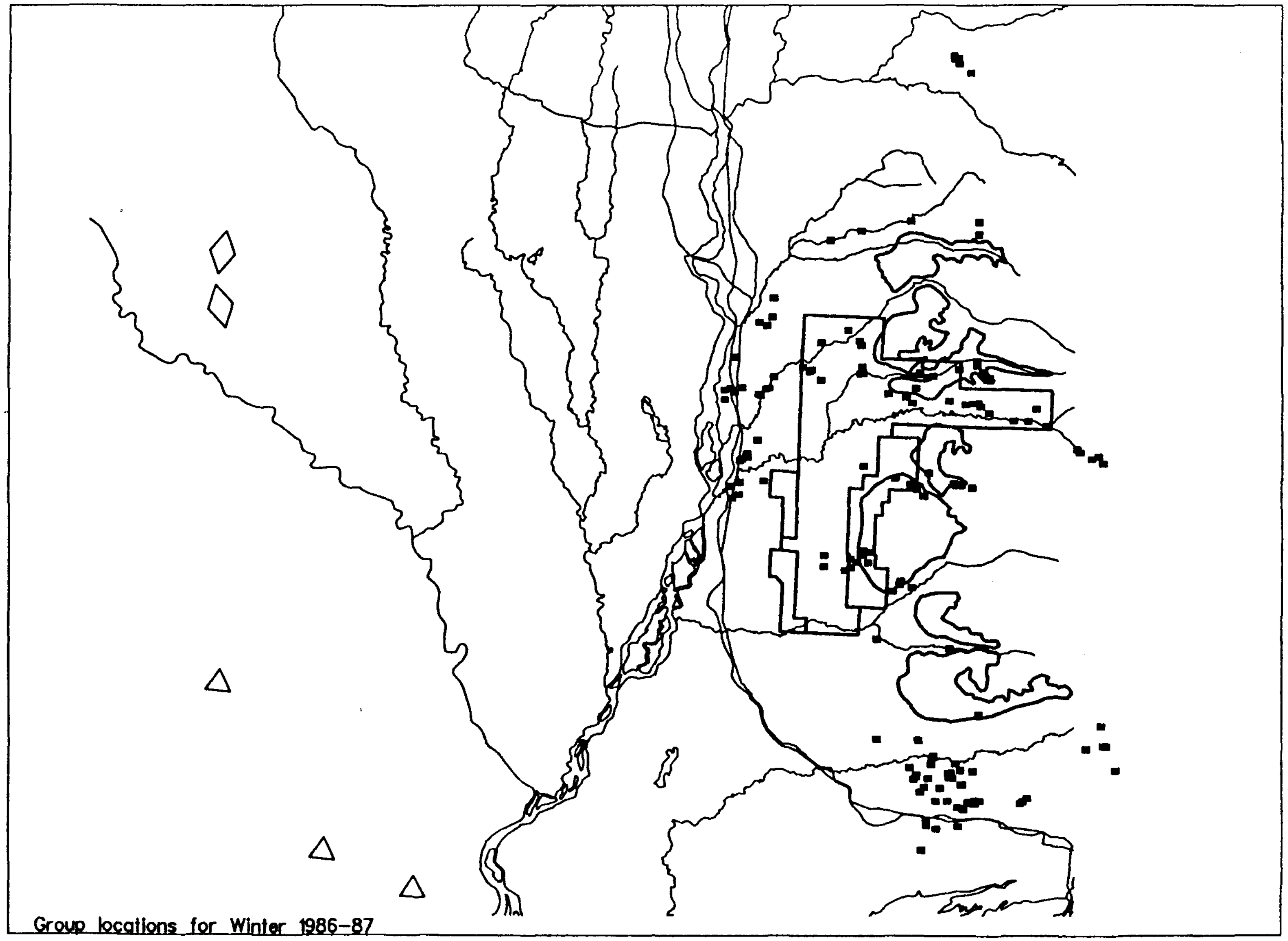

Fig. 36. Winter (20 January-20 March) point locations from moose radio-marked in alpine habitat postrut areas in the western foothills of the Talkeetna Mountains in southcentral Alaska, 1987. Alpine habitat postrut areas, Willow Mountain Critical habitat, and the Kashwitna Corridor Forest are delineated (see Fig. 6).

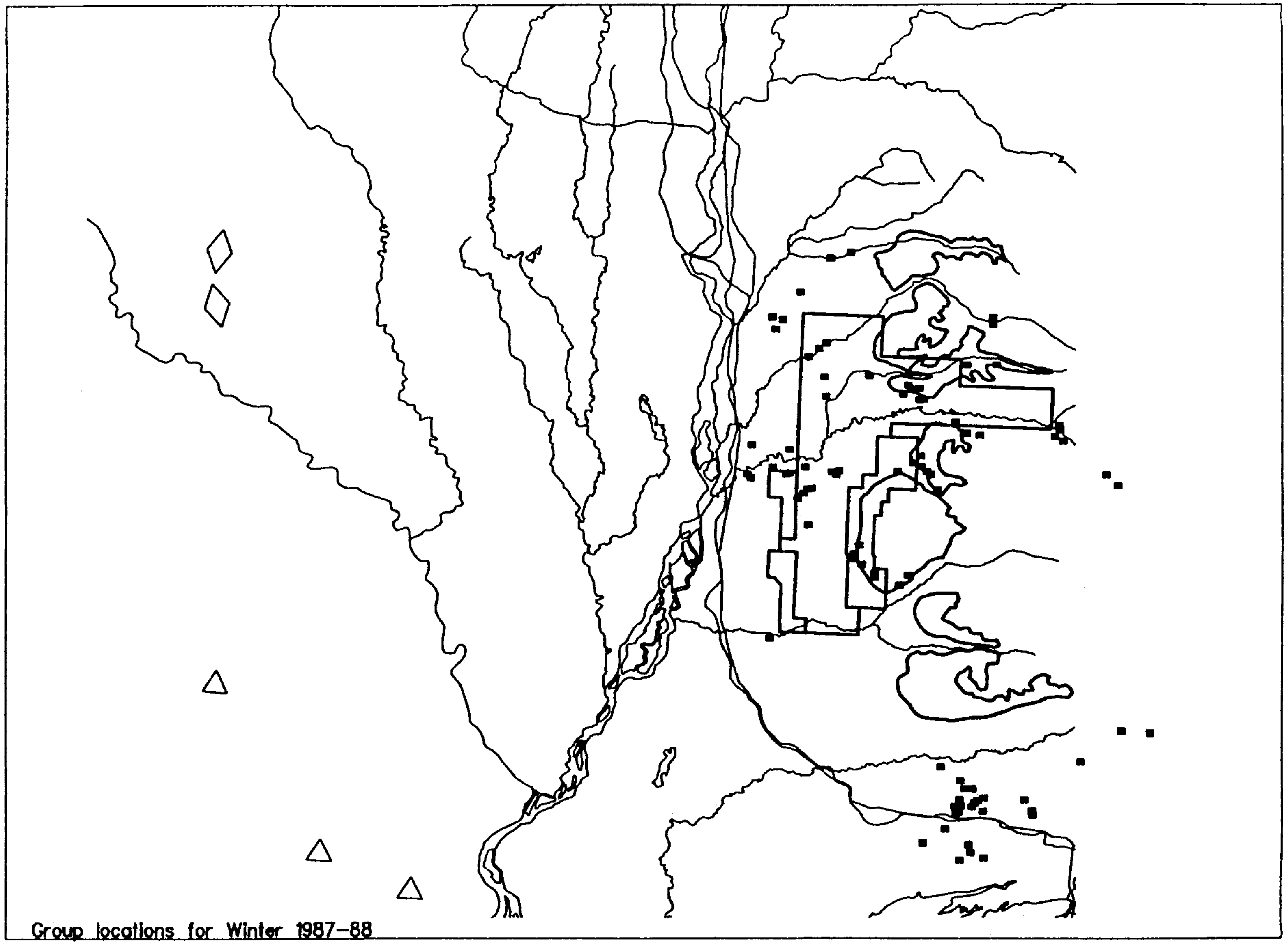

Fig. 37. Winter (20 January-20 March) point locations from moose radio-marked in alpine habitat postrut areas in the western foothills of the Talkeetna Mountains in southcentral Alaska, 1988. Alpine habitat postrut areas, Willow Mountain Critical Habitat, and the Kashwitna Corridor Forest are delineated (see Fig. 6).

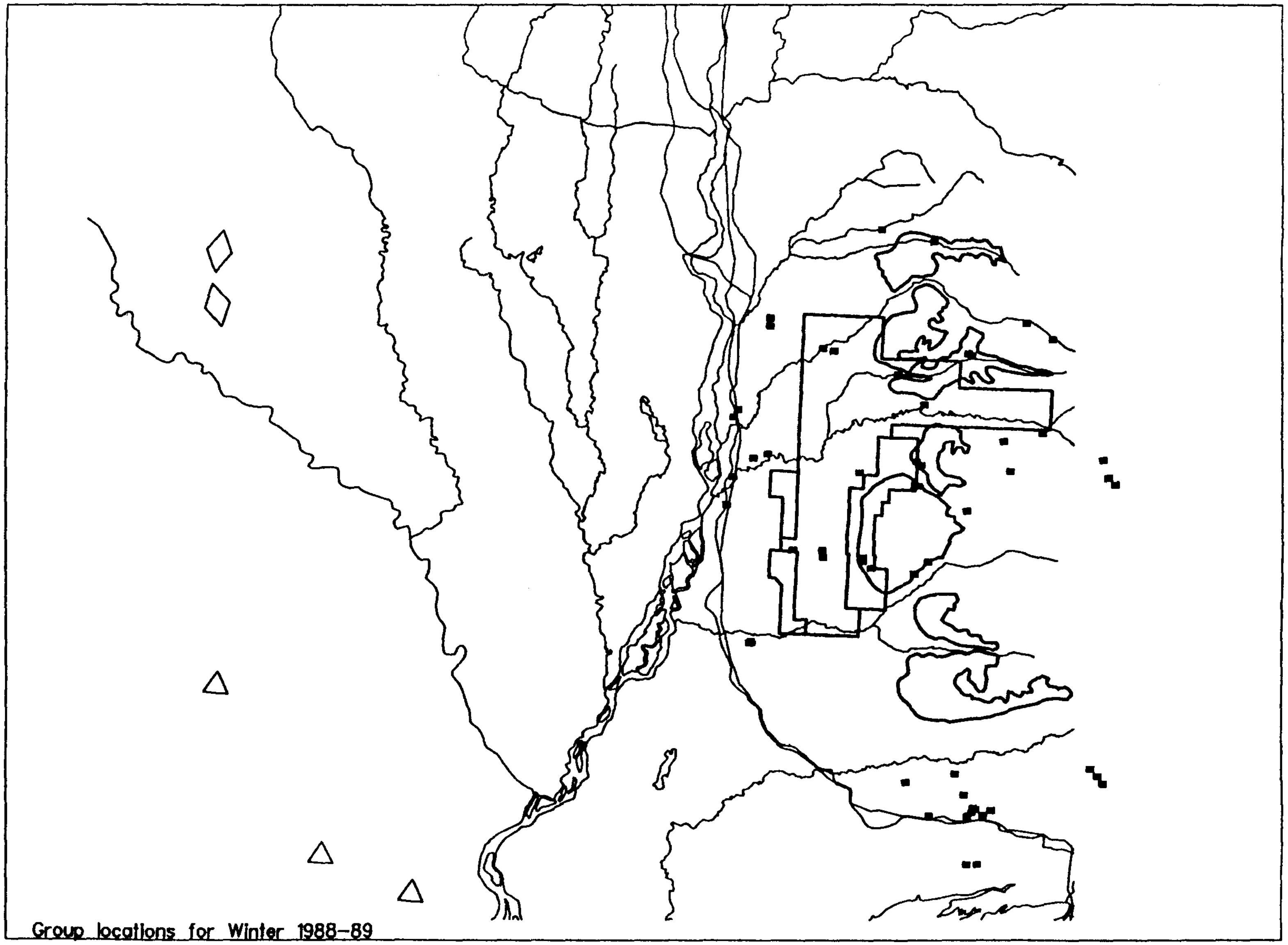

Fig. 38. Winter (20 January-20 March) point locations form moose radio-marked in alpine habitat postrut areas in the western foothills of the Talkeetna Mountains in southcentral Alaska, 1989. Alpine habitat postrut areas, Willow Mountain Critical habitat, and the Kashwitna Corridor Forest are delineated (see Fig. 6).

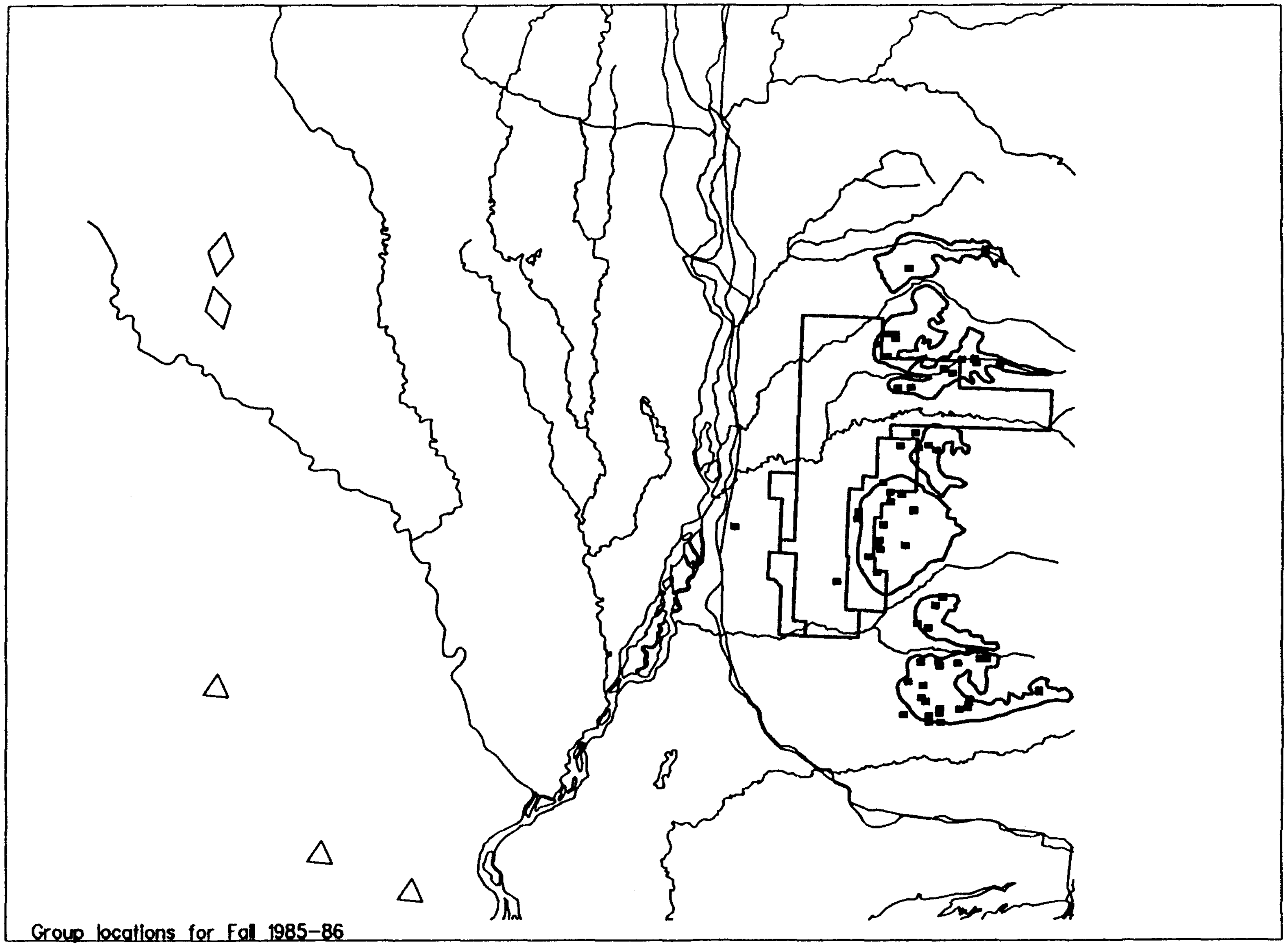

Fig. 39. Fall (23 December-7 January) point locations from moose radio-marked in alpine habitat postrut areas in the western foothills of the Talkeetna Mountains in southcentral Alaska, 1985-86. Alpine habitat postrut areas, Willow Mountain Critical Habitat, and the Kashwitna Corridor Forest are delineated (see Fig. 6).

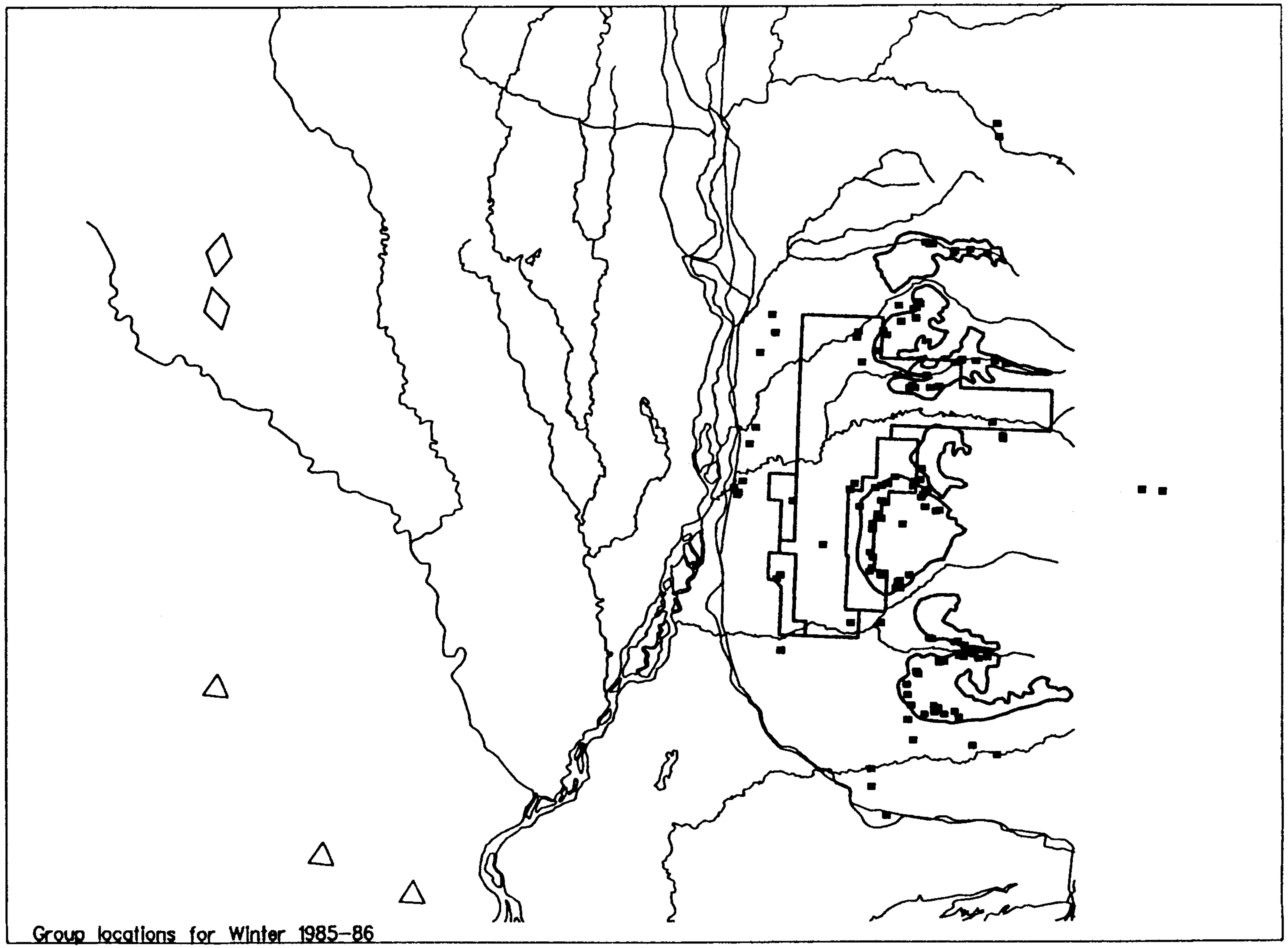

Fig. 40. Winter (20 January-20 March) point locations from moose radio-marked in alpine habitat postrut areas in the western foothills of the Talkeetna Mountains in southcentral Alaska, 1986. Alpine habitat postrut areas, Willow Mountain Critical Habitat, and the Kashwitna Corridor forest are delineated (see Fig. 6).

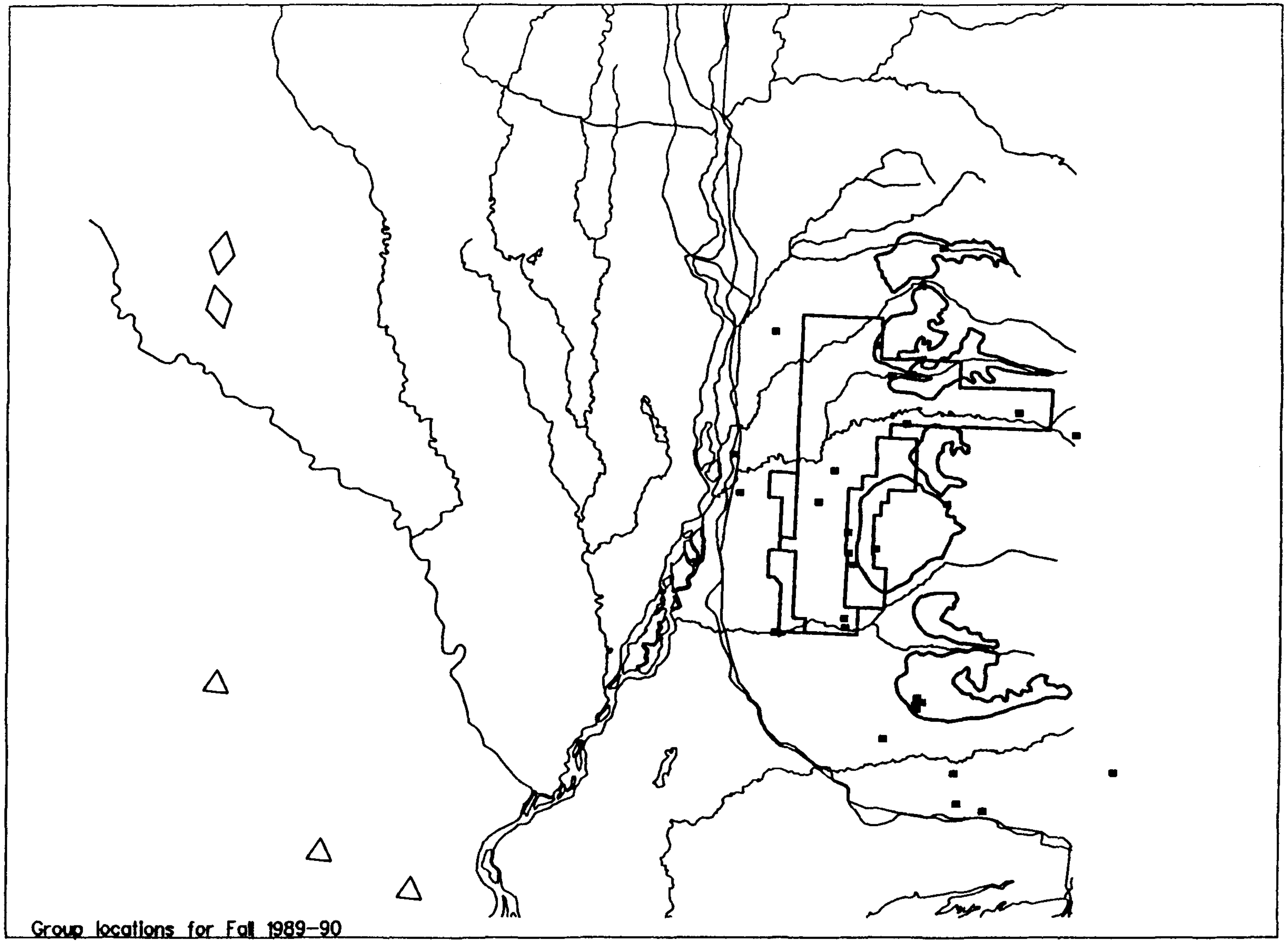

Fig. 41. Fall (28 October-25 November) point locations from moose radio-marked in alpine habitat postrut areas in the western foothills of the Talkeetna Mountains in southcentral Alaska, 1989. Alpine habitat postrut areas, willow Mountain Critical habitat, and the Kashwitna Corridor Forest are delineated (see Fig. 6).

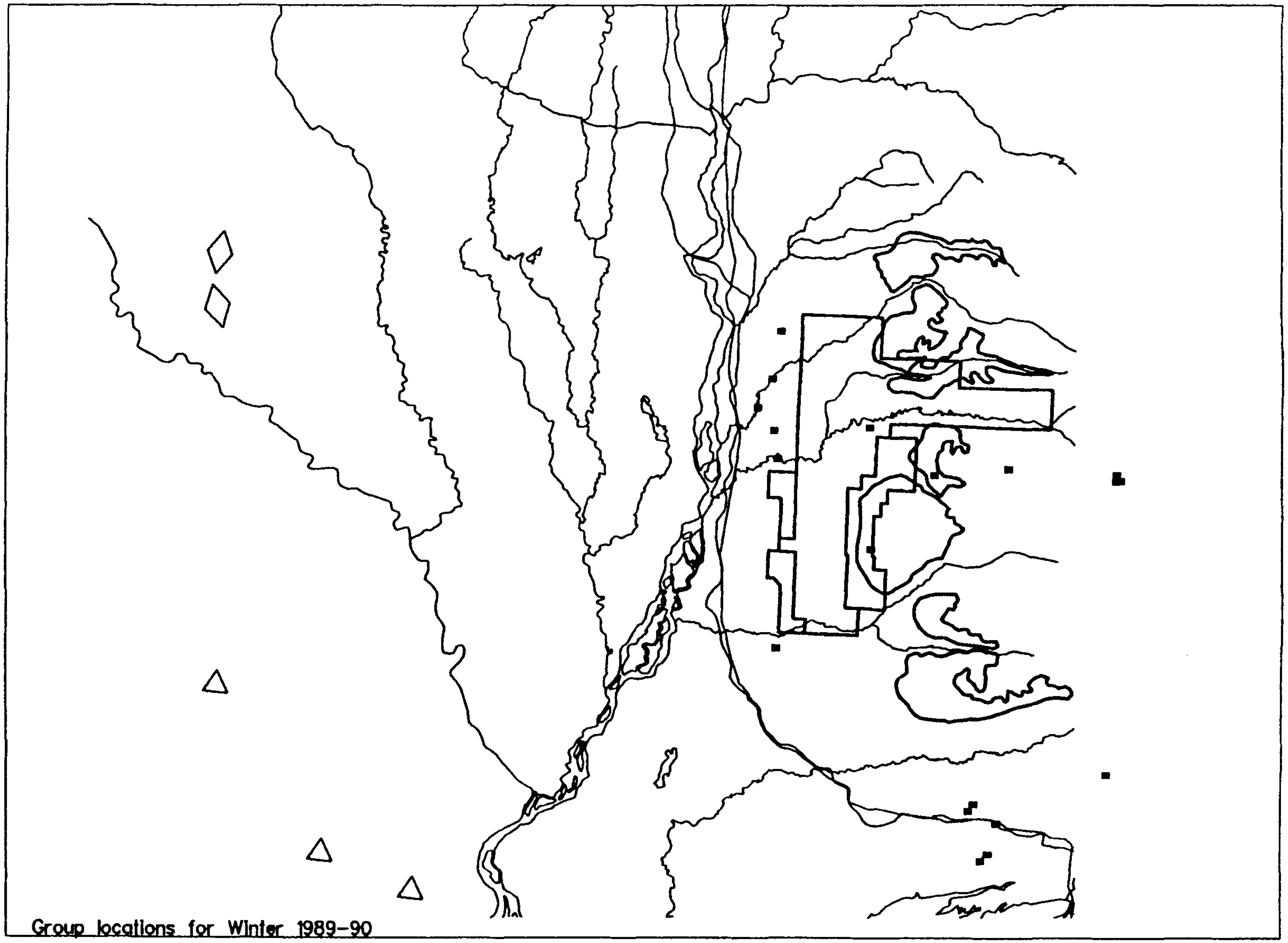

Fig. 42. Winter (20 January-20 March) point locations from moose radio-marked in alpine habitat postrut areas in the western foothills of the Talkeetna Mountains in southcentral Alaska, 1990. Alpine habitat postrut areas, Willow Mountain Critical habitat, and the Kashwitna Corridor Forest are delineated (see Fig. 6).

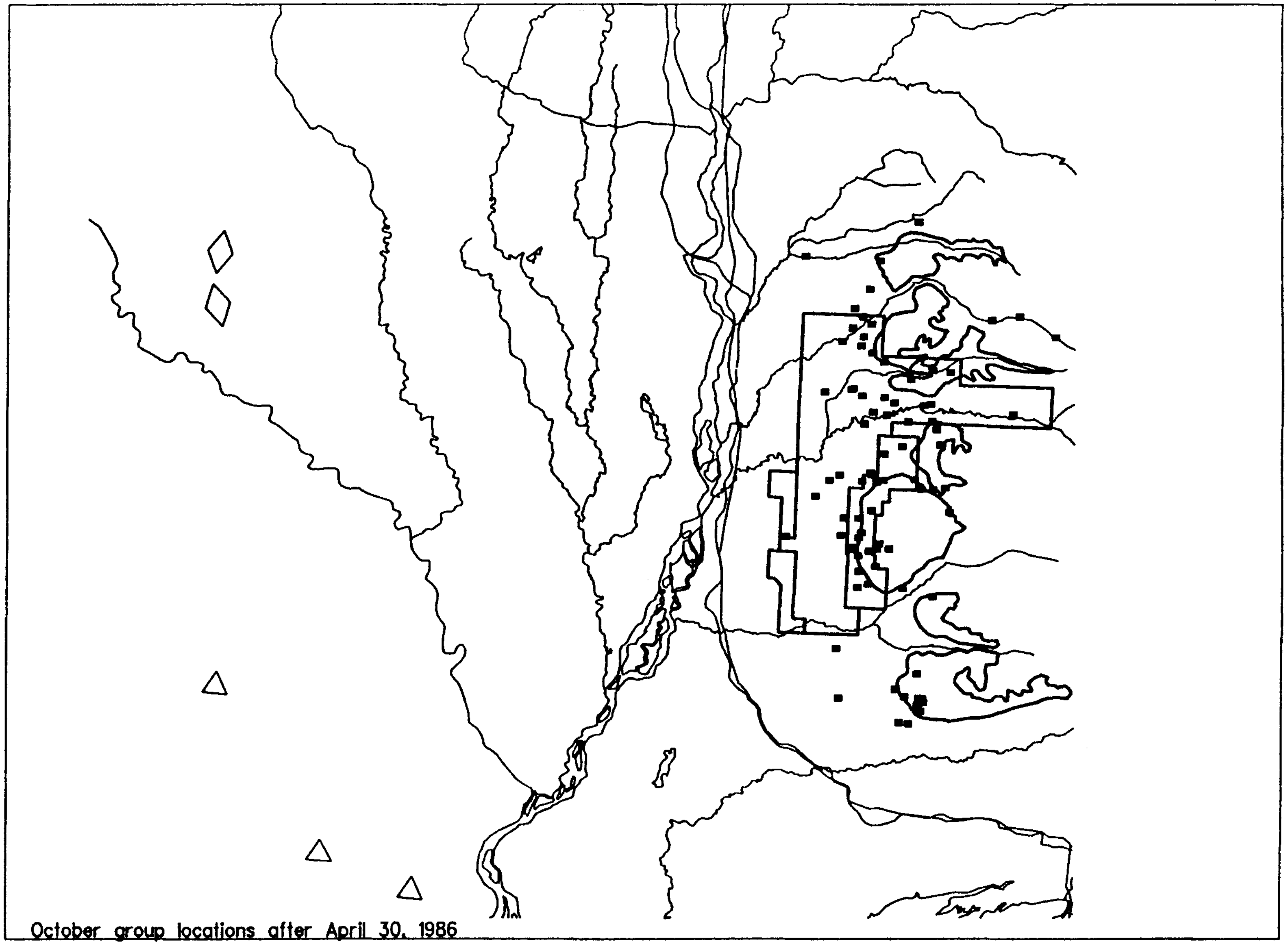

Fig. 43. October point locations from moose radio-marked in alpine habitat postrut areas in the western foothills of the Talkeetna Mountains in southcentral Alaska, 1986-89 . Alpine habitat postrut areas, Willow Mountain Critical Habitat, and the Kashwitna Corridor Forest are delineated (see Fig. 6).

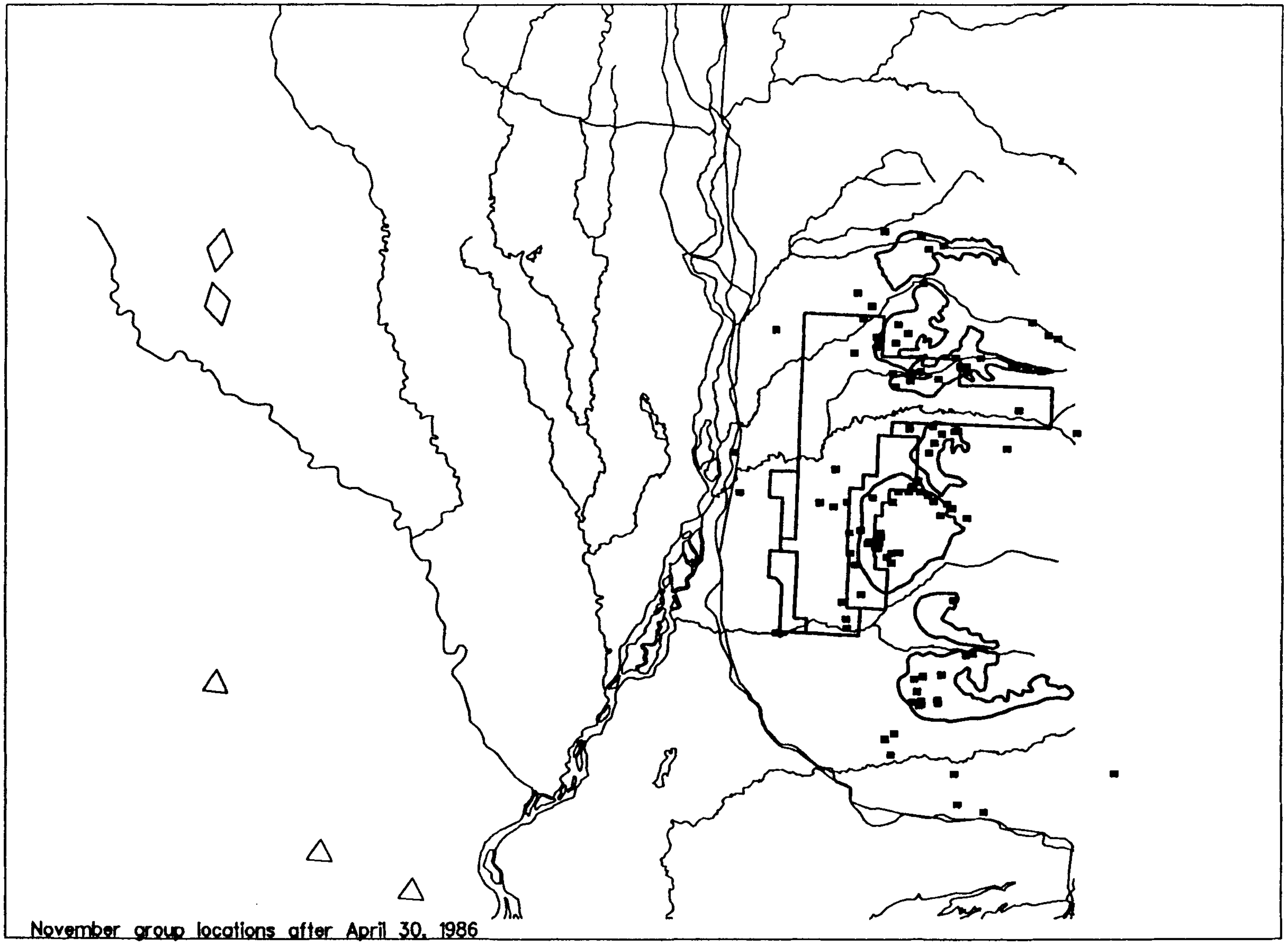

Fig. 44, November point locations from moose radio-marked in alpine habitat postrut areas in the western foothills of the Talkeetna Mountains in southcentral Alaska, 1986-89. Alpine habitat postrut areas, Willow Mountain Critical Habitat, and the Kashwitna Corridor Forest lands are delineated (see Fig. 6).

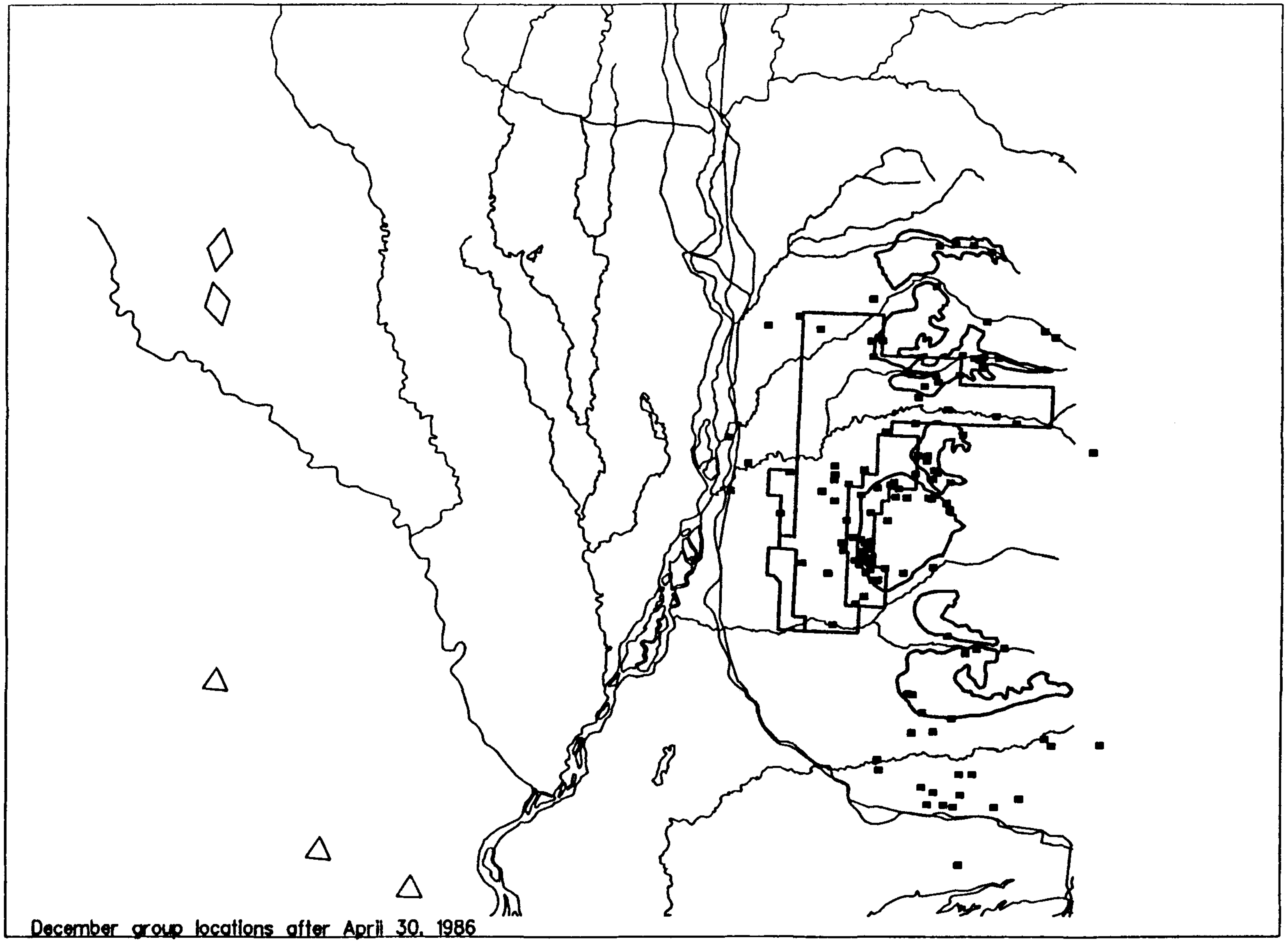

Fig. 45. December point locations from moose radio-marked in alpine habitat postrut areas in the western foothills of the Talkeetna Mountains in southcentral Alaska, 1986-89. Alpine habitat postrut areas, Willow Mountain Critical Habitat, and the Kashwitna Corridor Forest lands are delineated (see Fig. 6).

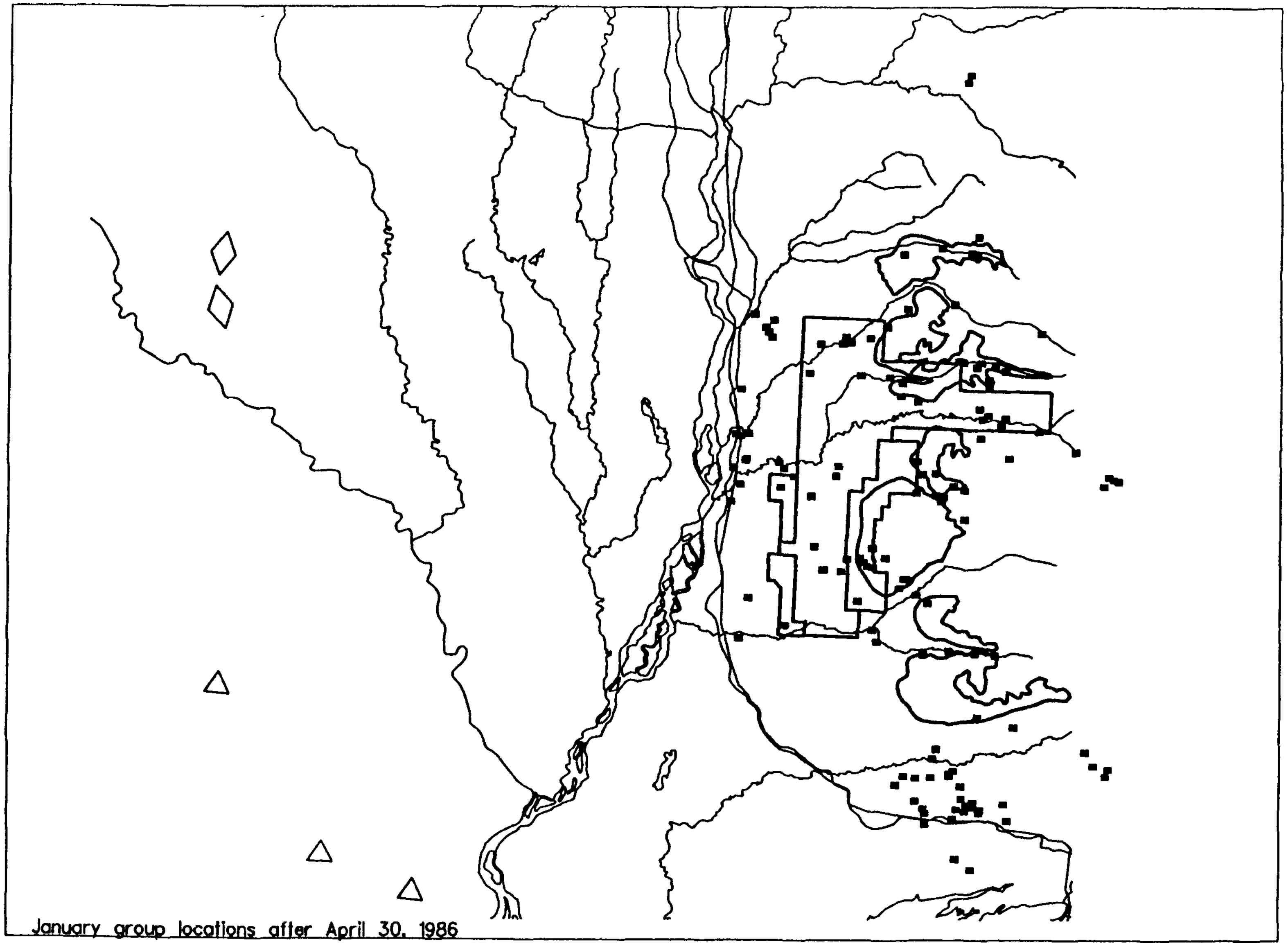

Fig. 46. January point locations from moose radio-marked in alpine habitat postrut areas in the western foothills of the Talkeetna Mountains in southcentral Alaska, 1987-90. alpine habitat postrut areas, Willow Mountain Critical Habitat, and the Kashwitna Corridor forest lands are delineated (see Fig. 6).

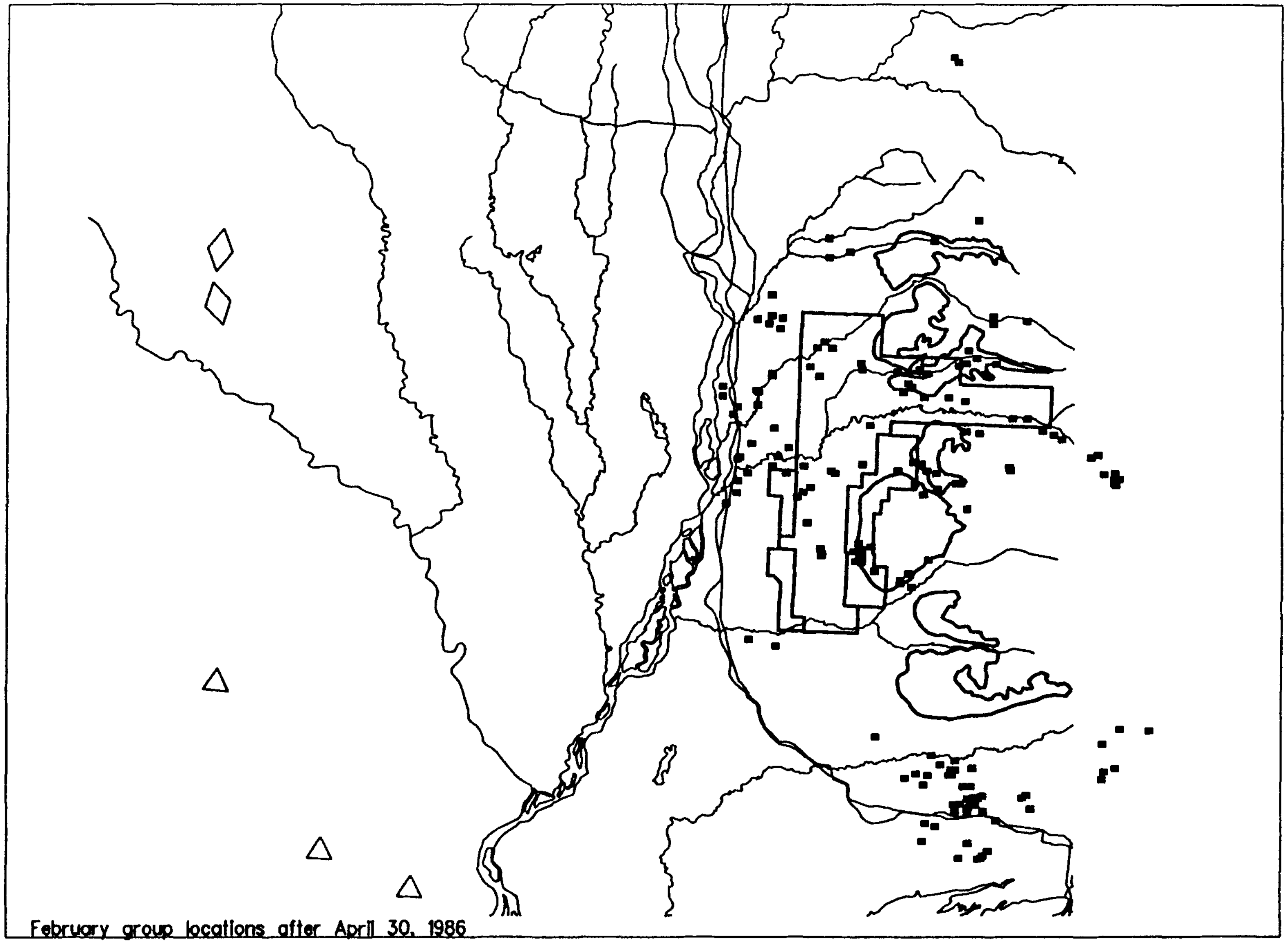

Fig. 47. February point locations from moose radio-marked in alpine habitat postrut areas in the western foothills of the Talkeetna Mountains in southcentral Alaska, 1987-90. Alpine habitat postrut areas, Willow Mountain Critical Habitat, and the Kashwitna Corridor Forest lands are delineated (see Fig. 6).

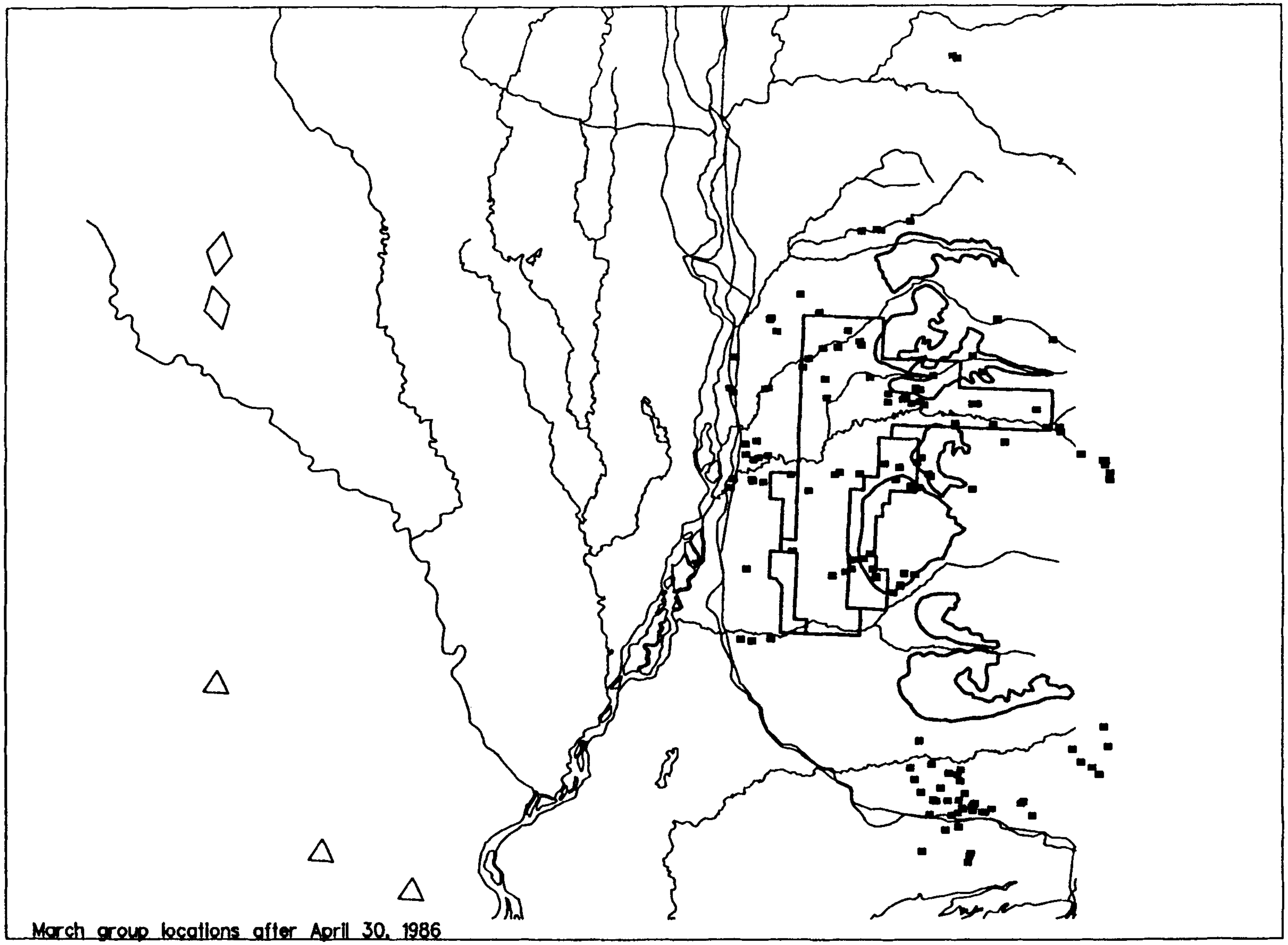

Fig. 48. March point locations from moose radio-marked in alpine habitat postrut areas in the western foothills of the Talkeetna Mountains in southcentral Alaska, 1987-89. Alpine habitat postrut areas, Willow Mountain Critical Habitat, and the Kashwitna Corridor Forest lands are delineated (see Fig. 6).

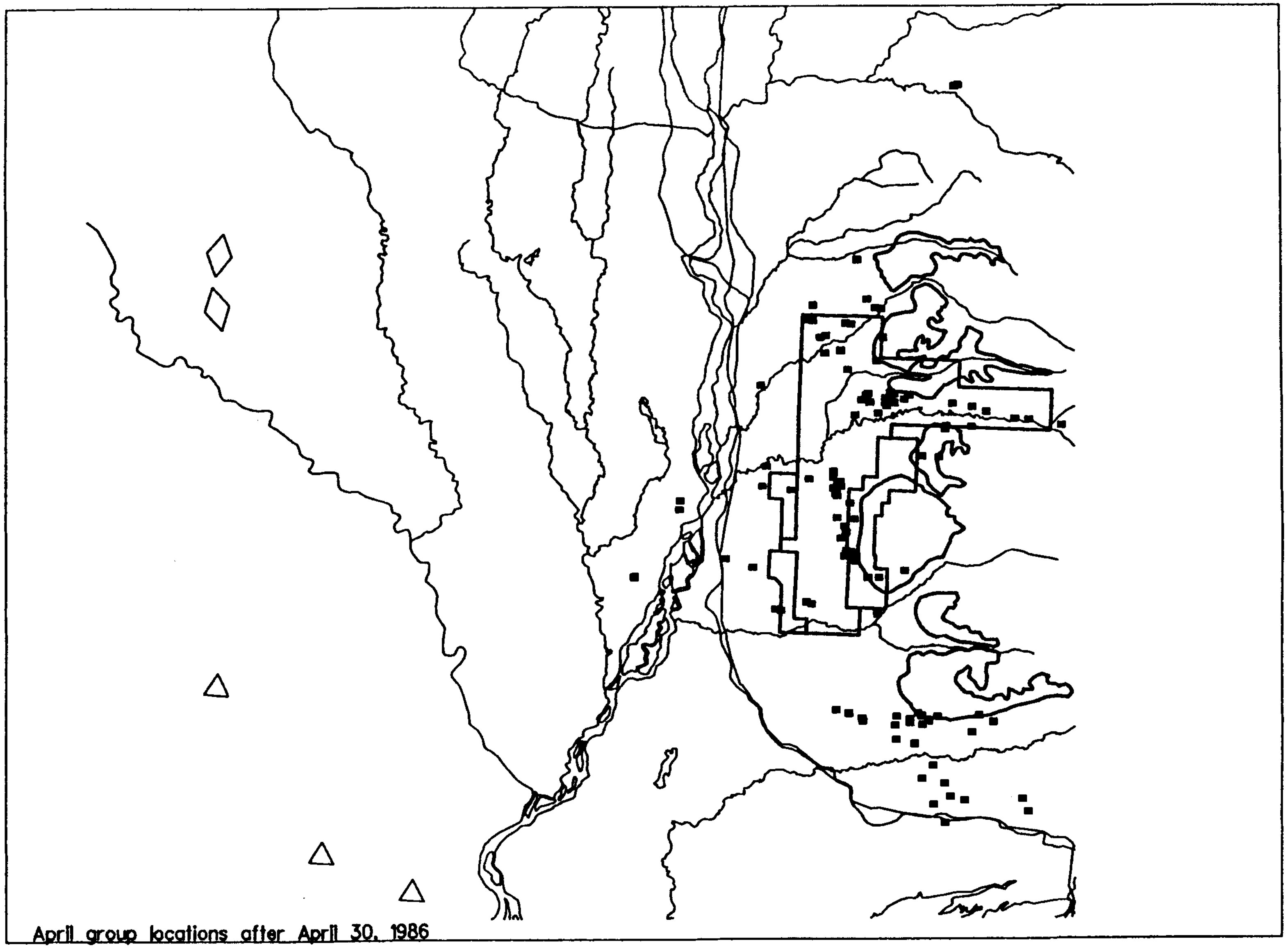

Fig. 49. April point locations from moose radio-marked in alpine habitat postrut areas in the western foothills of the Talkeetna Mountains in southcentral Alaska, 1987-89. Alpine habitat postrut areas, Willow Mountain Critical Habitat, and the Kashwitna Corridor Forest lands are delineated (see Fig. 6).

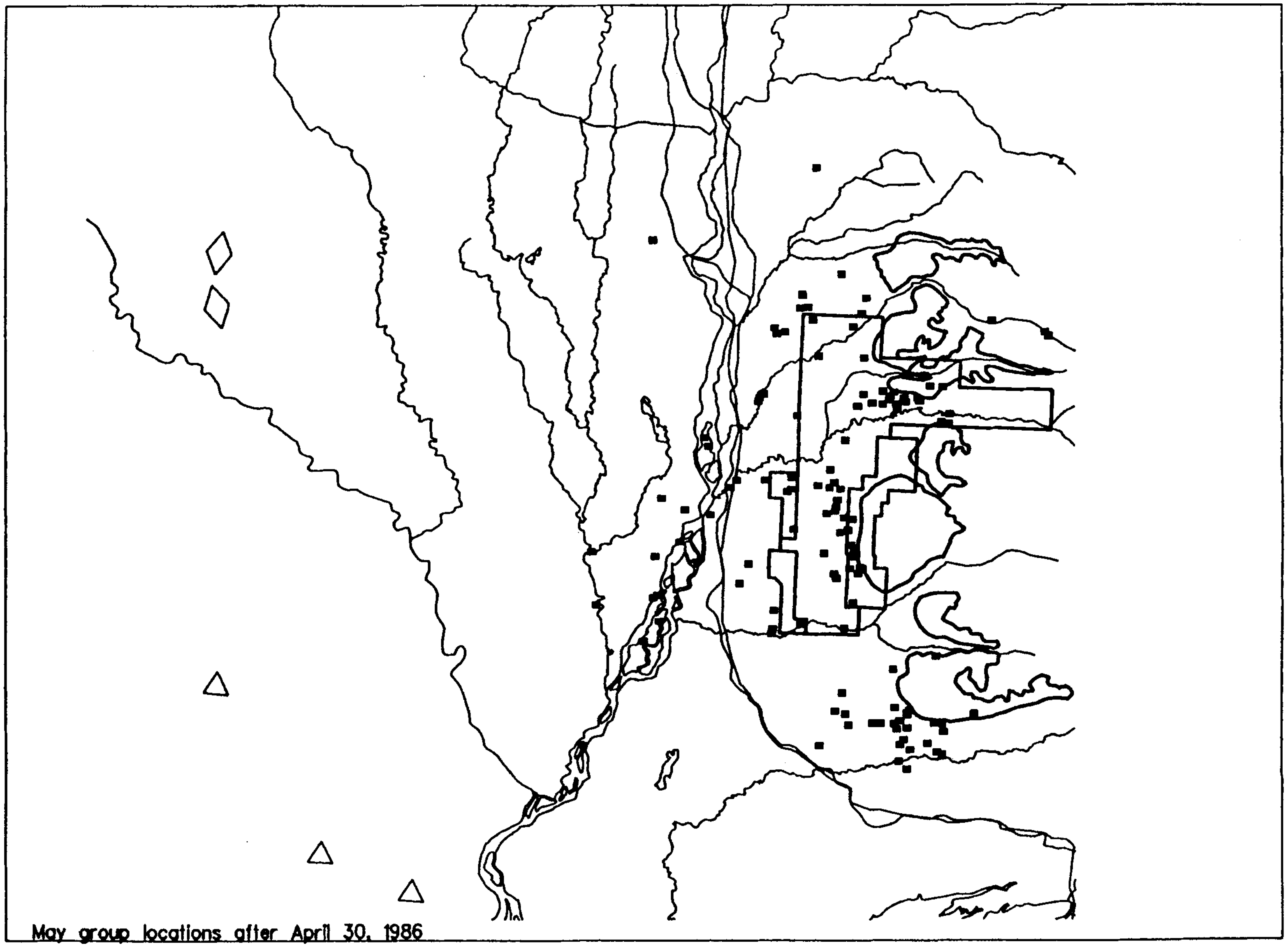

Fig. 50. May point locations from moose radio-marked in alpine habitat postrut areas in the western foothills of the Talkeetna Mountains in southcentral Alaska, 1986-89. Alpine habitat postrut areas, Willow Mountain Critical Habitat, and the Kashwitna Corridor forest lands are delineated (see Fig.6).

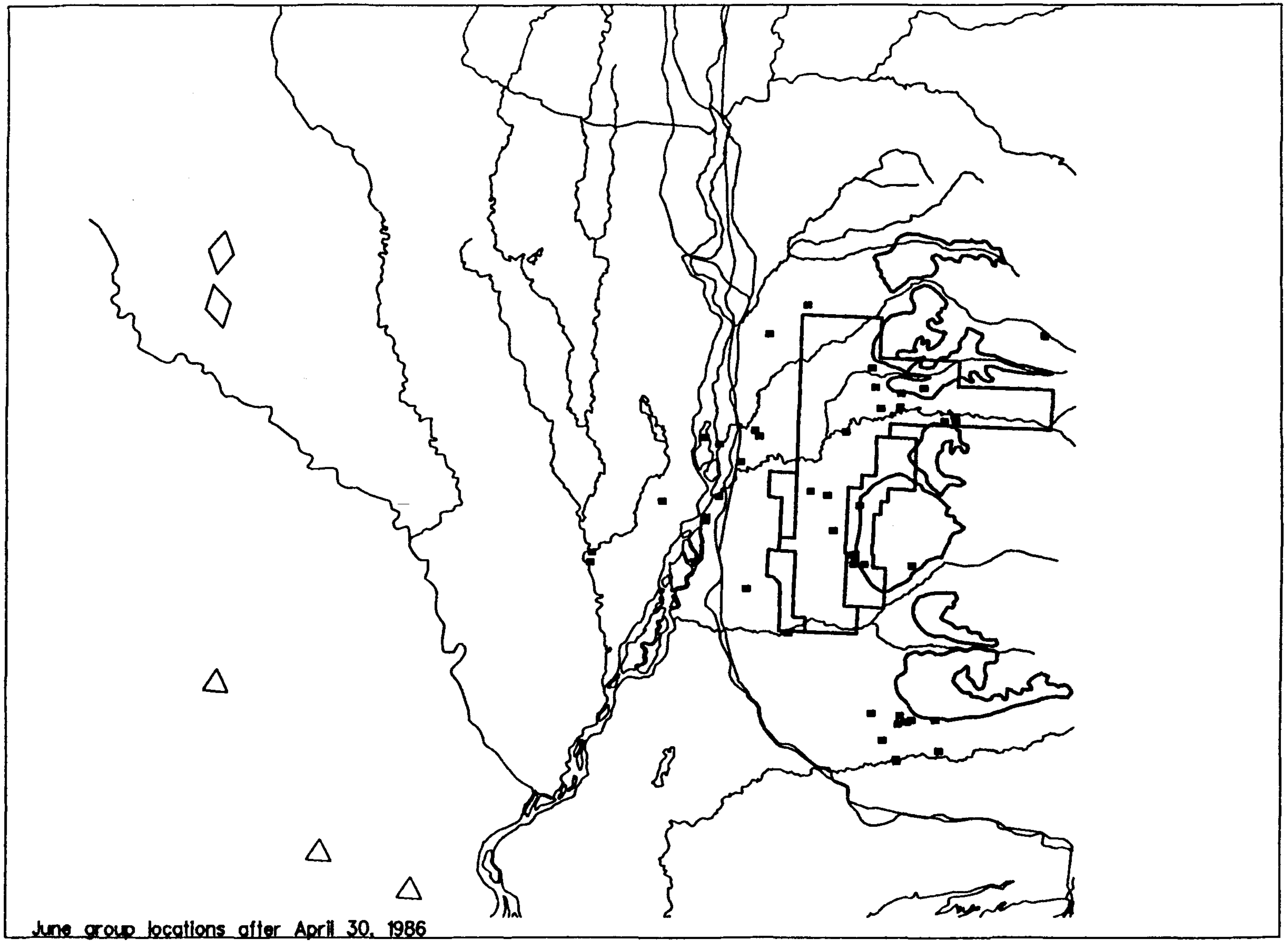

Fig. 51. June point locations from moose radio-marked in alpine habitat postrut areas in the western foothills of the Talkeetna Mountains in southcentral Alaska, 1986-89. Alpine habitat postrut areas, Willow Mountain Critical habitat, and the Kashwitna Corridor Forest lands are delineated (see Rig. 6).

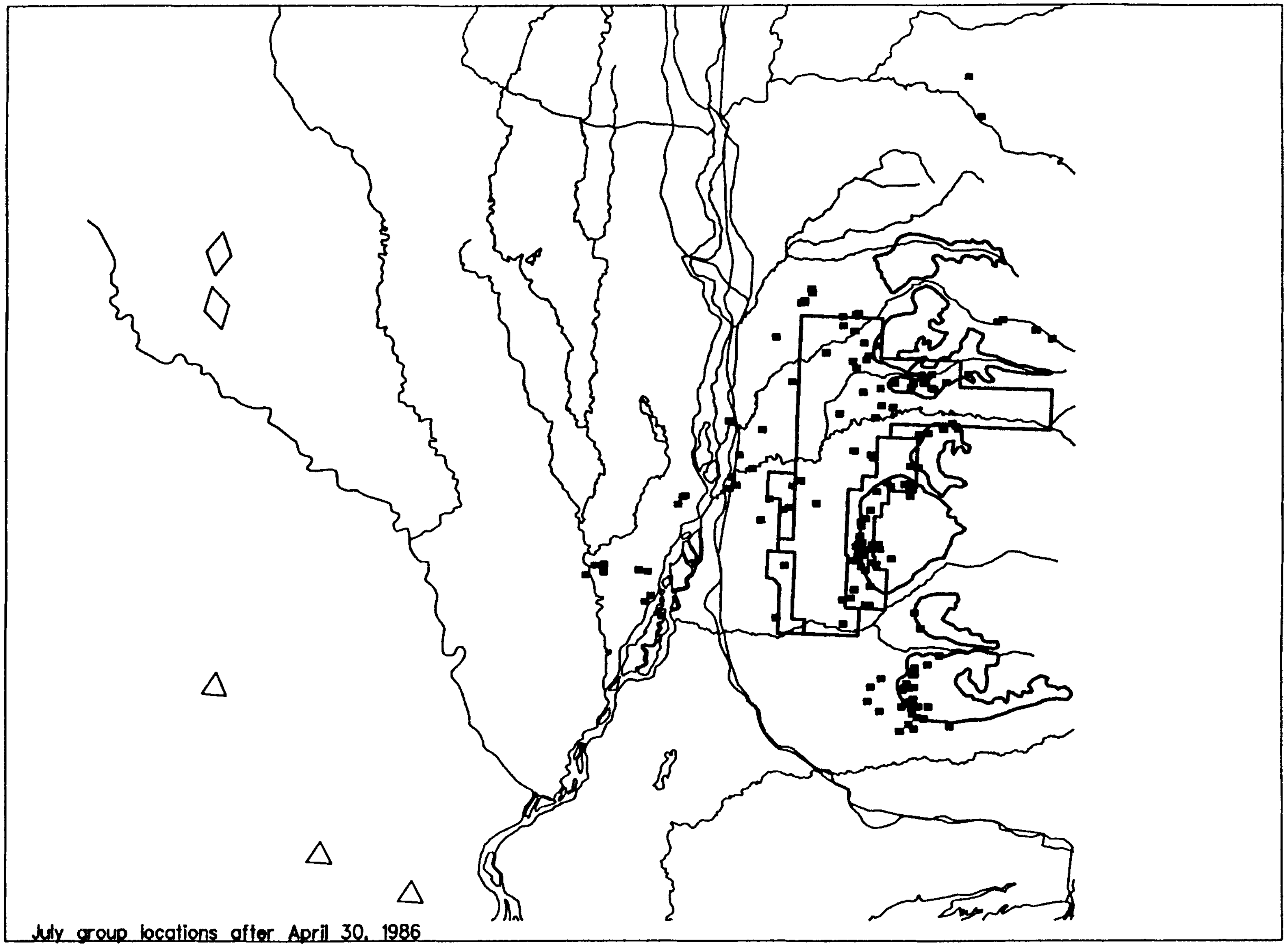

Fig. 52. July point locations from moose radio-marked in alpine habitat postrut areas in the western foothills of the Talkeetna Mountains in southcentral Alaska, 1986-89. Alpine habitat postrut areas, Willow Mountain Critical Habitat, and the Kashwitna Corridor Forest lands are delineated (see Fig. 6).

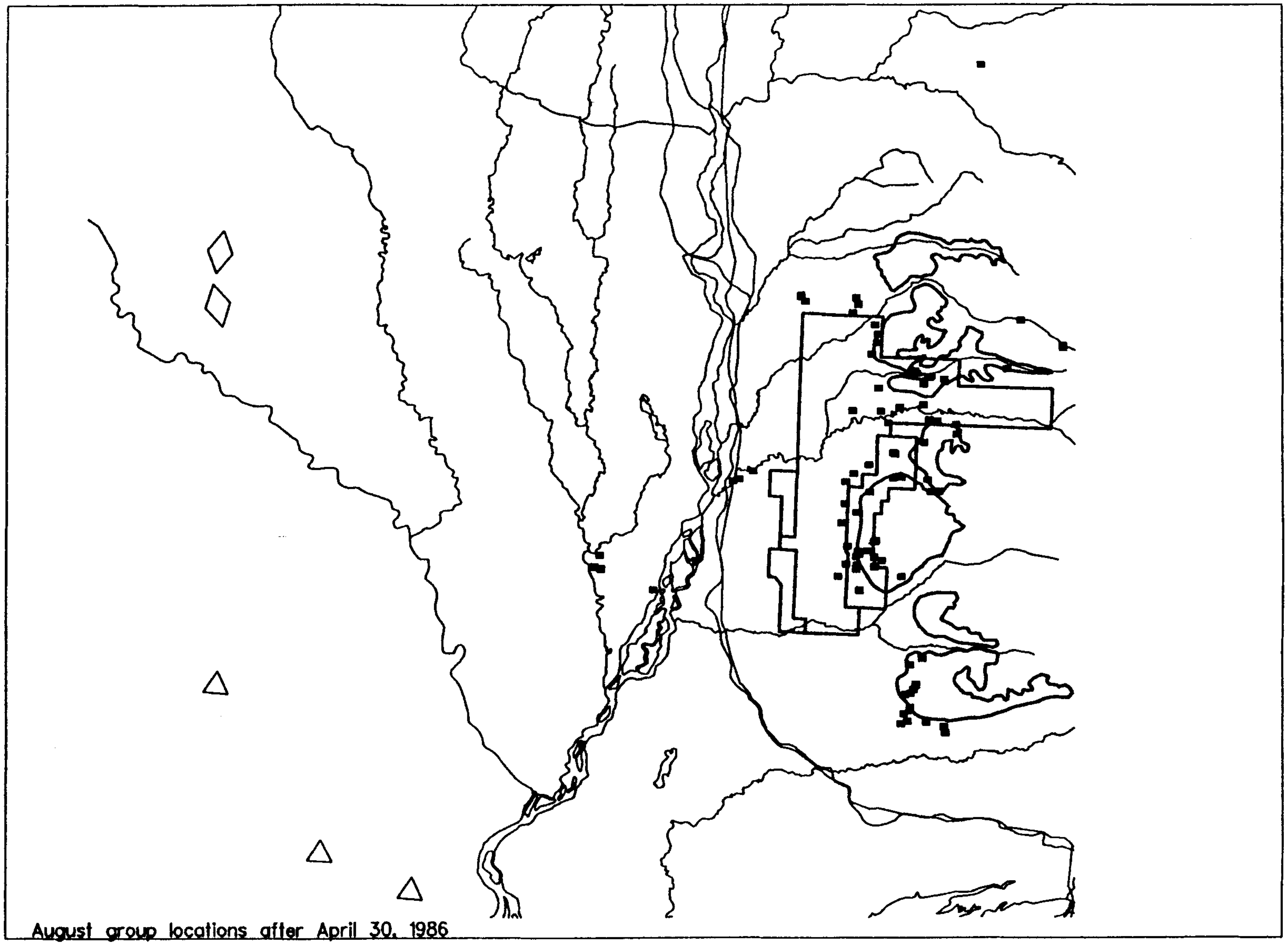

Fig. 53. August point locations from moose radio-marked in alpine habitat postrut areas in the western foothills of the Talkeetna Mountains in southcentral Alaska, 1986-89. alpine habitat postrut areas, Willow Mountain Critical Habitat, and the Kashwitna Corridor Forest lands are delineated (see Fig. 6).

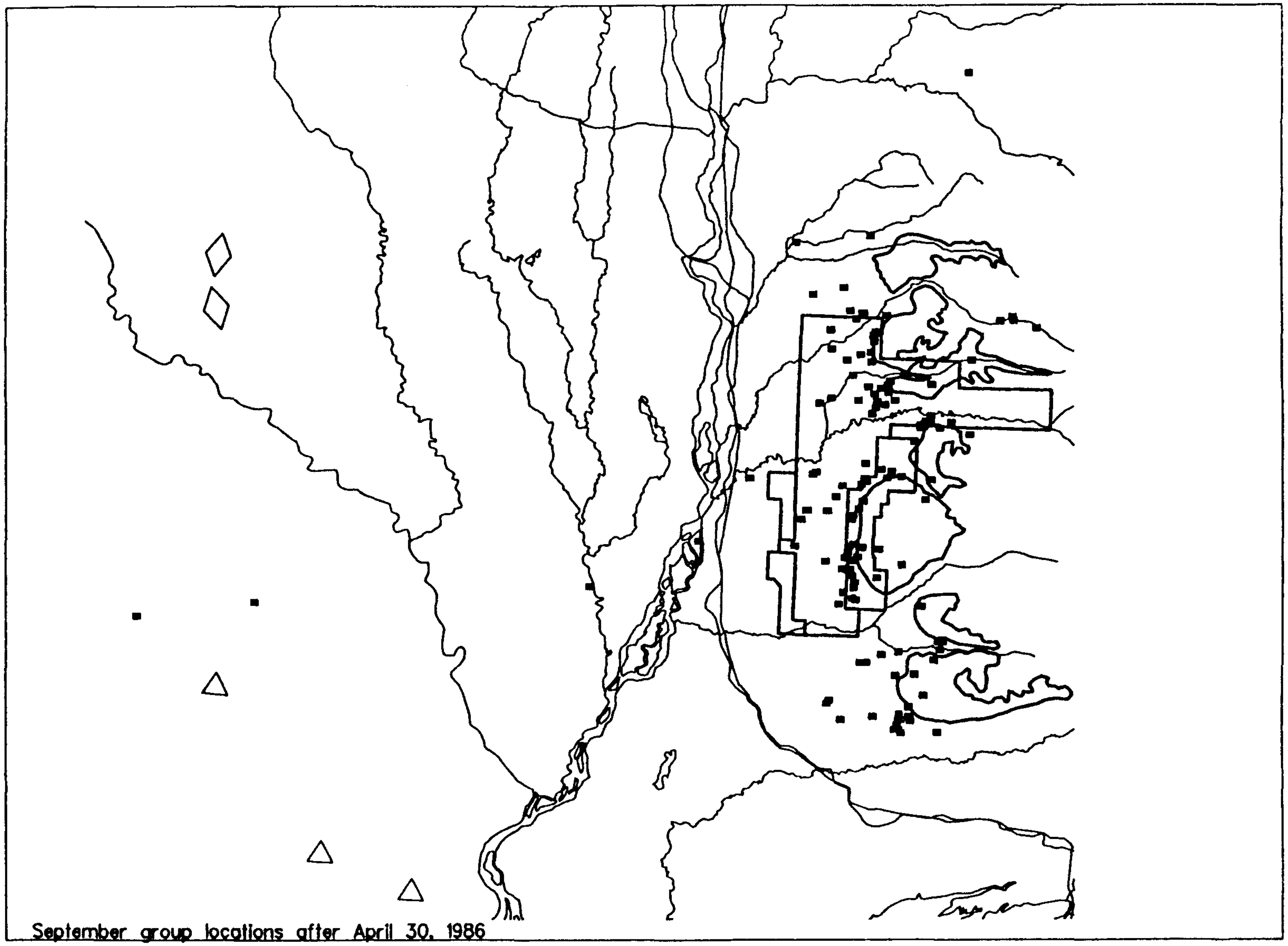

Fig. 54. September point locations form moose radio-marked in alpine habitat postrut areas in the western foothills of the Talkeetna Mountains in southcentral Alaska, 1986-89. Alpine habitat postrut areas, Willow Mountain Critical Habitat, and the Kashwitna corridor Forest lands are delineated (see Fig. 6).

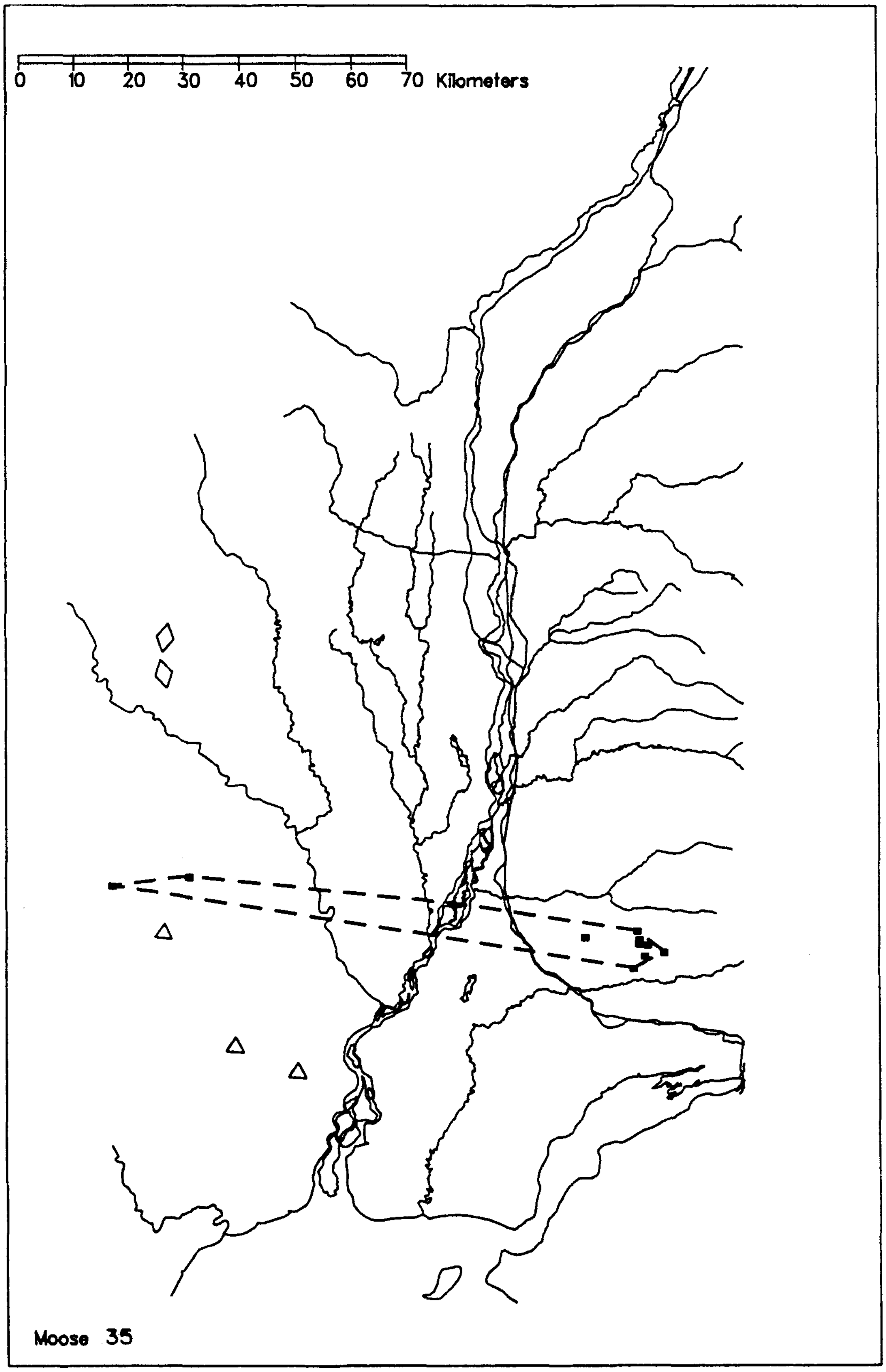

Fig. 55. Polygon encompassing point locations from a radio-marked moose (No. 35M) from the Bald Mountain postrut area that migrated across the boundary between Subunits 14A-16B in southcentral Alaska, 1985-86.

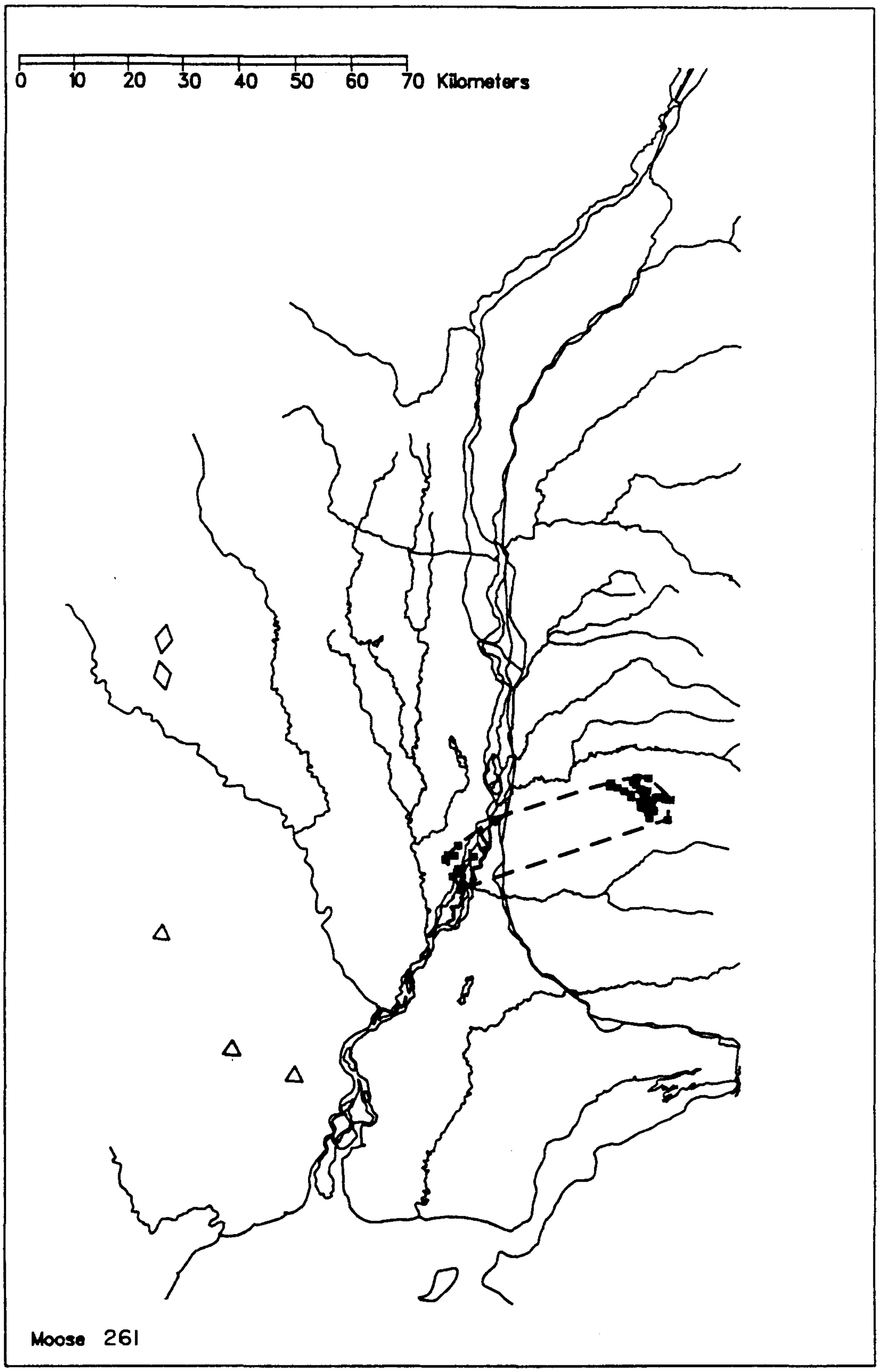

Fig. 56. Polygon encompassing point locations from a radio-marked moose (No. 261F) from the Willow Mountain postrut area that migrated across the boundary between Subunits 14B and 16A in southcentral Alaska, 1985-90.

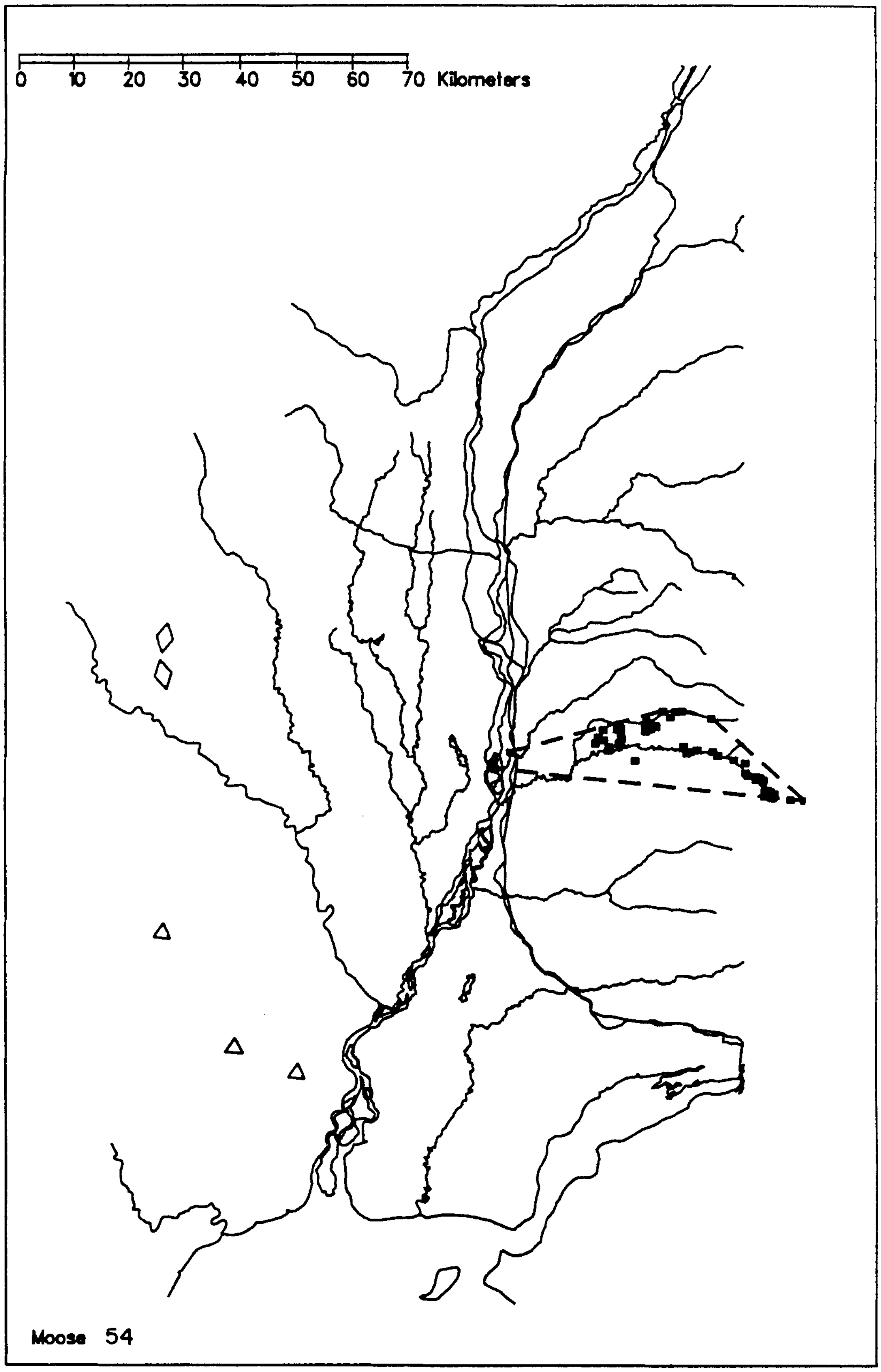

Fig. 57. Polygon encompassing point locations from a radio-marked moose (No. 54F) from the Brownie Mountain postrut area that migrated across the boundary between Subunits 14B and 16A boundary in southcentral Alaska, 1986-90.

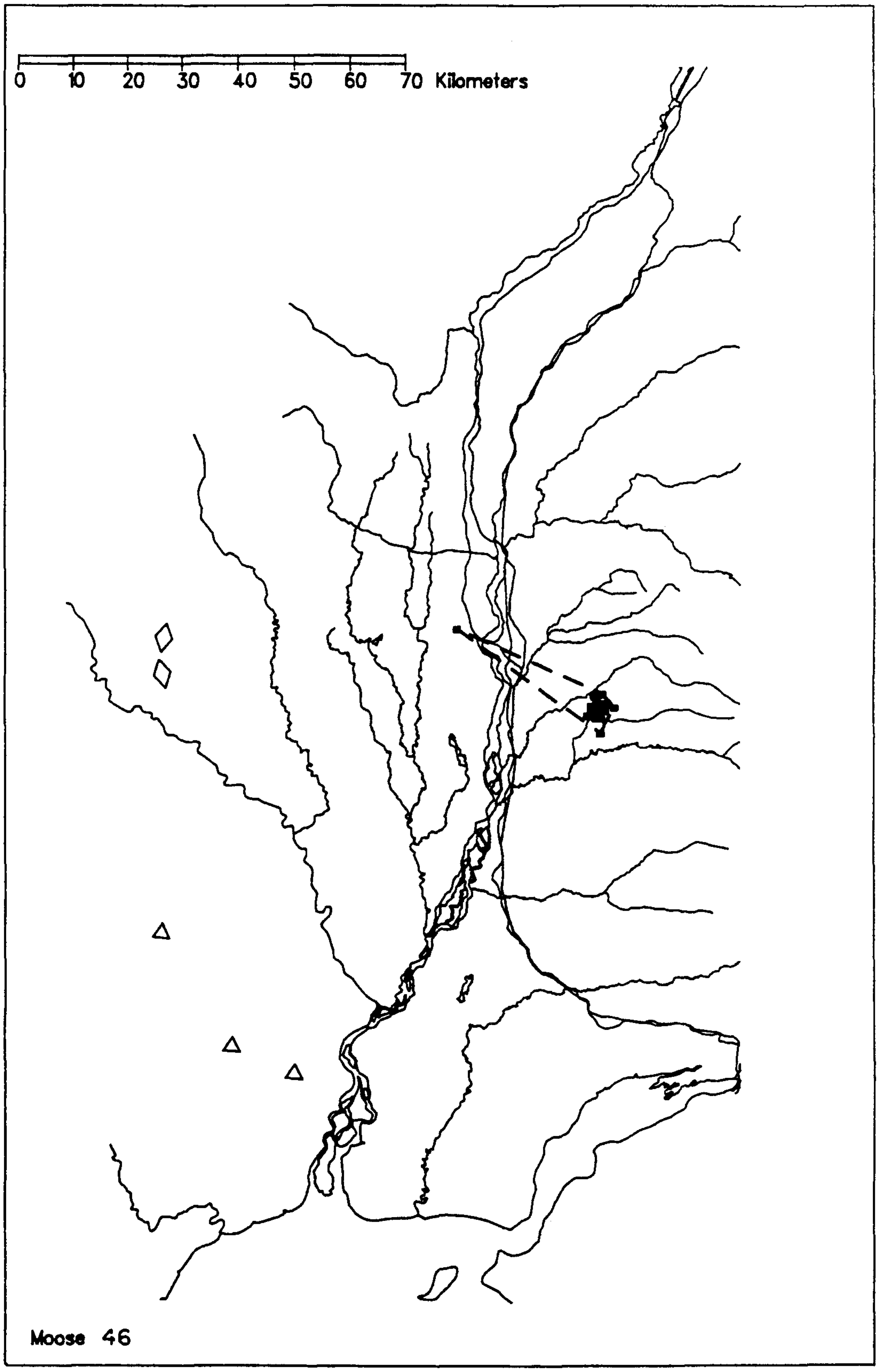

Fig. 58. Polygon encompassing point locations from a radio-marked moose (No. 46F) from the Wolverine Mountain postrut area that migrated across the boundary between Subunits 14B and 16A in southcentral Alaska, 1986-87.

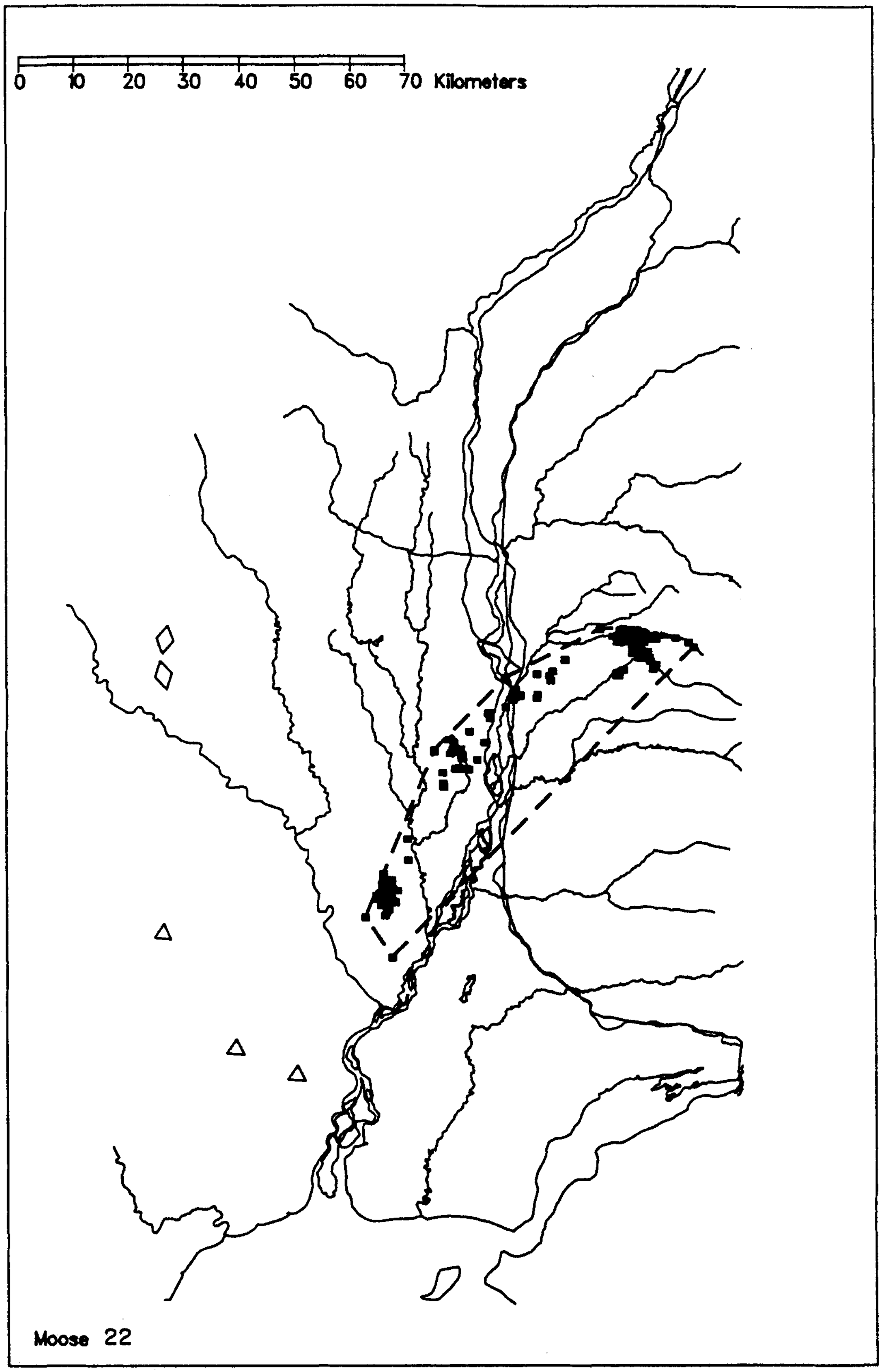

Fig. 59. Polygon encompassing point locations from a radio-marked moose (No. 22F) from the Sunshine Mountain postrut area that migrated across the boundary between Subunits 14A and 16B in southcentral Alaska, 1980-90.

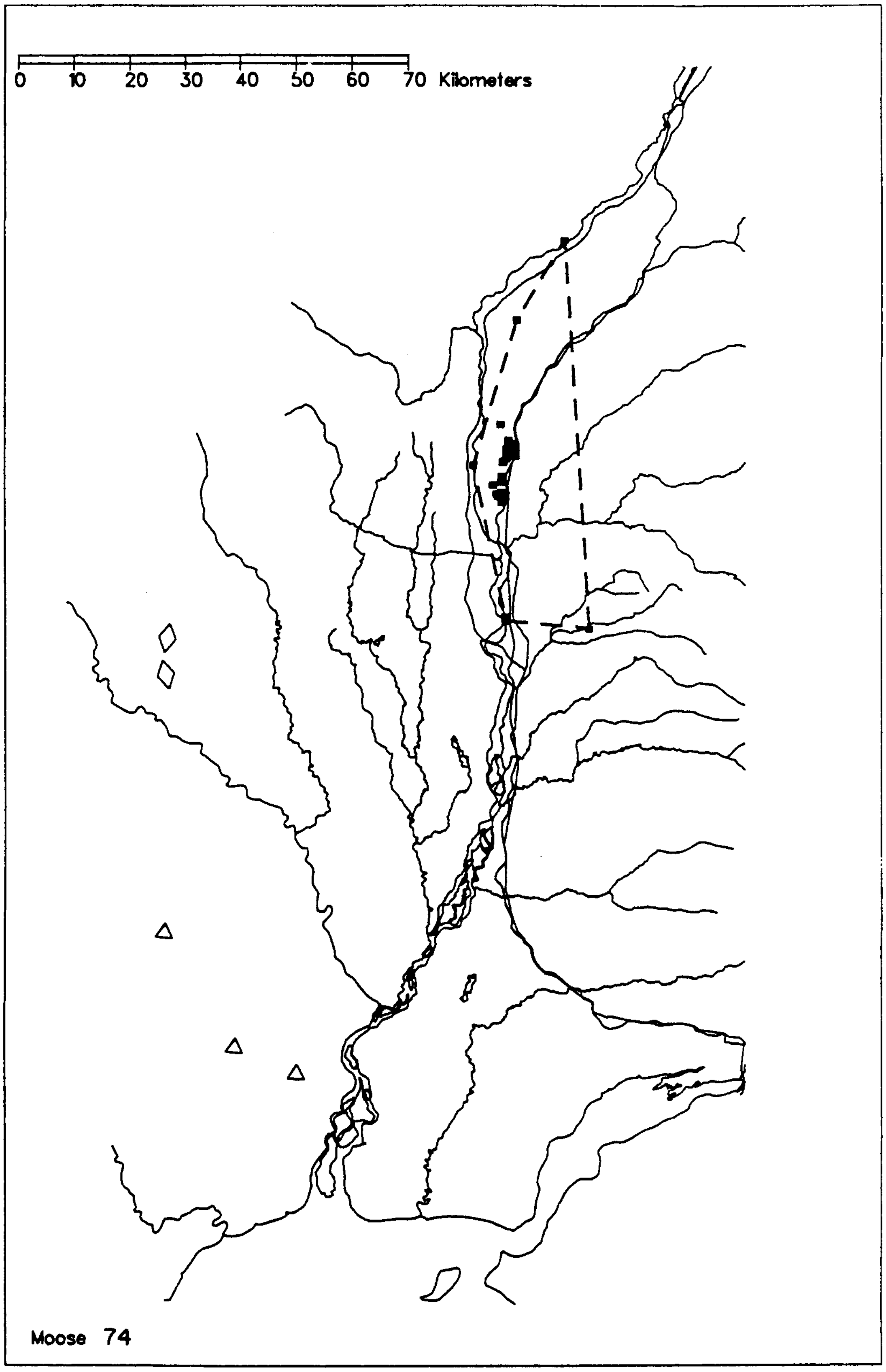

Fig. 60. Polygon encompassing point locations from a a radio-marked moose (No. 74F) from the Susitna River Area 1 winter range capture site that migrated across the boundary between Subunits 13E, 14B, and 16A in southcentral Alaska, 1981-82.

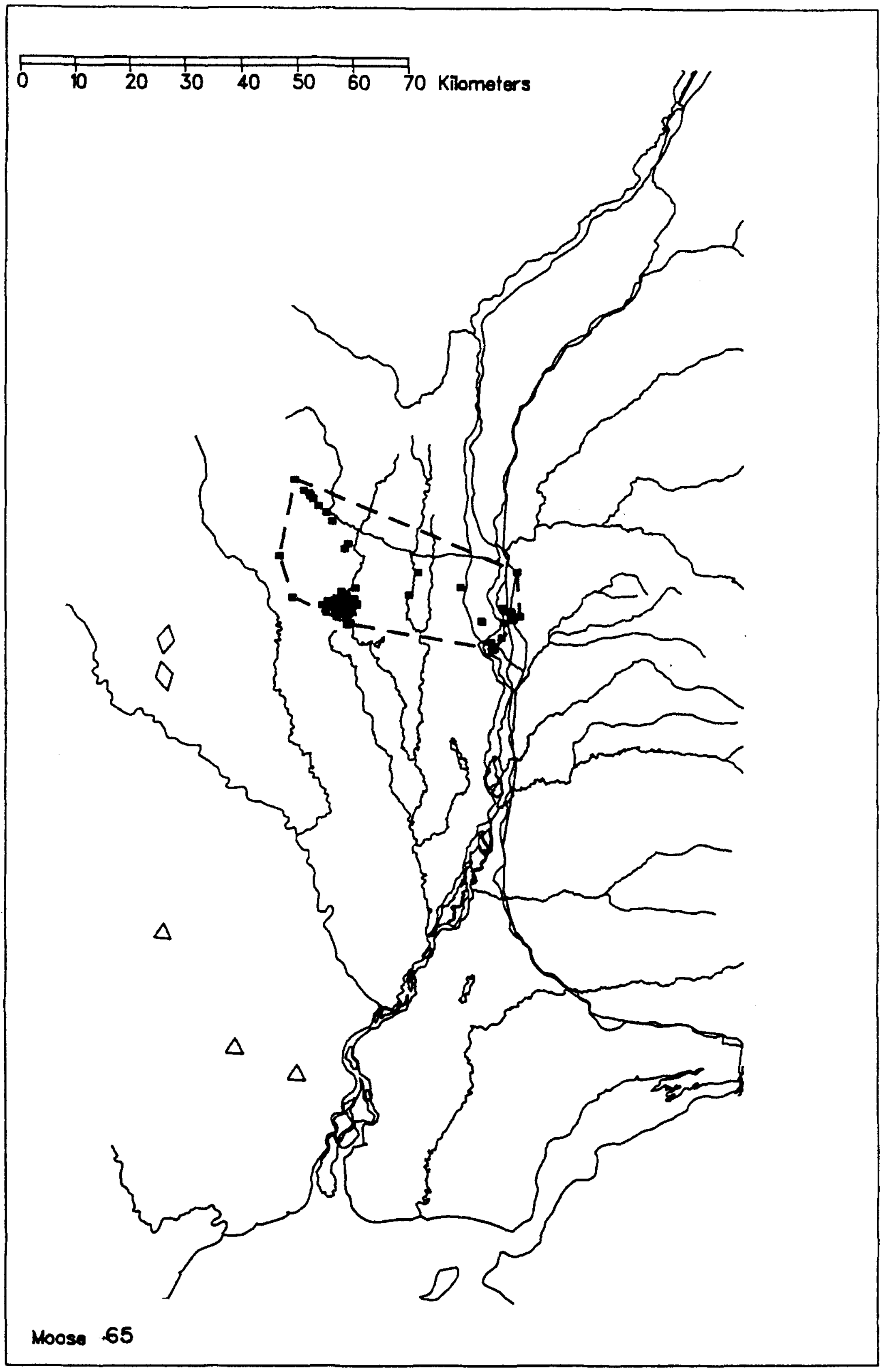

Fig. 61. Polygon encompassing point locations from a radio-marked moose (No. 65M) from the Susitna river Area 21 winter range capture site that migrated across the boundary between Subunits 16a and 14B in southcentral Alaska, 1981-83.

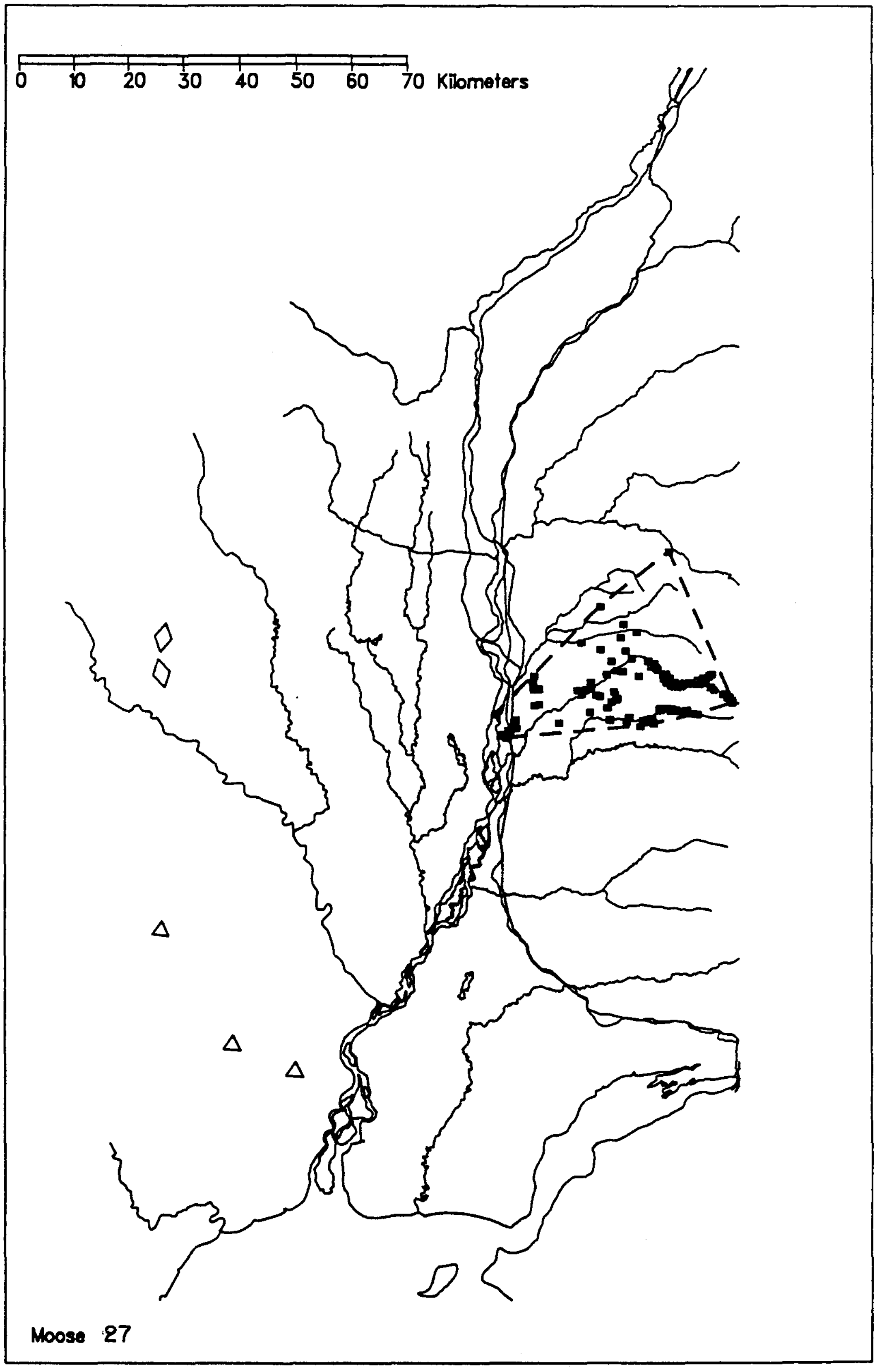

Fig. 62. Polygon encompassing point locations from a radio-marked moose (No. 27M) from the Susitna River area 3 winter range capture site that migrated across the boundary between Subunits 14B and 16A in southcentral Alaska, 1980-85.

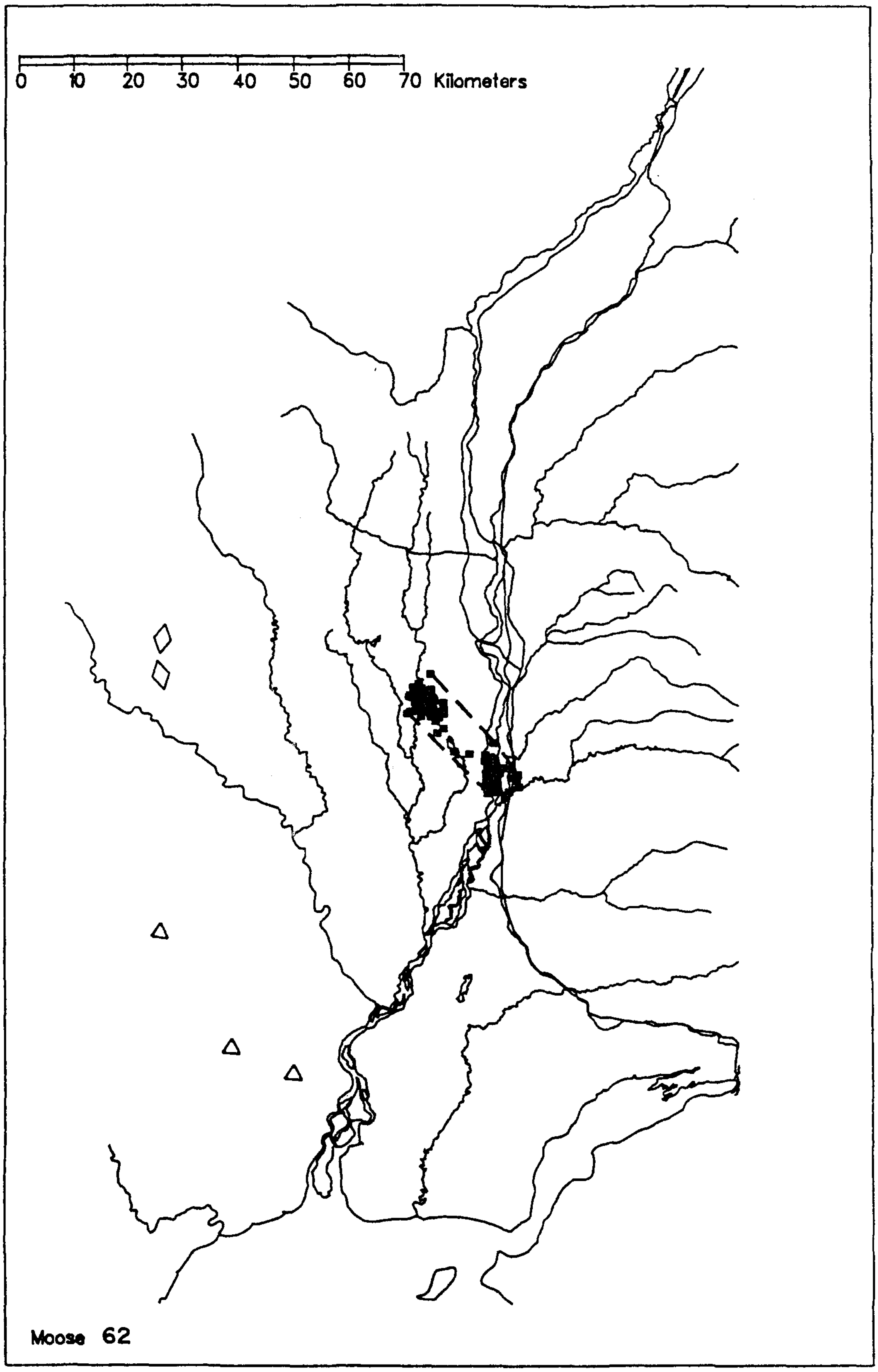

Fig. 63. Polygon encompassing point locations from a radio-marked moose (No. 62F) from the Susitna River Area 3 winter range capture site that migrated across the boundary between Subunits 16A and 14B in southcentral Alaska, 1980-90.

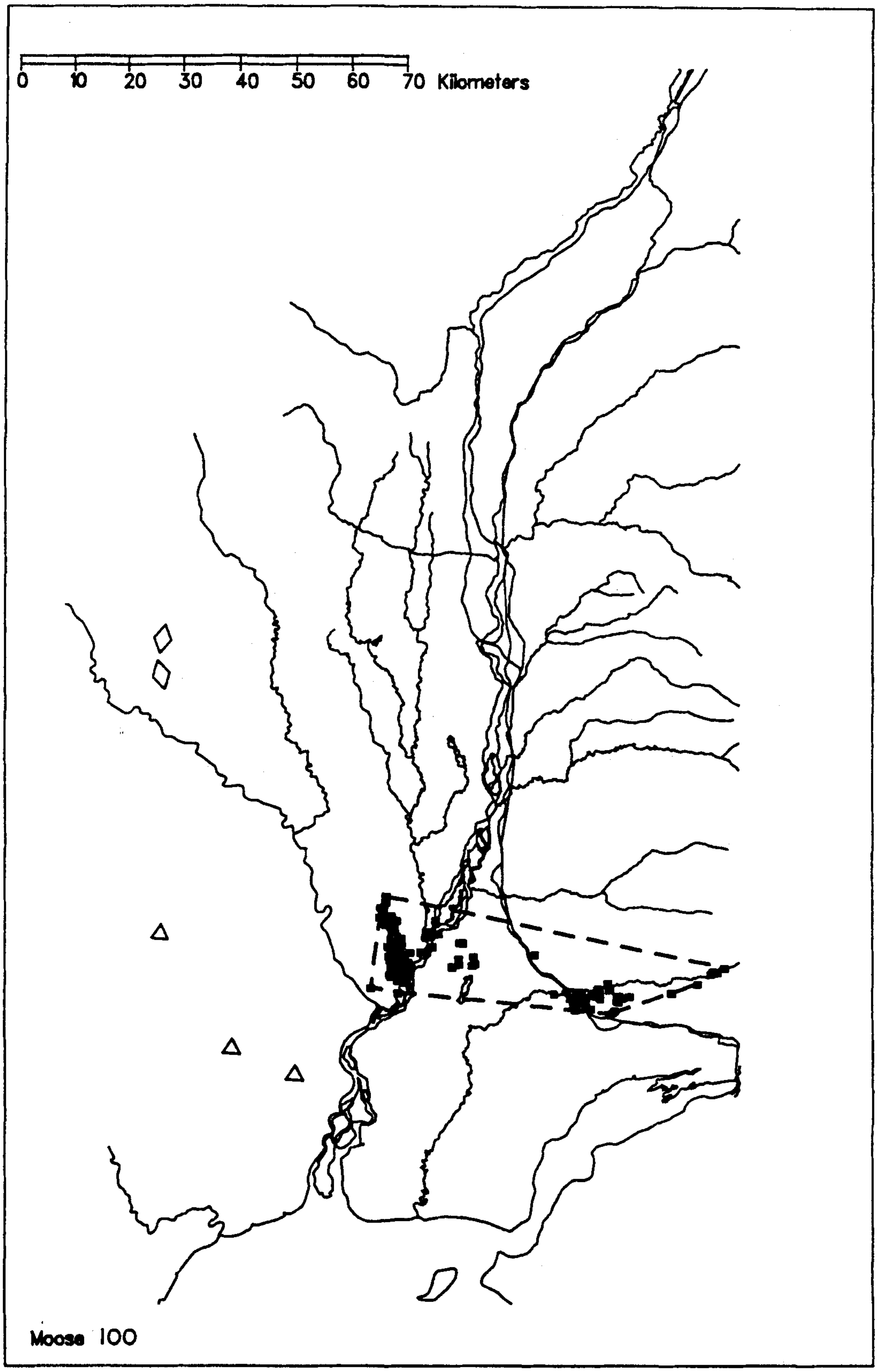

Fig. 64. Polygon encompassing point locations from a radio-marked moose (No. 100F) from the Susitna River Area 3 winter range capture site that migrated across the boundary between Subunits 16A and 14A in southcentral Alaska, 1982-89.

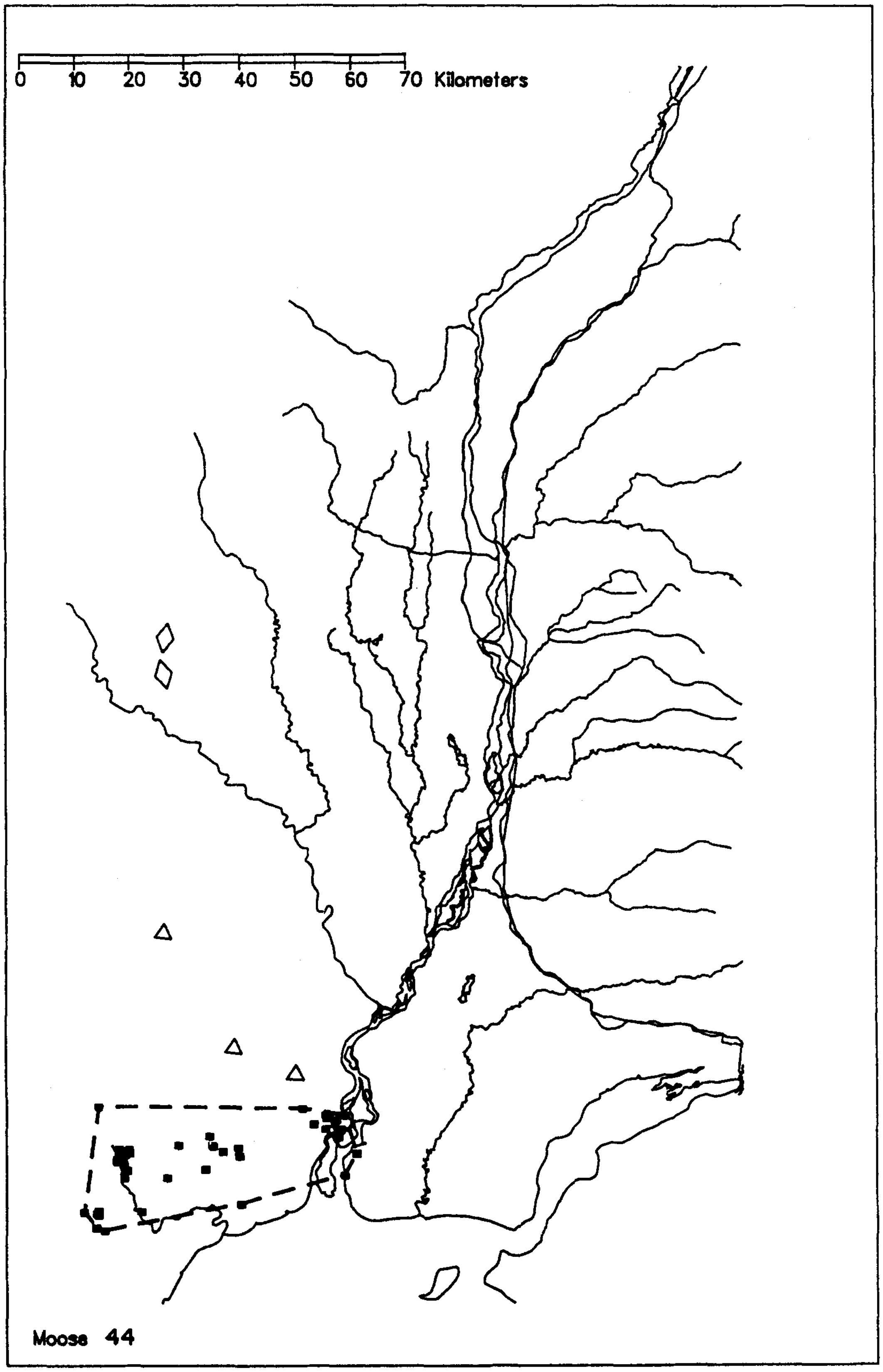

Fig. 65. Polygon encompassing point locations from a radio-marked moose (No. 44M) from the Susitna river Area 4 winter range capture site that migrated across the boundary between Subunits 16B and 14A in southcentral Alaska, 1982-83.

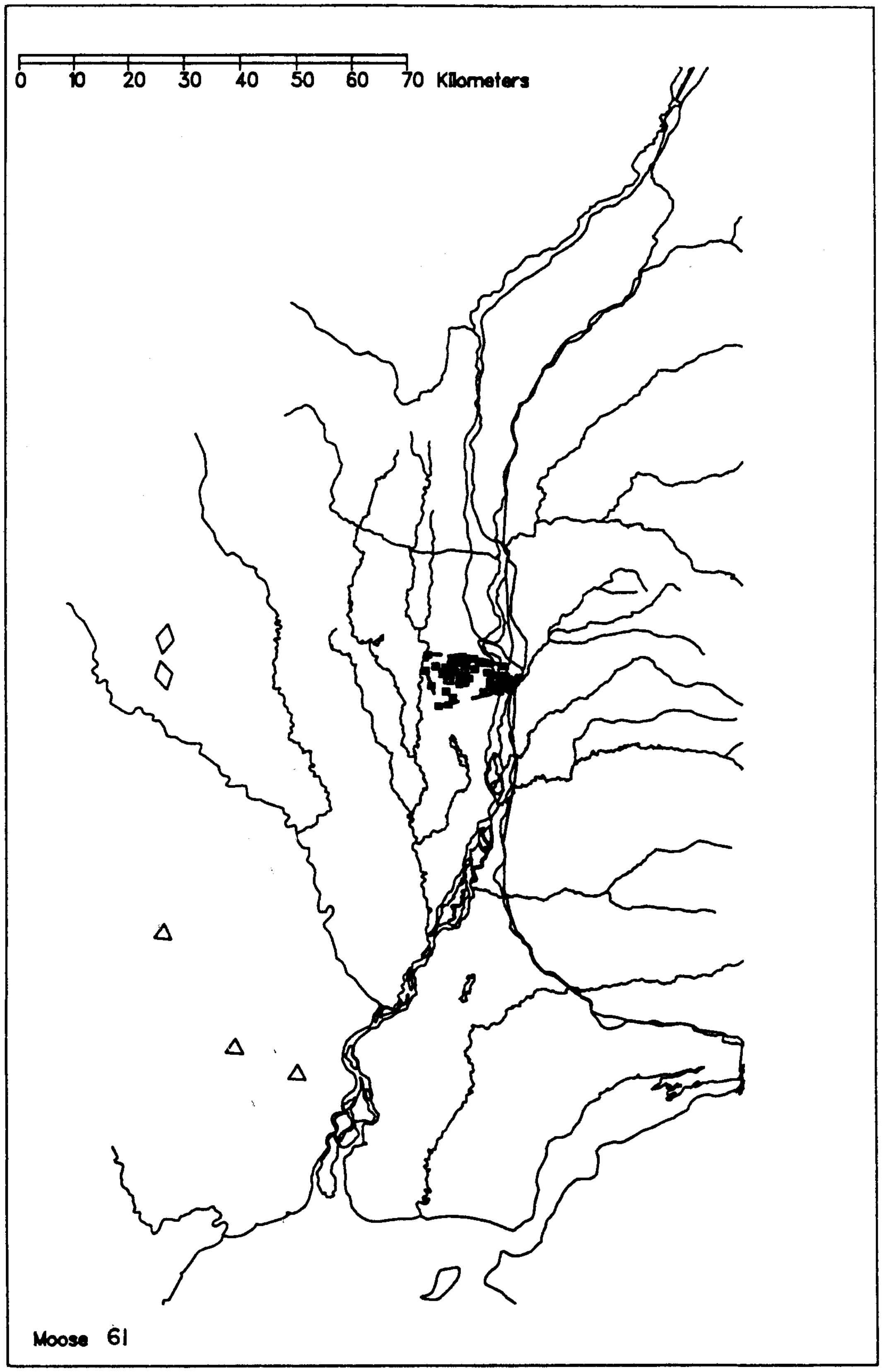

Fig. 66. Polygon encompassing point locations from a radio-marked moose (No. 61F) from the Susitna River Area 5 winter range capture site that migrated across the boundary between Subunits 16A and 14B in southcentral Alaska, 1984-90.

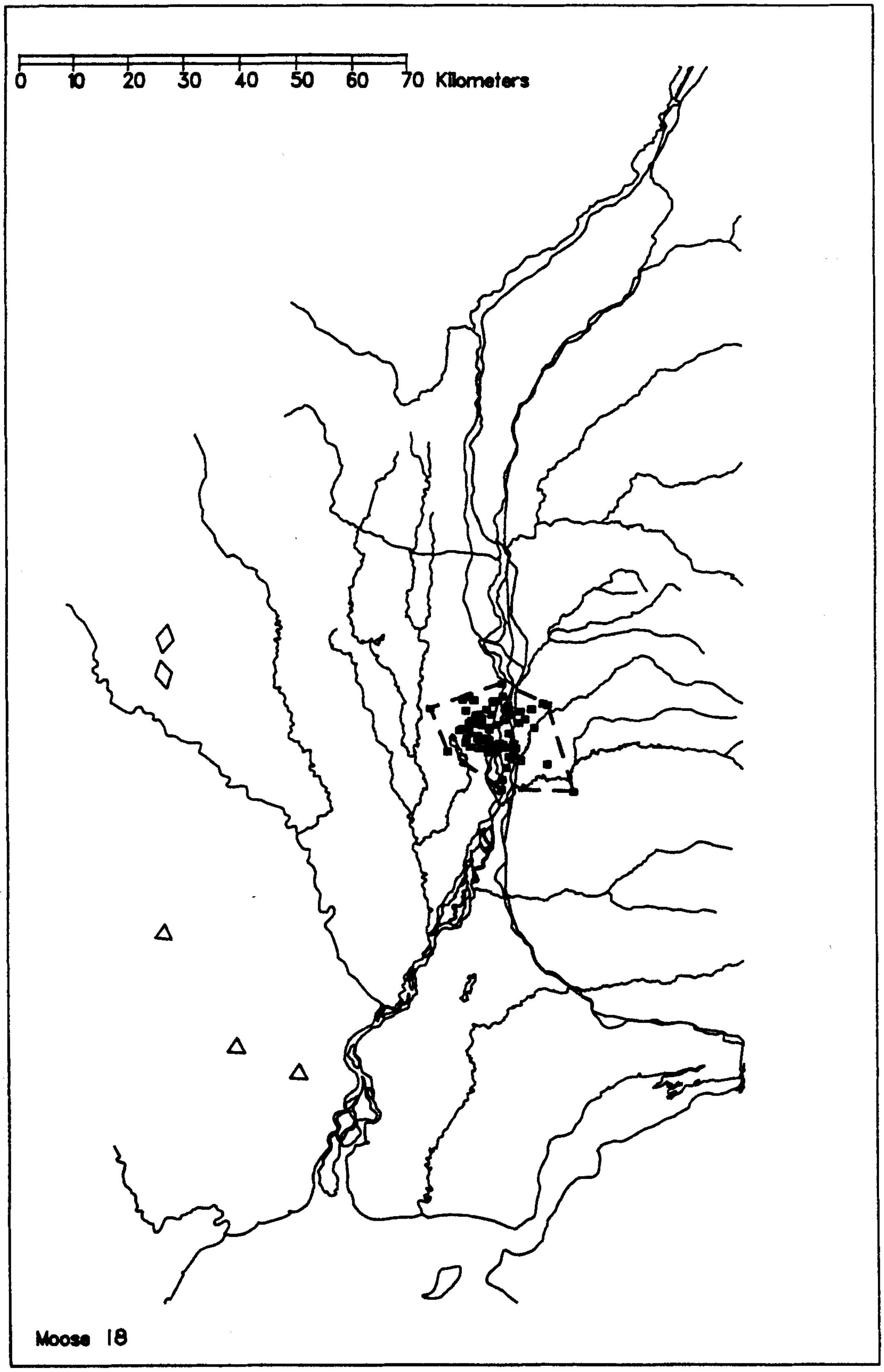

Fig. 67. Polygon encompassing point locations from a radio-marked moose (No. 18F) from the Susitna River Area 5 winter range capture site that migrated across the boundary between Subunits 16A and 14B in southcentral Alaska, 1984-90.