SUSITNA HYDROELECTRIC PROJECT

PHASE II PROGRESS REPORT

BIG GAME STUDIES

Volume II MOOSE - DOWNSTREAM

Ronald D. Modafferi

ALASKA DEPARTMENT OF FISH AND GAME
Submitted to the Alaska Power Authority
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PREFACE

In early 1980, the Alaska Department of Fish and Game contracted with the Alaska Power Authority to collect information useful in assessing the impacts of the proposed Susitna Hydroelectric Project on moose, caribou, wolf, wolverine, black bear, brown bear and Dall sheep.

The studies were broken into phases which conformed to the anticipated licensing schedule. Phase I studies, January 1, 1980 to June 30, 1982, were intended to provide information needed to support a FERC license application. This included general studies of wildlife populations to determine how each species used the area and identify potential impact mechanisms. Phase II studies continued to provide additional information during the anticipated 2 to 3 year period between application and final FERC approval of the license. Belukha whales were added to the species being studied. During Phase II, we are narrowing the focus of our studies to evaluate specific impact mechanisms, quantify impacts and evaluate mitigation measures.

This is the first annual report of ongoing Phase II studies. In some cases, objectives of Phase I were continued to provide a more complete data base. Therefore, this report is not intended as a complete assessment of the impacts of the Susitna Hydroelectric Project on the selected wildlife species.

The information and conclusions contained in these reports are incomplete and preliminary in nature and subject to change with further study. Therefore, information contained in these reports is not to be quoted or used in any publication without the written permission of the authors.

The reports are organized into the following 9 volumes:

Volume I.	Big Game Summary Report
Volume II.	Moose - Downstream
Volume III.	Moose - Upstream
Volume IV.	Caribou
Volume V.	Wolf
Volume VI.	Black Bear and Brown Bear
Volume VII.	Wolverine
Volume VIII.	Dall Sheep
Volume IX.	Belukha Whale

SUMMARY

Recent demand for non-fossil fuel energy has stimulated public interest and initiated the formulation of a proposal to develop the hydroelectric potential of the Susitna River. The proposal is founded on construction of two water impoundments, an earth/rock filled dam at a site between Tsusena and Deadman Creeks and a concrete arch dam at Devil Canyon, each with electric generating facilities, and together capable of about 1200 Mw of capacity.

Feasibility of the proposed project will be determined in part by evaluating environmental impacts as well as the economic base. Environmental impacts can be divided into 2 hydrological categories: 1) pre-impoundment, those impacts occurring in areas upstream from the impoundments and 2) post-impoundment, those impacts occurring in areas downstream from the impoundments. Pre-impoundment impacts will primarily involve immediate loss of habitats through inundation. Post-impoundment impacts will probably involve gradual and less dramatic changes in riparian environments through altered flow regimes and altered characteristics of the water itself and alterations in other environmental features. Such environmental effects may affect wildlife directly through hydrologic conditions and/or be mediated indirectly through several intermediate environmental components.

Irrespective of the nature of the cause, the ultimate impacts of indirect effects or direct effects on migratory species of wildlife may be realized at distances quite removed from their proximate cause.

In its 215 km course from Devil Canyon to Cook Inlet, the Susitna River is an outstanding component of a very productive watershed. Perhaps the innate value of the lower Susitna River Valley as wintering habitat for moose is unsurpassed elsewhere in the State.

Objectives of this study were to determine the probable nature and approximate magnitude of impacts of the proposed Susitna River hydroelectric project on moose (*Alces alces gigas* Miller) in areas along the Susitna River downstream from the prospective Devil Canyon dam site to Cook Inlet. To accomplish this objective one must thoroughly understand how moose depend on floodplain habitats along the Susitna River. Only then, will one be able to assess the relative importance of various floodplain characteristics to moose and integrate those findings with hypothetical post-project conditions to fully evaluate project impacts on subpopulations of moose. This report is primarily based on data gathered between 15 October 1982 and 15 October 1983 but also includes pertinent findings from the Phase I study final report (Modafferi 1982).

Data on patterns of movement, habitat use, productivity, survival and identity of subpopulations for moose ecologically affiliated with the Susitna River were primarily synthesized from 2178 radio relocations obtained from samples of 10, 29 and 18 moose captured and radio-collared on 17 April 1980, 10-12 March 1981 and 24 February to 10 March 1982, respectively, in floodplain habitats along the Susitna River between Devil Canyon and Cook Inlet and subsequently radio-relocated through 15 October 1982.

Radio-collared moose, were relocated at about biweekly intervals through 16 March 1981 and about 10-day intervals from that time through 15 October 1982. This schedule provided 7, 10, 12, 7, 7 relocation sites for most individuals monitored during the winter (1 January thru 28 February), calving (10 May thru 17 June), summer (1 July thru 31 August), "hunting season" (1 September thru 30 September) and breeding (14 September thru 15 October) periods, respectively. Most data collected from radio-collared moose were analyzed relative to these periods in the life history of moose. Effects of sex, subpopulation and year factors were considered in interpretive analyses. Radio-relocations dated outside of these periods were grouped within spring, summer, autumn and post-breeding transitory intervals.

To assess magnitude of seasonal and regional moose use of floodplain habitats along the Susitna River from Cook Inlet to Devil Canyon, radio-relocation data were integrated with information collected on 6 and 7 aerial censuses for moose conducted between 9 December 1981 and 12 April 1982 and between 29 October 1982 and 22 February 1983, respectively.

Data from river censuses, in turn provided additional and independent information on productivity/survival of moose which winter in Susitna River floodplain habitats. In these interpretive analyses, sex, seasonal period and subpopulation categories were considered.

Preliminary findings from radio-collared samples exhibited grossly different patterns of behavior and geographically discrete breeding areas for three groups of moose and resulted in subpopulation classifications for individuals with breeding ranges centered in areas: 1) to the north of Talkeetna, 2) to the south of Talkeetna and on the eastside of the Susitna River and 3) to the south of Talkeetna and not in eastside areas. Observations of movement patterns from a more recently radio-collared sample of moose suggest that two other discrete subpopulations of moose which frequent: 1) the Little Susitna River/Wasilla area or the Mt. Susitna/Beluga Lake area at other seasonal periods, also winter in Susitna River floodplain habitats.

Some individual moose were found to range mostly within Susitna River floodplain habitats, other individual moose only used those habitats during the winter and/or more frequently during the calving period, and other moose used floodplain habitats during one of those periods and also traversed riparian areas when moving from one range to another. Though most radio-collared moose used the Susitna River primarily as a winter range between January through April, about 16 percent of the radio-collared moose frequented floodplain habitats in extensively islanded areas throughout the year. For the second consecutive year of study, radio-collared female moose north of Talkeetna sought island and riparian habitats along the Susitna River near the time of calving. The later movement pattern was attributable to availability of nutritous food and/or avoidance of predators.

Radio-collared moose north of Talkeetna seldom ranged farther than 8 km from riparian habitats; moose south of Talkeetna commonly ranged farther than 8 km from the Susitna River and relocations up to 40 km from floodplain areas were not uncommon for the later area. Though moose north of Talkeetna did not range far from riparian habitats, some did travel greater distances, parallel to the river, during each annual cycle.

Large variation between individuals and sexes within years and within individuals and sexes between years was observed in movements and sizes of ranges for radio-collared moose. Males generally ranged over greater distances than females. Many individual moose were found to range over larger areas during the second year of study. Similar but smaller increases in range size were observed after 2 years of study.

Most radio-collared moose returned to floodplain habitats each winter but moose of each sex were not known to return in consecutive years and one male did not return to Susitna River riparian habitats for two consecutive winter periods.

Since magnitude of use of winter range by Susitna River Valley subpopulations of moose is partly related to severity of climatic conditions, findings presented in this report must be considered as preliminary since sampling occurred and data were accumulated during the relatively mild or average winters between 1979 and 1983. The later winter, which was characterized by large amounts of snowfall through December and was subsequently followed by mild conditions and recession of snowcover provided some information on weather related variations in behavior of moose and substantiated importance of this concern.

In the winter of 1981-82, a maximum of 369 moose were observed in 6 censuses of floodplain habitats along the Susitna River between Cook Inlet and Devil Canyon. A maximum of 934 moose were observed in 7 similar censuses conducted in the winter of 1982-83. For the later winter, densities of moose greater than four per km^2 of surface area were calculated for moose occupying floodplain habitats between the Yentna River and Cook Inlet in late December. Overall observations indicated unequal distribution of moose within and between four geographic zones of the Susitna River. Within and between year variation in moose use of floodplain habitats were associated with winter weather conditions.

Movements and distribution of radio-collared moose during specific life history periods were analyzed and discussed in relation to potential impacts of hydrologic development and mitigation options. These data substantiated that impacts to moose which occur within Susitna River floodplain habitats may ultimately be realized at great distances from the Susitna River and that each subpopulation of moose may be vulnerable to different types of impacts. Similarly, mitigation measures need not be limited to floodplain areas to be affective but may have to be specific for a particular subpopulation of moose.

Ninety-seven percent of the radio-collared female moose were known to produce young in 1982; of them 59 percent produced twins. Calf production in 1982 appeared greater than in 1981 after parturition, but by November ratios of calves per female were similar for both years. Early winter weather conditions were more severe in 1982 than in 1981 and may account for the decrease in calf survival observed in 1982.

Effort expended to hunt moose, and numbers of moose killed by hunters indicate that moose in subunits 14B and 16A provide recreational opportunity, and sustenance for large numbers of participants, many of which are from urban areas. Subpopulations of moose in areas along the Susitna River north of Talkeetna provide for significantly fewer people than subpopulations in the aforementioned subunits but in this subunit most users are probably local residents.

Mortality of moose recorded during the study was attributed to hunting (on male and female moose), accidents associated with the Susitna River such as slipping on ice, drowning, perhaps on ice or log jams during high water, and predation by brown bears. Data indicated that males sustained higher rates of hunting mortality and females experienced higher rates of non-hunting mortality.

Moose winter use of sites where vegetative associations have been altered to more seral communities by activities of humans was documented. During the winters of 1981-82 and 1982-83, it was not uncommon to observe 40-60 moose in each of several sub-climax sites about 3 km^2 in size.

Because of the potential for habitat rehabilitation as a mitigation option, it was recommended that research studies designed to more fully understand the interrelationships between rehabilitated habitat and ecology of moose in the lower Susitna River Valley be initiated.

Limitations of sampling methods and present samples and their relationship to differential behavior and winter weather conditions were discussed. It was proposed that more radio-collared moose, particularly males, need to be studied north of Talkeetna. It was also suggested additional males be radio-collared and monitored in other areas further downstream. The need for a contingency plan designed to study all subpopulations of moose during a severe winter, was reiterated.

Potential impact mechanisms were listed along with particular associated affects. General mechanisms considered were the following: 1) altered seasonal river flow patterns and loss of annual variation in river flow, 2) altered water temperature, 3) alteration of habitat, 4) increased access, 5) human encroachment, 6) increased railway and vehicular traffic, 7) loss of habitat at impoundment, 8) salt water encroachment at Cook Inlet, 9) altered turbidity and 10) altered ecosystem.

Recommendations for future research included: 1) continuation of present monitoring of radio-collared moose, 2) radio-collar additional individuals, particularly males, north of Talkeetna, 3) radio-collar additional males south of Talkeetna, 4) continue floodplain censuses during the winter of 1983-84, 5) capture and radio-collar moose in disturbance subclimax vegetative sites studied in previous years and 6) design and be prepared to implement a severe winter contingency study plan.

ACKNOWLEDGEMENTS

The following persons deserve special thanks for various phases of this study:

K. Schneider, Alaska Dept. Fish and Game, for providing numerous helpful suggestions and comments on all aspects of the research and for his willingness to ease the burden of administrative tasks and meetings which occasionally occurred at inopportune times.

D. C. McAllister, Alaska Dept. Fish and Game, for willing and able assistance and suggestions and comments in all aspects of this study.

V. Loftstedt, Kenai Air Alaska, Inc., and J. Swiss, John Swiss and Family, big game guiding, outfitting and air charter service, for piloting the helicopter and fixed-wing aircraft, respectively during the live capture and radio-collaring of moose.

Dr. C. C. Schwartz, T. H. Spraker, M. A. Chihuly, all Alaska Dept. of Fish and Game employees, for their assistance in the capture and radio-collaring of moose.

C. Allen, Charlie Allen Flight Service, and M. Houte and C. Loftstedt, Kenai Air Alaska, Inc., for piloting aircraft on the many long and tedious radio-relocating surveys. They deserve special recognition for ability, desire and safety.

N. Tankersley, Alaska Dept. Fish and Game, for frequent assistance on radio-relocating surveys.

J. Swiss, John Swiss and Family, big game guiding, outfitting and air charter service, for his ability and safety in piloting and navigating aircraft on patterned aerial censuses for moose and for his enthusiasm in helping to spot moose during those censuses.

D. Anctil, T. Otto and S. Miller, all Alaska Dept. Fish and Game employees, for assistance in management and analysis of data.

C. Reidner, Alaska Dept. Fish and Game, for drafting the figures.

H. Griese, B. Taylor and M. Chihuly, all Alaska Dept. Fish and Game employees, for occasional assistance on radio-relocation surveys.

E. Goodwin, Alaska Dept. Fish and Game, for processing samples of blood from moose.

P. Miles and S. Lawler, Alaska Dept. Fish and Game employees, for tolerating the many corrections, changes and redrafts of redrafts and lengthy tables which occurred in the typing of this report.

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INTRODUCTION

More than 30 years ago, the search for an economical source of power to serve Alaska's railbelt region stimulated interest in construction of a hydroelectric facility on the upper Susitna River. Feasibility assessments then, by the U.S. Bureau of Reclamation and subsequently by the U.S. Army Corps of Engineers indicated that the proposed project was economically feasible and that environmental impacts would not be of sufficient magnitude to affect its authorization.

More recently, in response to an anticipated demand for a non-fossil fuel source of energy, previous ideas and plans were rejuvenated in 1976 as attention was again focused on a Susitna River hydroelectric project. At that time, the Alaska State Legislature created the Alaska Power Authority to administer detailed studies to re-evaluate the feasibility of developing the hydroelectric potential of the upper Susitna River, since technical field research studies designed to assess environmental impacts of such a project were never adequately addressed in the past and in recent times, regulations and public sentiment for environmental conservation have become increasingly more conservative.

Environmental impacts of the proposed hydroelectric project can be divided into 2 general hydrological categories: those upstream (pre-impoundment) and those downstream (post-impoundment) from the impoundments. Initial environmental impact assessments emphasized concern in the pre-impoundment area; environmental assessments in the post-impoundment area were "token" in nature. Perhaps, conceptually, acute effects involving loss of habitats through inundation were considered to be more significant than indirect, long-term chronic type effects that would occur in habitats downstream as a result of altered characteristics of the water and hydrologic flow regimes.

Though impoundments will be located in the upper reaches of the Susitna River, environmental impacts resulting from altered hydrologic flow regimes will occur throughout the 215 km downstream section of river; indirect effects will also be realized in a corridor of terrestrial habitats adjacent to the river. An assessment of the types and magnitude of influence of the Susitna River hydraulics on environments at perpendicular distances from the river is as important to determine as those impacts that occur immediately along the river. For migratory species of wildlife, ultimate effects of proximate impacts may be geographically distant and not obvious, but should not be overlooked nor regarded lightly.

The Susitna River flows about 215 km downstream from Devil Canyon before entering Cook Inlet. In a narrow sense, the surrounding Susitna River Valley watershed encompasses approximately 800,000 km^2 of extremely productive habitat for many species of wildlife.

Perhaps, its innate value as wintering habitat for moose (*Alces alces gigas* Miller) is unsurpassed elsewhere in the State.

Prior to statehood, the Susitna Valley was ranked as the most productive moose habitat in the territory (Chatelain 1951). During this same time period, some wintering areas were said to sustain moose at concentrations greater than $22/km^2$ (Spencer and Chatelain 1953). More recent evidence indicates that concentrations and densities of moose in the Susitna Valley are greatest when deep snows in surrounding areas and at higher elevations persist into late winter and obscure browse species (Rausch 1959). Such dense aggregations are the probable result of moose from numerous subpopulations, some as remote as 30-40 km (LeResche 1974) to more than 110 km away (Van Ballenberghe 1977), gathering to seek refuge and forage in lowland habitats. It appears that many moose, from an extensive area and numerous subpopulations, utilize winter range in the Susitna River Valley.

The desirability of this area for moose in the early 1950's was greatly enhanced by early successional stages of vegetation resulting from wildfires, mild winters, and abandonment of land cleared for homesteads, highway and railroad construction and rights of way.

By the 1970's, browse on previously cleared land had been lost through succession, strict fire suppression efforts had essentially eliminated fire subclimax vegetation, and moose populations began to decline in response to the loss of important winter range browse species. In subsequent years, several severe winters compounded the population decrease. A low proportion of males in the breeding population may also have been another contributory factor (Bishop and Rausch 1974). Presently, many habitats in the Susitna River Valley have reverted to the pre-1930 pristine state and populations of moose have responded accordingly. This does not mean that the area is any less important to moose than in the early 1950's, but that fewer moose may be using it.

In the past, wildfire and extensive land clearing were the most dominant disruptive factors involved in creation and maintenance of young second-growth browse species for moose. Other phenomena, as beaver activity, periodic flooding, ice scouring, riparian erosion, and aluvial or loess translocation of soil, which acted on a smaller and less dramatic scale, were primarily restricted to riparian habitats along the Susitna River, and were considered to be relatively insignificant.

However, recent policies and efficiency in suppression of wildfire and disposal of only small parcels of land for private "homesites" instead of larger parcels for "homesteads" have, for all practical purposes eliminated the influence of fire and land clearing on habitat alteration. For these same reasons, disruptive factors once viewed as of little significance have become paramount in the creation and maintenance of habitats and browse species for moose wintering in the Susitna River Valley.

In the near future, habitats in the Susitna River Basin may again experience a broad ecological perturbation if the hydrologic regime and other characteristics of the Susitna River are altered to accommodate hydroelectric development. Though alterations in the flow regime and other characteristics of the Susitna River (temperature, turbidity, ice formation and scouring, substrate erosion and deposition, ice fog, icing of vegetation, and etc.) could impact moose in a number of ways; one of the most profound would be through changes in vegetative communities which occur along the river course to the extent that critical habitats or winter browse species were no longer available to various subpopulations of moose.

The present research study was designed to assess the potential impacts of the proposed Susitna River hydroelectric project on subpopulations of moose which are ecologically affiliated with that portion of the Susitna River between the proposed Devil Canyon impoundment and Cook Inlet and to suggest possible actions for mitigating those impacts.

Primary objectives of this study are the following: 1) to identify subpopulations of moose that are ecologically affiliated with the Susitna River downstream from Devil Canyon; 2) to determine seasonal distribution and movement patterns for each identified subpopulation; 3) to determine timing, location and relative magnitude of moose use of various riparian habitats along the lower Susitna River; 4) to identify specific mechanisms through which impacts will be transferred to subpopulations of moose; 5) to determine the probable nature and approximate magnitude of identified impacts on those particular subpopulations of moose; 6) to delineate a zone in which impacts of the proposed hydro-electric project may affect subpopulations of moose; and 7) to determine and suggest potential options for mitigating actions.

The following report is an interim update to the Phase I Final Report (Modafferi 1982) and largely addresses studies continuing between 15 October 1981 and 20 October 1982.

Though this report is based primarily on information obtained since completion of the Phase I report, where appropriate, both data sets are integrated to provide a more complete and meaningful assessment of particular findings.

More detailed overall accounts of the Introduction, Study Area and Methods pertinent to this study are available in the Phase I Final Report (Modafferi 1982) and will not be treated again here.

STUDY AREA

The Susitna River flows about 215 km downstream from the proposed Devil Canyon dam site before emptying into Cook Inlet. In its course to the sea, it descends about 300 m in elevation, it accepts glacial and non-glacial contributions from numerous tributary streams, its character changes greatly and it is a dominant force influencing characteristics of adjacent terrestrial habitats along the way (Fig. 1). The map in Fig. 1, excluding labels for features, is used as a geographical base for many other figures in this report. A more detailed description of the general ecological features in the Susitna River Valley are available in Modafferi (1982).

Boundaries delineating the research study area will be determined by the extent of actual movements documented for moose which were known to utilize habitats along the Susitna River. Until further research proves otherwise, it will be assumed that moose which use Susitna River floodplain habitat in any manner, in any seasonal period for any length of time may be impacted by hydroelectric development. Ultimately, the spatial area or zone where impacts may be realized by subpopulations of moose will encompass all movements of all moose which were at one time known to use Susitna River floodplain habitats.

Boundaries for geographical areas in which human use of the moose resource is administratively regulated and locations of other areas where plant succession has been altered and which provide attractive winter range for moose are noted in Fig. 2.

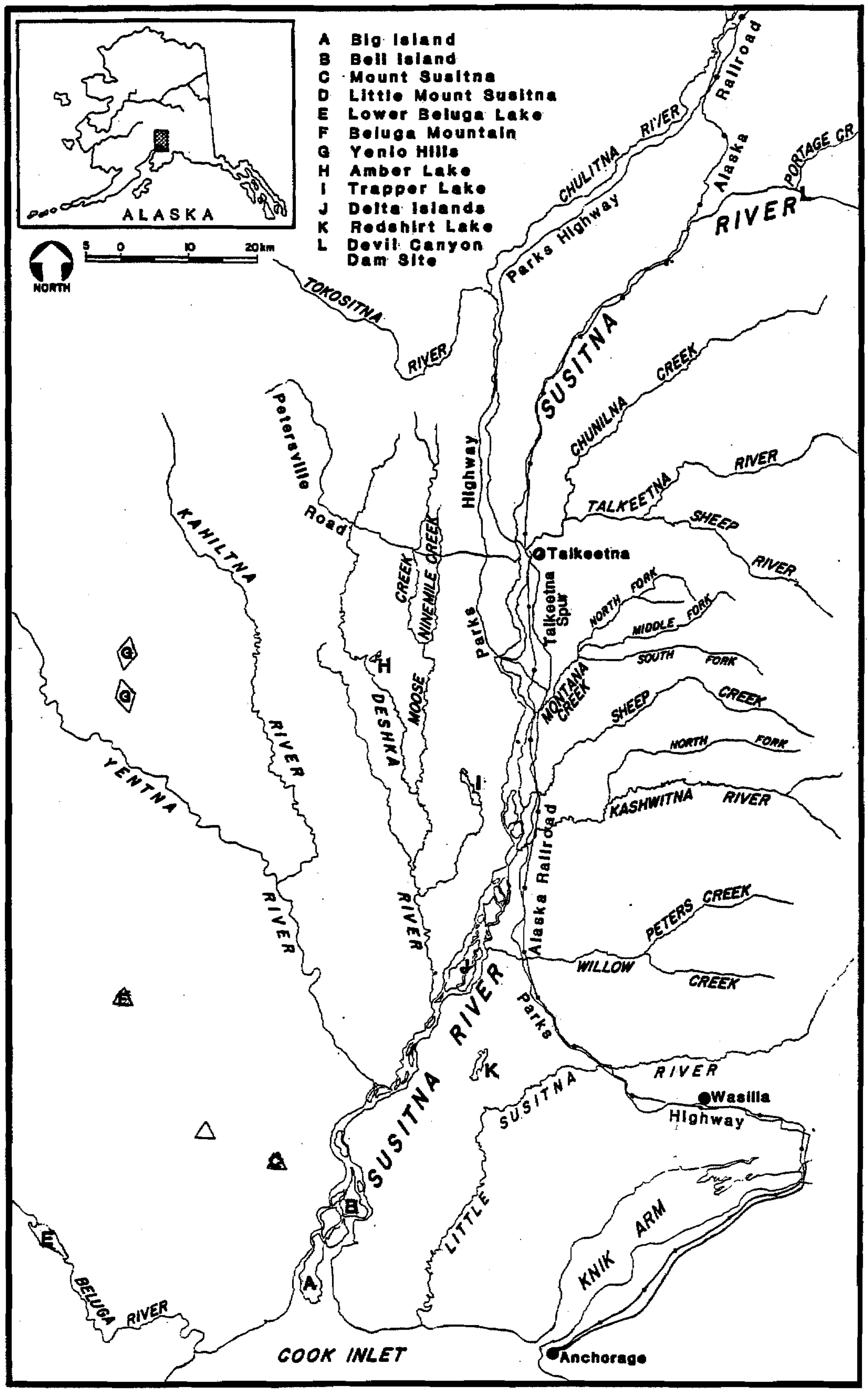

Figure 1. Map showing location of the study area in Alaska with names listed for rivers, lakes and other prominent landscape features.

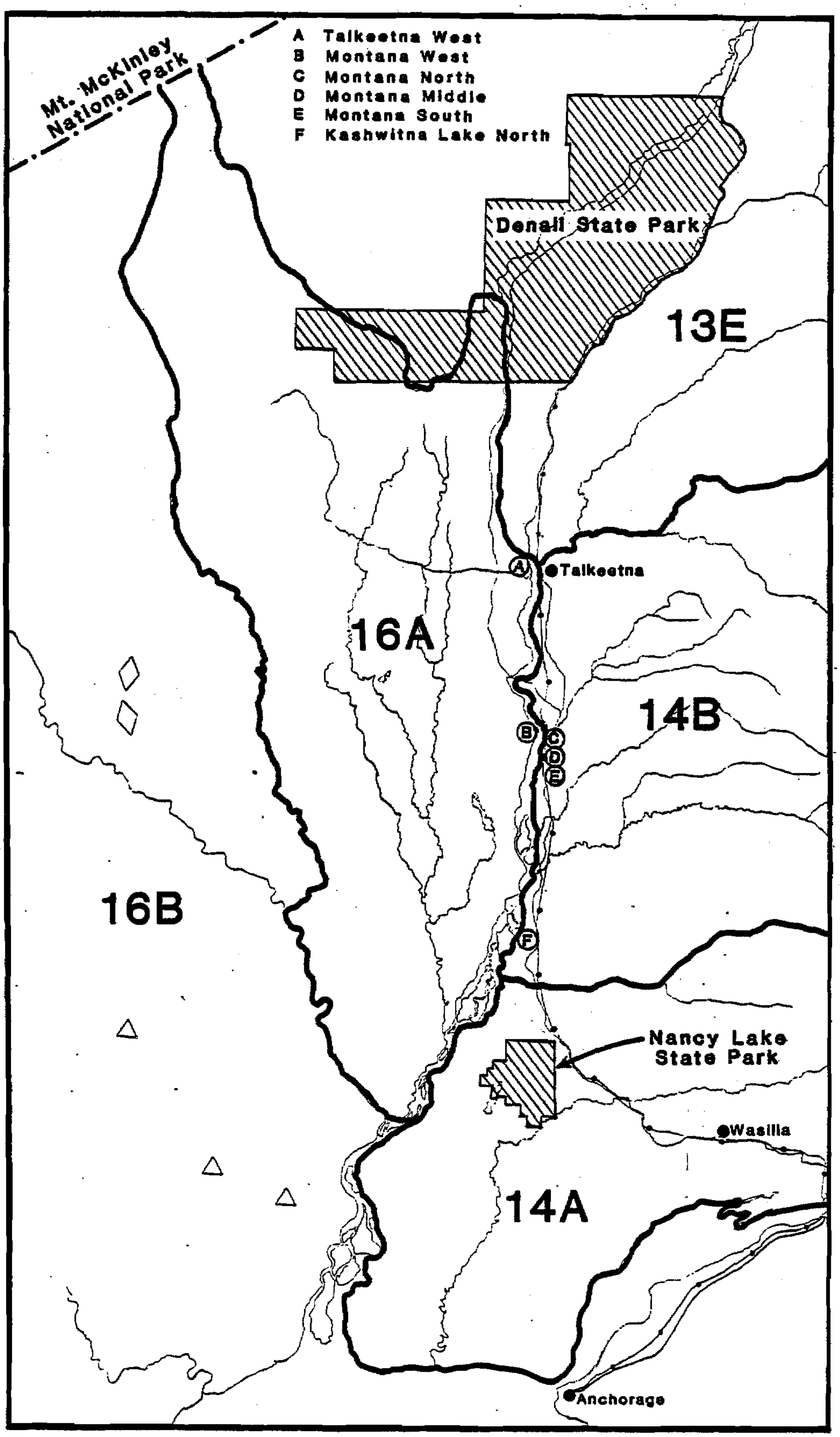

Figure 2. Map of study area showing locations of Game Management Subunits (13E, 14A, 14B, 16A and 16B), State and National Parks and areas where vegetation and/or plant succession has been disturbed by activities of man (A - F).

METHODS

In order to provide individually identifiable animals that could be located regularly, samples of moose were captured and tagged with visual and radio transmitting collars. Each collar featured a discrete number and radio frequency.

For tagging, moose were captured during the winter within the banks of the ice and snow covered Susitna River between Sheep Creek and Sherman in 1980, between the Delta Islands and Portage Creek in 1981 (Modafferi 1982) and between the Delta Islands and Cook Inlet in 1982 (Fig. 3 and Appendix A). Due to the relative unavailability of moose north of Talkeetna, some individuals were captured up to 400 m on either side of the river proper.

Typically moose were immobilized with an etorphine (M-99): rompum (xylazine hydrochloride) mixture (10-12:1cc @ 9 mg and 100 mg/cc, respectively) administered intramuscularly with Palmer Cap-Chur equipment by personnel aboard a hovering Bell 206B helicopter. Immobilized moose were revived with an intraveneous injection of diprenorphine (M50-50, 10-12cc @ 2 mg/cc).

While immobilized moose were collared, measured, palpated for feti, tagged with monel metal ear tags, a sample of whole blood was taken, an incisor tooth was extracted, physical conformation was assessed and for females, association with calves was noted. Moose immobilized in 1982 were not palpated.

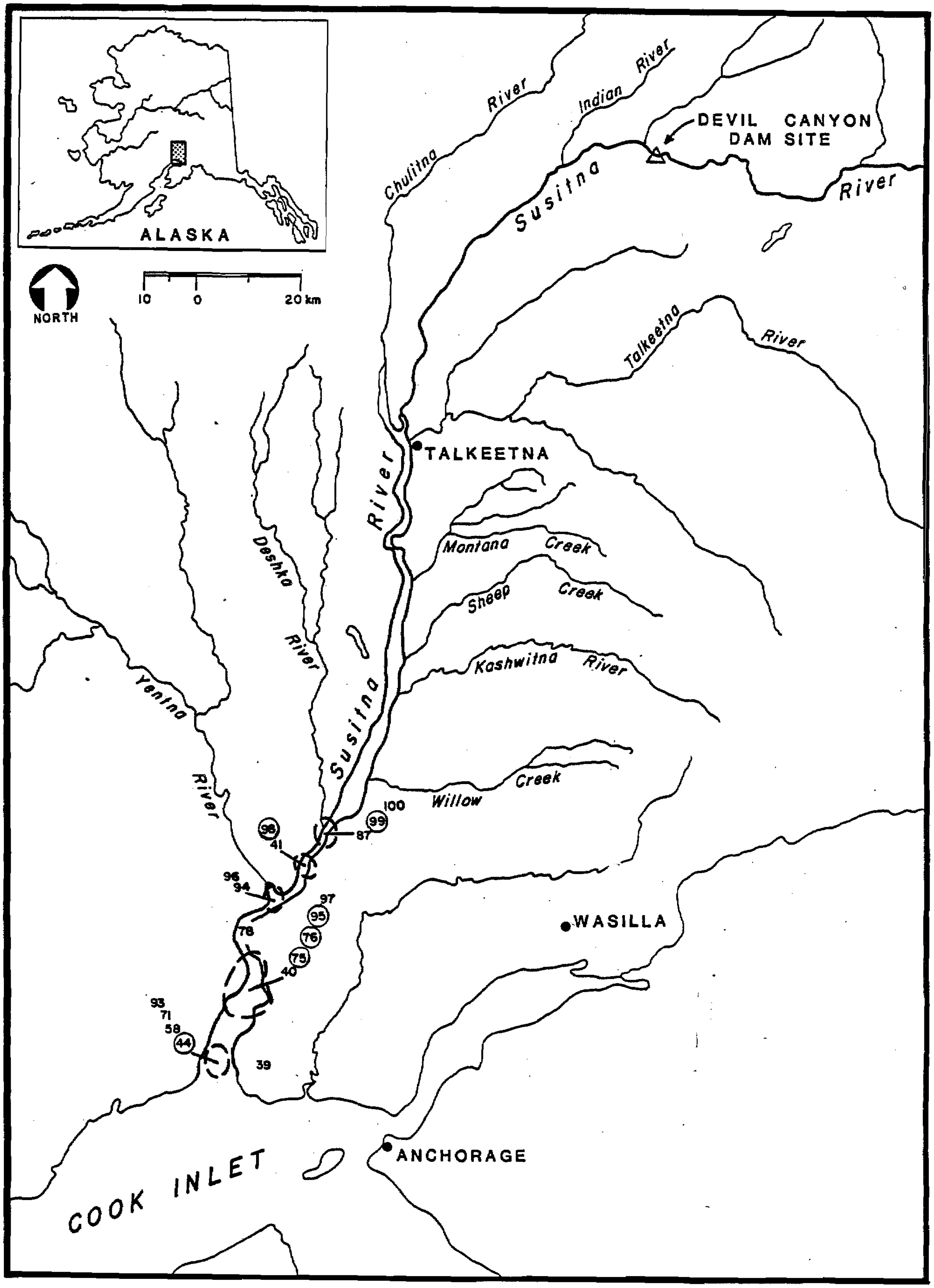

Figure 3. Locations of capture for 13 moose radio-collared 24 February (#40, 41, 75, 76, 78, 87, 94, 95, 96, 97, 98, 99, 100), 2 moose radio-collared 26 February (#39, 44) and 3 moose radio-collared 10 March (#58, 71, 93) on the Susitna River between the Delta Islands and Cook Inlet, Alaska, 1982. (circled numbers = males)

General health of captured moose was assessed by assigning each individual a rating of condition based on physical conformation (fatness, robustness, or lack of). Condition was rated on a scale from 1 to 10; a rating of 7 indicated that the animal was in average to better than average health.

Relocation flights with Cessna 172, 180 or 185 aircraft equipped with a yagi antenna on each wing were conducted at intervals of about two-three weeks in 1980 and about every 10-14 days in 1981 and 1982. Inclement weather occasionally altered this schedule.

To relate and illustrate the relative use and timing of use of Susitna River floodplain habitats by moose a descriptive technique based on life history phenomena and their inclusive calendar dates, was employed. A description of the life history base and inclusive calendar dates for those periods are presented in Table 1.

Calendar dates for the ranges did not encompass the entire year. Between dates for ranges, intervals were delineated to accommodate movement or transition from one range or period to another. To prevent transitory movements from affecting calculation of location, a very narrow spread of inclusive dates was selected to describe locations for respective life history activity periods. Perhaps determination of extent of these ranges suffered at the expense of their location, but the latter data and their spatial relationship to the Susitna River were considered to be of greater importance and relevance in this study.

Table 1. Inclusive calendar dates of theoretical ranges based on life history phenomena for populations of moose along the Susitna River from Devil Canyon to Cook Inlet, Alaska.

Range or transitory interval	Relevance to life history	Calendar dates
Winter range	Males recondition from breeding. Pregnant females nurture fetus and prepare for parturition. First winter for calves.	1 January thru 28 February
Spring transitory interval	------------	---
Calving range	Females bear young.	10 May thru 17 June
Summer transitory interval	------------	---
Summer range	Growth of new born young. Females recondition from parturition and lactation. Males begin antler growth.	1 July thru 31 August
Autumn transitory interval	------------	---
Breeding range	Males establish breeding units. Sexes breed. Location of breeding perhaps critical for denoting subpopulation units.	14 September thru 31 October
Post breeding transitory interval	------------	---

To indicate spatial distribution for potential consumptive use of moose which use Susitna River riparian habitats, locations of radio-collared moose during the the usual open hunting season are presented.

Locations (audio-visual or audio) of moose were noted on 1:63,360 scale USGS topographic maps and later transferred to mylar overlays for computer digitization. For more complete details of data management, see Miller and Anctil (1981). Three subsamples of moose provided information on movements, population identity, habitat use, physical condition and productivity; a subsample of 10 moose captured between Sheep Creek and Sherman on 17 April 1980, a subsample of 29 moose captured between the Delta Islands and Portage Creek on 10-12 March 1981 and a subsample of 18 moose captured between the Delta Islands and Cook Inlet on 24 February, 3 and 10 March 1982. This report contains data on radio-collared moose monitored through 20 October 1982, at which time up to 78, 57 and 19 relocations were available for some individuals captured in the 1980, 1981 and 1982 samples, respectively.

Moose use the Susitna River year round; however, circumstantial evidence indicated that the magnitude (time and numbers) of use is significantly greater during the winter and particularly so during winters characterized by deep snows which persist late into early spring (Rausch 1958). In order to determine the magnitude of use, to delineate the timing of use and to determine the location and spatial distribution of use, a series of periodic censuses were conducted within the floodplain of the Susitna River from Cook Inlet to Devil Canyon.

By the time I became familiar with this project in early 1981, radio collared moose had already begun to leave the Susitna River floodplain and censuses then would have been futile. No periodic river census were conducted in the winter of 1980-81.

In the winter of 1981-82 censuses were conducted on 9 and 10 December, 28 December and 4 January, 2 and 6 February, 1 and 2 March, 23 and 24 March and 12 April. During the winter of 1982-83 censuses were conducted on 29 October and 6 November, 10 and 18 November; 1, 2, and 6 December; 20, 21 and 22 December; 5 and 6 January, 20 and 24 January; and 7 and 9 February. Though the timing of these censuses extended beyond the October cut-off date for radio-relocation data included in this report, salient aspects of those censuses are presented and analyzed here due to their relative importance in this study.

Aerial river censuses were conducted with a PA-18 aircraft flown at low elevation in a parallel transect pattern from floodplain bank to opposite floodplain bank, up the Susitna River from Cook Inlet to Devil Canyon. Weather and numbers of moose counted affected duration of individual censuses. Though limitations of aerial surveys of moose were known (LeResche and Rausch 1974), the object of aerial river censuses was to count all moose within the banks of the Susitna River floodplain and any of its inter-connecting sloughs. During aerial river censuses the following categories of moose were distinguished: large antlered males, small antlered males, lone non-antlered animals, females with one calf, females with two calves, and lone calves.

Location of each moose observed was recorded on USGS 1:63,360 scale topographic maps. Additional aerial river censuses will be conducted between mid-February and mid-April, through the winter of 1982-83.

River censuses were conducted over a time period to encompass the build up, peak and decline in moose use of winter range in Susitna River floodplain habitats. Censuses were conducted at frequent intervals to assess population dynamics in moose use of these floodplain habitats and to correlate those data with factors which may be responsible for observed dynamics.

To calculate densities of moose which were observed wintering in habitats within each of the four riparian zones on each census of Susitna River floodplain habitats, surface area surveyed was determined by making visual estimates of those land areas as they appeared on 1:63,360 scale USGS topographic maps. These visual estimates revealed that riparian zones I, II, III and IV each contained 28 and 31, 23 and 21, 65 and 104 and 65 and 29 km^2 of aquatic and terrestrial habitats, respectively.

Attempts will be made to determine why some habitats or areas are more attractive to moose (food, cover, geographic location, and etc.) than others, if aerial river censuses reveal non-random distribution of moose along the river course.

Information on consumptive use of the moose resource in areas adjacent to the Susitna River was provided by hunter kill records obtained from Alaska Department of Fish and Game harvest ticket master file.

Information on productivity of moose that are affiliated with habitats along the Susitna River was gathered from 2 sources: 1) observation of radio-collared female moose during routine aerial relocation flights and 2) aerial river censuses.

FINDINGS AND DISCUSSION

WINTER FLOODPLAIN CENSUSES

Interaction between hydraulics of the Susitna River and adjacent terrestrial ecosystems have, over time, resulted in a heterogeneous assemblage of early successional plant communities which along with local climatic conditions appear to provide attractive winter range for moose (Collins 1983).

Greatest use of Susitna River riparian habitats by moose generally occurs between November and April when moose are attracted to floodplain areas because of more shallow snow conditions and/or greater availability of winter forage (Rausch 1958).

Periodic censuses of floodplain habitats within a given winter and over several winters provide information on: 1) when moose seek these habitats; 2) which habitats or areas are most attractive to moose; 3) numbers of moose which utilize floodplain habitats in a particular winter; 4) numbers of moose which floodplain habitats may potentially support; 5) sex and age-class specific use of riparian habitats, and 6) when moose depart from these habitats. Surveys conducted prior to an influx or after departure of wintering subpopulations may additionally provide indirect information on numbers of moose which are resident to floodplain habitats throughout the year.

Information obtained from thirteen censuses for moose in floodplain habitats along the Susitna River downstream from Devil Canyon to Cook Inlet (Modafferi 1982 and Tables 2-11) substantiate beliefs of Rausch (1958) and others (Chatelain 1951 and LeResche 1974) about behavior of the "railbelt populations" of moose and their use of winter range along the Susitna River. Six of the censuses were conducted from 9 December through 12 April during the relatively mild winter of 1981-82 and seven censuses have been conducted from 29 October through 9 February during the winter of 1982-83. The latter winter was characterized by record snowfalls in October and November but climatic conditions from December through mid-February were mild and generally similar to those of the previous winter.

During the winter of 1981-82 the greatest number of moose (369) were observed on the 1 and 2 March 1982 census, in spite of relatively poor counting conditions in river zone IV. Though census 4 yielded the greatest total number of moose, more moose were observed in zones I, II and IV on censuses 3, 5 and 1, respectively. Considering these findings, the maximum number of moose observed in zones I-IV were 36, 25, 238 and 123, respectively; an aggregate total of 422 different moose. For these calculations, it is assumed that no movement of moose occurred between different zones over the time period between censuses. Data from radio-collared moose lead me to believe this assumption is not greatly violated. If movements did occur up or down the river, there is little reason to believe that they would not be countered by similar movements in the opposite direction.

Table 2. Sex, age composition and zone of location for moose observed on the 1 and 2 March aerial census of the Susitna River from Devil Canyon to Cook Inlet, Alaska, 1982.

River zone [1]	Census # 4								
	Males [2]		Females [3]			Lone calves	Total		
	Ad	Im	W/O	W/1	W/2		Ads	Calves	Moose
I	0	0	7	0	0	0	7	0	7
II	0	0	10	2	1	0	13	4	17
III	0	0	165	35	1	0	201	37	238
IV [4]	0	0	68	15	3	0	86	21	107
Total	0	0	250	52	5	0	307	62	369

1 I = Devil Canyon to Talkeetna, II = Talkeetna to Montana Creek, III = Montana Creek to Yentna River and IV = Yentna River to Cook Inlet.

2 Im = small antlered males, mostly yearlings, probably some two-year old males; Ad = males with large antlers.

3 W/O =females without young, W/1 females with one young; W/2 females with 2 young. The W/O category also includes males, most of which have shed their antlers by mid-December.

4 Snow cover incomplete in this zone; conditions for observing moose less than ideal.

Table 3. Sex, age composition and zone of location for moose observed on the 23 and 24 March aerial census of the Susitna River from Devil Canyon to Cook Inlet, Alaska, 1982.

River zone [1]	Census # 5								
	Males [2]		Females [3]			Lone calves	Total		
	Ad	Im	W/O	W/1	W/2		Ads	Calves	Moose
I	0	0	16	3	1	0	20	5	25
II	0	0	9	5	2	0	16	0	25
III	0	0	100	30	2	0	132	34	166
IV [4]	0	0	25	8	0	0	33	8	41
Total	0	0	150	46	5	0	201	56	257

1 I = Devil Canyon to Talkeetna, II = Talkeetna to Montana Creek, III = Montana Creek to Yentna River and IV = Yentna River to Cook Inlet.

2 Im = small antlered males, mostly yearlings, probably some two-year old males; Ad = males with large antlers.

3 W/O =females without young, W/1 females with one young; W/2 females with 2 young. The W/O category also includes males, most of which have shed their antlers by mid-December.

4 Snow cover incomplete in this zone; conditions for observing moose less than ideal.

Table 4. Sex, age composition and zone of location for moose observed on the 12 April aerial census of the Susitna River from Devil Canyon to Cook Inlet, Alaska, 1982.

	Census # 6								
River zone [1]	Males [2]		Females [3]			Lone calves	Total		
	Ad	Im	W/O	W/1	W/2		Ads	Calves	Moose
I	0	0	5	1	0	0	6	1	7
II	0	0	12	3	0	0	15	3	18
III	0	0	24	12	3	1	39	18	57
IV [4]	-	-	-	-	-	-	-	-	-
Total	0	0	41	16	3	1	60	22	82

1 I = Devil Canyon to Talkeetna, II = Talkeetna to Montana Creek, III = Montana Creek to Yentna River and IV = Yentna River to Cook Inlet.

2 Im = small antlered males, mostly yearlings, probably some two-year old males; Ad = males with large antlers.

3 W/O =females without young, W/1 females with one young; W/2 females with 2 young. The W/O category also includes males, most of which have shed their antlers by mid-December.

4 Insufficient snow cover in this zone for observing moose.

Table 5. Sex, age composition and zone of location for moose observed on the 29 October and 6 November aerial census of the Susitna River from Devil Canyon to Cook Inlet, Alaska, 1982.

River zone [1]	Census # 7								
	Males [2]		Females [3]			Lone calves	Total		
	Ad	Im	W/O	W/1	W/2		Ads	Calves	Moose
I	2	1	7	4	0	0	14	4	18
II	0	0	2	1	0	0	3	1	4
III	2	5	18	13	3	0	41	19	60
IV [4]	9	7	25	20	2	2	63	26	89
Total	13	13	52	38	5	2	121	50	171

1 I = Devil Canyon to Talkeetna, II = Talkeetna to Montana Creek, III = Montana Creek to Yentna River and IV = Yentna River to Cook Inlet. Zones I, II and III-IV were censused on 6 November and 29 October, respectively.

2 Im = small antlered males, mostly yearlings, probably some two-year old males; Ad = males with large antlers.

3 W/O =females without young, W/1 females with one young; W/2 females with 2 young.

4 Snow conditions in this zone excellent for observing moose.

Table 6. Sex, age composition and zone of location for moose observed on the 10 and 18 November aerial census of the Susitna River from Devil Canyon to Cook Inlet, Alaska, 1982.

	Census # 8								
River zone [1]	Males [2]		Females [3]			Lone calves	Total		
	Ad	Im	W/O	W/1	W/2		Ads	Calves	Moose
I	10	4	23	10	0	0	47	10	57
II	0	0	8	10	0	0	18	10	28
III	20	17	87	46	5	1	175	57	232
IV [4]	17	10	53	36	2	1	118	41	159
Total	47	31	171	102	7	2	358	118	476

1 I = Devil Canyon to Talkeetna, II = Talkeetna to Montana Creek, III = Montana Creek to Yentna River and IV = Yentna River to Cook Inlet.

2 Im = small antlered males, mostly yearlings, probably some two-year old males; Ad = males with large antlers.

3 W/O =females without young, W/1 females with one young; W/2 females with 2 young. The W/O category includes males which have shed their antlers; this becomes prevalent by mid-December.

4 Snow cover in this zone excellent for observing moose.

Table 7. Sex, age composition and zone of location for moose observed on the 1, 2 and 6 December aerial census of the Susitna River from Devil Canyon to Cook Inlet, Alaska, 1982.

	Census # 9								
River zone [1]	Males [2]		Females [3]			Lone calves	Total		
	Ad	Im	W/O	W/1	W/2		Ads	Calves	Moose
I	4	5	42	11	1	0	63	13	76
II	1	9	16	9	0	2	35	11	46
III [4]	12	10	101	67	11	2	201	91	292
IV [5]	31	21	220	61	6	0	339	73	412
Total	48	45	379	148	18	4	638	188	826

1 I = Devil Canyon to Talkeetna, II = Talkeetna to Montana Creek, III = Montana Creek to Yentna River and IV = Yentna River to Cook Inlet.

2 Im = small antlered males, mostly yearlings, probably some two-year old males; Ad = males with large antlers.

3 W/O = females without young, W/1 females with one young; W/2 females with 2 young. The W/O category includes males which have shed their antlers; this becomes prevalent by mid-December.

4 Frost and snow on vegetation during survey of Zone III made observing moose difficult; counts may be relatively lower than in other zones.

5 Snow conditions in this zone excellent for observing moose.

Table 8. Sex, age composition and zone of location for moose observed on the 20, 21 and 22 December census o the Susitna River from Devil Canyon to Cook Inlet, Alaska, 1982.

	Census # 10								
River zone [1]	Males[2]		Females[3]			Lone calves	Total		
	Ad	Im	W/0	W/1	W/2		Ads	Calves	Moose
I [4]	8	3	36	13	1	0	61	15	76
II	1	4	28	20	4	1	57	29	86
III	2	13	204	104	10	3	333	127	460
IV [5]	9	11	163	62	1	2	246	66	312
Total	20	31	431	199	16	6	697	237	934

1 I = Devil Canyon to Talkeetna, II = Talkeetna to Montana Creek, III = Montana Creek to Yentna River and IV = Yentna River to Cook Inlet.

2 Im = small antlered males, mostly yearlings, probably some two-year old males; Ad = males with large antlers.

3 W/0 =females without young, W/1 females with one young; W/2 females with 2 young. The W/0 category includes males which have shed their antlers; this was prevalent by mid-December.

4 Snow conditions in zones I-III good to excellent for counting moose.

5 Snow conditions fair (patchy, dusty, and melted out) and flying conditions fair (windy) during census of this zone; overall conditions fair for observing moose.

Table 9. Sex, age composition and zone of location for moose observed on the 5 and 6 January aerial census of the Susitna River from Devil Canyon to Cook Inlet, Alaska, 5 and 6 January 1983.

	Census # 11								
River	Males[2]		Females[3]			Lone	Total		
zone[1]	Ad	Im	W/0	W/1	W/2	calves	Ads	Calves	Moose
I[4]	2	2	45	16	1	0	66	18	84
II	1	2	43	19	3	1	68	26	94
III	0	2	160	73	11	4	246	99	345
IV[5]	-	-	-	-	-	-	-	-	-
Total	3	6	248	108	15	5	380	143	523

1 I = Devil Canyon to Talkeetna, II = Talkeetna to Montana Creek, III = Montana Creek to Yentna River and IV = Yentna River to Cook Inlet.

2 Im = small antlered males, mostly yearlings, probably some two-year old males; Ad = males with large antlers.

3 W/0 = females without young, W/1 females with one young; W/2 females with 2 young. The W/0 category includes males which have shed their antlers; this was prevalent by mid-December.

4 In this survey, 7 moose were observed on Indian River 200 m up from the Susitna River and 8 moose were observed on Portage Creek 800 m up from the Susitna River; neither group was included in the talley for that respective zone but this note may indicate that more moose are moving toward the Susitna River.

5 Snow conditions in this zone insufficient for observing moose.

Table 10. Sex, age composition and zone of location for moose observed on the 20 and 24 January aerial census of the Susitna River from Devil Canyon to Cook Inlet, Alaska, 1983.

River zone [1]	Census # 12								
	Males[2]		Females[3]			Lone calves	Total		
	Ad	Im	W/O	W/1	W/2		Ads	Calves	Moose
I [4]	0	0	21	13	3	0	37	19	56
II	0	0	40	8	2	0	50	12	62
III	0	1	146	77	8	4	232	97	329
IV [5]	-	-	-	-	-	-	-	-	-
Total	0	1	207	98	13	4	319	128	447

1 I = Devil Canyon to Talkeetna, II = Talkeetna to Montana Creek, III = Montana Creek to Yentna River and IV = Yentna River to Cook Inlet.

2 Im = small antlered males, mostly yearlings, probably some two-year old males; Ad = males with large antlers.

3 W/O = females without young, W/1 females with one young; W/2 females with 2 young. The W/O category includes males which have shed their antlers; this was prevalent by mid-December.

4 Notes from the previous survey (5 January 1983) indicated that a group of 7 moose were observed on Indian River 200 m upstream from the Susitna River. On the 20 January 1983 census, a group of 7 moose were observed on the Susitna River 2.4 km upsteam from Indian River. I presume this group of moose was the same individuals observed on 5 January 1983.

On 20 January 1983, well defined moose trails were observed along the tops of ridges which parallel the steep-walled section of the Susitna River between the Devil Canyon dam site and Indian River. It appeared that there had been a general movement of moose paralleling the river, and it was also apparent, in some locations that moose had attempted to descend to the river bottom but had to retreat due to steepness of the canyon's side walls.

5 Snow conditions in this zone inadequate for observing moose.

Table 11. Sex, age composition and zone of location for moose observed on the 7 and 9 February aerial census of the Susitna River from Devil Canyon to Cook Inlet, Alaska, 1983.

	Census # 13								
River zone [1]	Males[2]		Females[3]			Lone calves	Total		
	Ad	Im	W/O	W/1	W/2		Ads	Calves	Moose
I	0	0	8	6	2	0	16	10	26
II	0	0	25	8	1	0	34	10	44
III	0	1	107	63	4	5	175	76	251
IV [4]	0	0	118	42	1	1	161	45	206
Total	0	1	258	119	8	6	386	141	527

1 I = Devil Canyon to Talkeetna, II = Talkeetna to Montana Creek, III = Montana Creek to Yentna River and IV = Yentna River to Cook Inlet.

2 Im = small antlered males, mostly yearlings, probably some two-year old males; Ad = males with large antlers.

3 W/O = females without young, W/1 females with one young; W/2 females with 2 young. The W/O category may also include males which have shed their antlers; this is prevalent by mid-December.

4 Some snow and frost on trees, but overall condition excellent for observing moose in this zone.

Data gathered during the winter of 1982-83 indicate that the greatest number of moose (934) were counted on the 20-22 December 1982 census. The greatest total number of moose counted in zones I-IV, during this winter, were 84, 94, 460 and 412, respectively; an aggregate total of 1050 different moose.

Relatively early snowfall in the winter of 1982-83, enabled a census (No. 7) to be conducted on 29 October and 6 November 1982. Due to the earliness of this census and the promptness with it was conducted after the snowfall (probably before non-resident moose could move into the wintering area), I believe that the results are indicative of the numbers of moose which are relatively resident to floodplain habitats and seldom travel far from these areas during their annual cycle. The relative scarcity of snowfall after December and the melting of that which had fallen earlier in the winter were associated with a decrease in numbers of moose observed on censuses conducted after the 20-22 December 1982 census. This early decrease in numbers of moose in floodplain habitats is apparently in contrast to the much later peak in numbers of moose observed during the winter of 1981-82 on the 1 and 2 March census. Of course, additional snowfall in the winter of 1982-83 would most probably stimulate moose to return to winter floodplain habitats. Peak numbers of moose observed on any single census conducted in 1981-82 (369 moose) were less than one half the number of moose observed on a single census thus far during the winter of 1982-83 (934 moose).

A summary of the percentage of calf moose observed within each zone for each census is presented in Table 12. These data exhibit variation in percent of calves observed between zones and also over time (between censuses) within a particular year. Zones I and IV appeared to contain lower percentages of calf moose than zones II and III. No obvious seasonal change in percent of calf moose observed was noted over time. One would expect a decrease in the percent of calf moose within populations due to mortality but such theoretical changes may have been obscured by differential movement behaviors of sex-age categories within each subpopulation and/or difficulties in distinguishing calves from adults.

By mid-January, calf moose appear large and are sometimes difficult to distinguish from adult moose, and from that time on calves may be found at considerably greater distances from their parent, a behavior that contributes to the difficulty in assessing relative size of moose and in assigning them to an age class.

Casual observations during censuses lead me to believe that there is at least one area within zone III which always appears to contain a disproportionately larger number of female moose with calves than other areas. This observation and its biological significance will be investigated and tested in a future report, after more data are gathered and analyzed.

Table 12. Percent of calves observed on each of 13 censuses for moose in floodplain habitat along 4 zones of the Susitna River between Devil Canyon and Cook Inlet, Alaska 1981-83.

No. census	Date	River zone[1] (n)				Census total
		I	II	III	IV	
1	9 and 10 Dec 1981	22 (36)	31 (16)	31 (147)	28 (123)	29 (322)
2	28 Dec 81, 4 Jan 1982	22 (18)	26 (19)	26 (191)	28 (96)	26 (324)
3	2 and 6 Feb 1982	0 (8)	20 (5)	25 (134)	21 (92)	23 (239)
4	1 and 2 Mar 1982	0 (7)	24 (17)	16 (236)	20 (107)	17 (369)
5	23 and 24 Mar 1982	20 (25)	36 (25)	20 (166)	20 (41)	22 (257)
6	12 April 1982	14 (7)	17 (18)	32 (57)	-	27 (82)
7	29 Oct, 6 Nov 1982	22 (14)	25 (4)	32 (60)	29 (89)	29 (171)
8	10 and 18 Nov 1982	18 (57)	36 (28)	25 (232)	26 (159)	25 (476)
9	1,2 and 6 Dec 1982	17 (76)	24 (46)	31 (292)	18 (412)	23 (826)
10	20-22 Dec 1982	20 (76)	34 (86)	28 (460)	21 (312)	25 (934)
11	5 and 6 Jan 1983	21 (84)	28 (94)	29 (345)	-	27 (523)
12	20 and 24 Jan 1983	34 (56)	19 (62)	29 (329)	-	29 (447)
13	7 and 9 Feb 1983	38 (26)	23 (44)	30 (251)	22 (206)	27 (527)

1 I = Devil Canyon to Talkeetna, II = Talkeetna to Montana Creek, III = Montana Creek to Yentna River and IV = Yentna River to Cook Inlet.

Relative value of winter range to moose is often expressed in terms of the density of moose it supports during the winter period. Very rough approximations of the quantity of floodplain habitat surveyed for moose during each census was obtained by making visual estimates from 1:63,360 scale USGS topographic maps (Table 13). These data along with values from Tables 7-9 yielded maximum estimates of 1.4, 2.1, 2.6 and 4.0 moose per km^2 of surface habitat for river zones I-IV, respectively. Since approximately 38 to 52 percent of the surface area within a zone may be underlain by frozen portions of the river and does not support growth of forage or cover vegetation, densities per unit of "useful" habitat would be considerably higher.

Casual observations during floodplain censuses indicate apparent differences between densities of moose observed on the Delta Islands and on Bell Island (see Fig. 1). Both islanded areas are extensive but Bell Island apparently contains habitat more favorable for moose as it appears to support significantly greater numbers of wintering moose. These casual observations and their biological significance will be investigated more fully in a subsequent report when additional data are available and analyzed. These sorts of data will be extremely useful when information on characteristics of ideal moose winter range and biotic potential of various habitats are needed to adequately assess mitigation options.

Table 13. Surface area (km^2) of floodplain habitat types in four geographical zones of the Susitna River between Devil Canyon and Cook Inlet, Alaska.

Habitat type	River zone[1]			
	I	II	III	IV
Terrestrial	28[2]	23	104	65
Aquatic	31	21	70	39
Total	59	44	174	104

1 I = Devil Canyon to Talkeetna, II = Talkeetna to Montana Creek, III = Montana Creek to Yentna River and IV = Yentna River to Cook Inlet.

2 Values for surface area derived from visual estimates of habitat types illustrated on 1:63,360 scale USGS Topographic maps.

AFFINITIES FOR RIPARIAN HABITATS

Before one can knowledgeably assess impacts of the proposed Susitna Hydroelectric project on subpopulations of moose downstream from Devil Canyon, it must be known how and when those respective subpopulations of moose utilize Susitna River floodplain habitats. To knowledgeably predict potential impacts, one must also be cognizant of the annual (between year) variation which may be expected in those patterns of use so behavioral patterns for those subpopulations may be adequately "bounded".

Data obtained from radio-collared moose and presented in Tables 12 and 13 and Tables 14 and 15 summarize information available on timing and frequency of use of riparian habitats and on variation in affinities for those habitats, respectively.

Data gathered from individual moose north of Talkeetna indicated for 2 consecutive years that the greatest affinity for use of riparian habitats in that region occurred during May and June (Table 14). Since radio-collared moose throughout the study area calved between mid-May and mid-June, riparian habitats must be important to this subpopulation of moose for production and/or survival of newly born young. Particular factors involved in this association have not yet been identified but might be related to presence of early growing nutritious foods (LeResche and Davis 1973) and/or relative absence of predators (Stringham 1974 and Ballard *et al*. 1980). Apparent "unattractiveness" of riparian habitats from January through April may in part be related to the relatively mild winters of 1980-81 and 1981-82.

Table 14. Timing and frequency of use of Susitna River riparian habitats by individual radio collared female moose, between Talkeetna and Devil Canyon, Alaska 1981-1982.

Individual	1981					1982				
	Mar. and Apr.[a]	May and Jun.	Jul. and Aug.	Sep. and Oct.	Nov. and Dec.	Jan. and Feb.	Mar. and Apr.	May and Jun.	Jul. and Aug.	Sep. and Aug.
29	1/7 [b]	4/7	0/7	1/7	0/5	0/5	0/5	3/6	0/3	0/2
42	0/6	0/7	0/7	0/7	0/5	0/5	0/5	1/6	0/3	0/2
63	0/6	2/7	0/7	0/7	0/5	0/5	0/5	0/6	0/3	0/3
68	0/6	5/7	0/7	0/7	0/5	0/5	0/5	3/6	0/3	0/1
69	0/6	0/7	0/7	0/7	0/5	0/5	0/5	0/6	0/3	0/1
73	0/6	3/7	0/7	0/7	0/5	0/5	0/5	1/6	1/3 [c]	0/2
74	0/6	1/7	0/7	1/7	1/5	0/5	0/5	2/5 [d]		
80	0/6	3/4 [e]								
81	0/5	3/7	0/7	0/7	0/5	0/5	0/5	1/6	0/2	0/2
No. individuals relocated in riparian habitat/Total individuals	1/9	7/9	0/8	2/8	1/8	0/8	0/8	6/8	1/7	0/7

a Number of radio relocations in riparian habitat/total number of observations during respective time period.

b Riparian habitat observation on 28 April.

c Riparian habitat observation on 8 July.

d Individual observed dead in Susitna River south of Talkeetna on 16 July.

e Individual captured south of Talkeetna but moved north of Talkeetna and was found silted and dead on bank of Susitna River; died approximately 6 July.

Data presented in Table 15 indicate that for 2 consecutive years, moose radio-collared downstream from Talkeetna sought riparian habitats in December, were most frequently relocated in those habitats in February and March and proceeded to depart from them during April. However, some individuals in this region remained in riparian areas and apparently utilized those habitats throughout the year. This behavior was most typical of individuals which were found to range in and near extensive islanded areas in the Susitna River, i.e., the Delta Islands and the Big/Bell Island complexes. Available data indicated that roughly 16 percent (4 of 22 and 5 of 35 moose radio-collared in 1981 and 1982, respectively) of this subpopulation of moose which utilized riparian habitats in winter were found to be "resident" to those areas throughout the year. During more severe winter conditions one would probably expect that riparian habitats are shared amongst a higher proportion of "non resident" moose.

Though the greatest potential impacts to the upstream subpopulation may occur in May and June and to the downstream subpopulations from December through March, there is a portion of moose in the latter population which utilize riparian habitats throughout the year and will be vulnerable to impacts during any seasonal period.

Data exhibiting variation in affinities for riparian habitats and in behavioral patterns for both individuals and subpopulations of

Table 15. Dates indicating chronology of departure from Susitna River riparian habitat for female and male moose radio-collared in habitats downstream from Talkeetna, 1980-82.

Date	Females		Males	
	Riparian [a]	Non-riparian	Riparian	Non-riparian
1980				
Apr.	3 [b]		3	
May	ND [c]	ND	ND	ND
Jun.		3		3
Jul.		3		3
Aug.		3		3
Sep.		3		3
Oct.		3		2
Nov.		3		2
Dec.		3		3
1981				
Jan.		3	0	2
Feb. [d]		ND	ND	ND
Mar.	15	3	4	2
Apr.	7	11	1	5
May	2	16	0	6
Jun.	4	14	0	6
Jul.	5	13	1	5
Aug.	3	15	0	6
Sep.	4	14	1	4
Oct.	3	14	1	4
Nov.	2	15	0	5
Dec.	8	9	1	4
1982				
Jan. [e]	9	8	0	5
Feb. [f]	18	6	7	4
Mar.	17	10	5	6
Apr.	12	15	5	6
May	5	22	3	7
Jun.	5	22	3	6
Jul.	3	24	1	7
Aug.	4	23	1	7
Sep.	3	23	2	6

[a] Riparian = individuals relocated at least once during respective time period within outmost banks of the Susitna River; Non-riparian = individual not relocated during respective time period within outmost banks of the Susitna River.

[b] 3 females and 3 males radio-collared in riparian habitats.

[c] ND = no data collected during time period.

[d] 16 females and 4 males radio-collared in riparian habitats.

[e] 7 females and 6 males radio-collared in riparian habitats.

[f] 3 females radio-collared in riparian habitats.

moose are presented in Table 16. These data demonstrate considerable differences in movement patterns between upstream and downstream subpopulations of moose. Those subpopulations of moose downstream from Talkeetna spent a considerable amount of time at distances greater than 5 miles from the Susitna River, whereas their counterparts north of Talkeetna were seldom relocated farther than 5 miles from the Susitna River. Males in both subpopulations, usually ranged farther than females from the riparian habitats. These data also exhibit noteable differences between behavioral patterns of individual moose within a subpopulation.

These data illustrate that impacts to subpopulations of moose which utilize Susitna River riparian habitats primarily as winter range, may be realized in areas quite remote from the banks of the river and the source of the impact. Impacts most remote from the Susitna River will probably be realized in male moose of each subpopulation.

Data presented in Table 15 show how far individual moose were relocated from their initial capture site in consecutive years. In most cases, individual moose were consistent between years in the distance they moved away from their capture site or winter range; larger differences were apparent between individuals.

Table 16. Variation in and general affinities for floodplain habitats of the Susitna River exhibited by moose radio-collared and relocated periodically during complete yearly periods.

Area Population[1]	Sex[2]	Treatment[3]	No. Moose[4]	No. Relocations[5]	Percent of relocations at distances (mi) from floodplain (F): F	0-1	1-3	3-5	5-10	10-15	15-20	20+
Upstream	F	Max	1	39	15	64	21	0	0	0	0	
		Min	1	39	0	13	26	54	8	0	0	
		Total	8	310	7	44	37	9	2	0	T[6]	
	M	Max	1	40	3	30	45	23	0			
		Min	1	38	0	34	34	3	29			
		Total	3	103	1	40	39	10	11			
Downstream												
Ws	F	Max	1	41	95	5	0	0	0	0	0	
		Min	1	41	2	0	5	0	5	89	0	
		Total	13	524	33	8	16	1	19	21	1	
Es	F	Max	1	38	3	3	5	26	63	0	0	
		Min	1	38	0	3	3	13	34	21	26	
		Total	5	194	3	3	12	21	40	12	9	
All	M	Max	1	41	7	34	59	0	0	0	0	0
		Min	1	38	0	0	0	0	3	26	34	37
		Total	6	211	6	10	13	6	23	10	18	13

1 Upstream = north of Talkeetna, Downstream = south of Talkeetna, Ws = Westside of Susitna River, Es = Eastside of Susitna River.

2 F = female, M = male.

3 Max = data for individual moose which exhibited maximum affinity for floodplain habitats, Min = similar but for minimum affinity, Total = affinities calculated for respective population.

4 Moose = moose yrs, may represent 2 years of study for 1 moose.

5 Relocations = data collected for entire calendar years, sampling intensity relatively similar throughout year.

6 T = 0 0.5 percent.

These data may generally be interpreted to show how far individual moose may travel in an annual cycle in order to arrive at or to return to suitable and traditional winter range. Some moose may never range far from Susitna River riparian habitats but yet they may still have to travel substantial distances between seasonal ranges; i.e., ranges of individual moose are not always spatially arranged perpendicular to the Susitna River, some may be almost parallel to riparian habitats (re: Male No. 92).

MOVEMENTS OF RADIO-COLLARED MOOSE

To knowledgeably assess impacts of hydroelectric development of the Susitna River on moose, one must; 1) delineate subpopulations of moose which are ecologically affiliated with habitats potentially subject to alteration; 2) determine in what way, when and how many moose from those subpopulations utilize floodplain habitats; 3) determine how and where potential impacts to those subpopulations will ultimately be realized, and 4) propose various mitigation plans and determine their overall positive effects on the moose resource. These sorts of data can only be provided by studying movements of individual moose within those subpopulations and determining the ecological significance of those movements.

Data presented in Fig. 4 illustrate the extent of movements for moose captured and radio-collared along the Susitna River between Devil Canyon and Cook Inlet. These data may be used indicate the minimum spatial extent that impacts incurred by moose while utilizing Susitna River riparian habitats will be realized. These data show that impacts to moose on the Susitna River floodplain between Devil Canyon and Cook Inlet may ultimately become obvious in areas as far west as Beluga Lake, Little Peters Hills, the Chulitna River, as far north as Hurricane; or as far east as Chunilna Creek, Sheep River, the head waters of Sheep Creek, Pittman and Big Lake; an area covering approximately 8938 km^2.

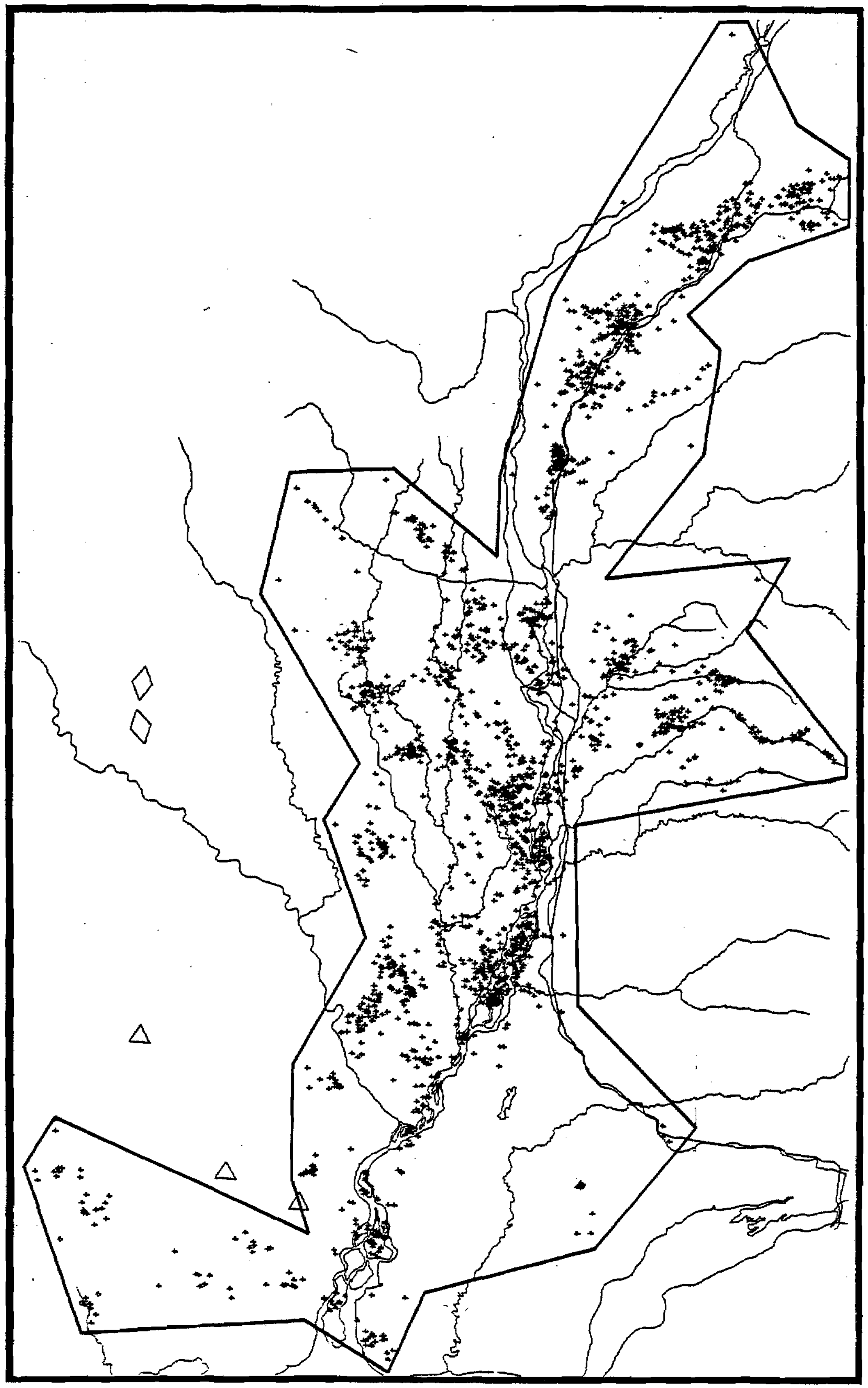

Figure 4. Polygon encompassing 2178 relocation points for 10 moose radio-collared 17 April, 1980, 29 moose radio-collared 10-12 March, 1981 and 17 moose radio-collared 26 February - 10 March, 1982 along the Susitna River between Devil Canyon and Cook Inlet, Alaska and monitored through 20 October, 1982. (inclusive area = 8938 km^2)

Likewise, positive impacts of mitigation efforts undertaken in riparian habitats may be realized throughout this same area. It is apparent that impacts to moose from hydroelectric development are very likely to ultimately be realized in areas quite distant from the Susitna River.

Figs. 5 and 6 illustrate points of relocation for female and male radio-collared moose, respectively. These data indicate that extent and spatial relationships of impacts will, in part, depend on the sex of affected moose. Though samples for males were considerably smaller than for females, particularly north of Talkeetna, the males as a whole appeared to range more widely. Impacts to male moose will most probably be realized farther from riparian habitats than for females.

Changes in environmental conditions along the Susitna River as a result of hydroelectric development may directly affect productivity of some subpopulations of moose or productivity of subpopulations of moose which calve in areas distant from riparian habitats may be secondarily affected through elimination of female moose or through alteration of their nutritive condition. Likewise, mitigation measures which improve the calving environment or winter range condition in riparian habitats may increase productivity of moose subpopulations in those particular areas. Consequently, enhancement of environments for moose in riparian areas which result in greater productivity, may subsequently place added stress on environments used by those subpopulations

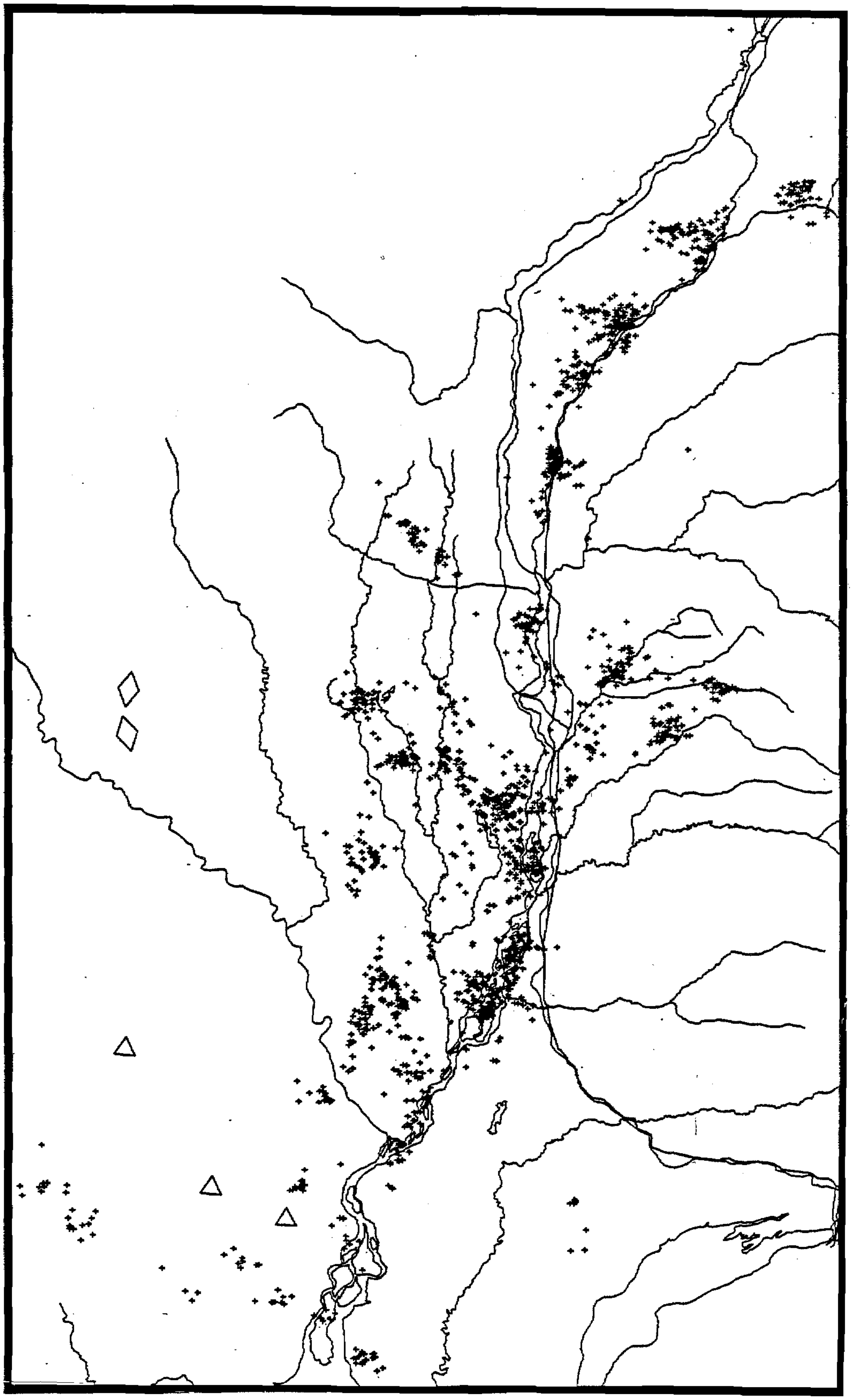

Figure 5. Radio-relocations (1671) for 40 female moose captured and radio-collared along the Susitna River between Devil Canyon and Cook Inlet, Alaska, 1980-82.

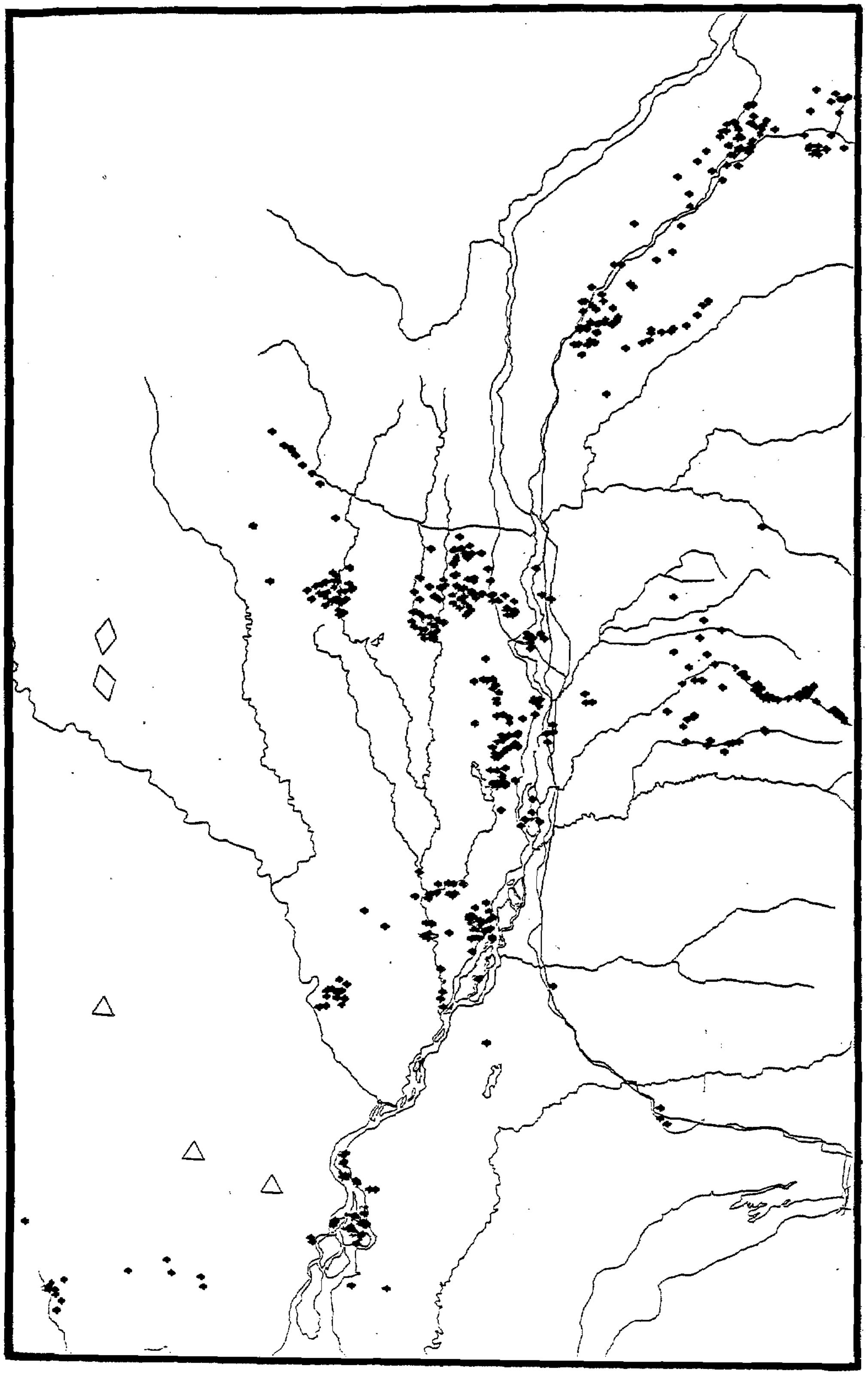

Figure 6. Radio-relocations (562) for 15 male moose captured and radio-collared along the Susitna River between Devil Canyon and Cook Inlet, Alaska, 1980-82.

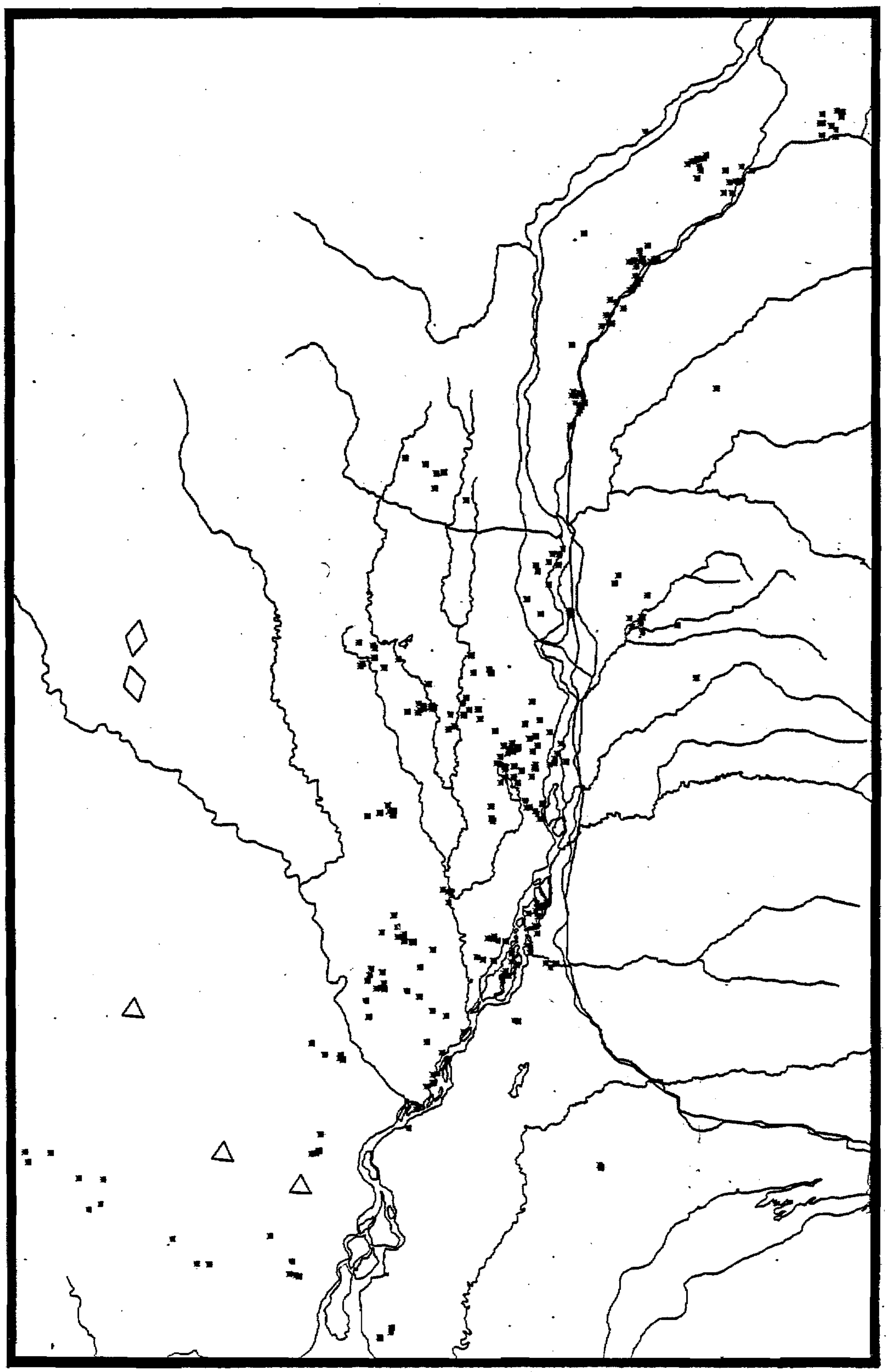

Figure 7. Locations (314) where 40 female moose captured and radio-collared along the Susitna River between Devil Canyon and Cook Inlet, Alaska, were radio-relocated during the calving period (10 May - 17 June), 1980-82.

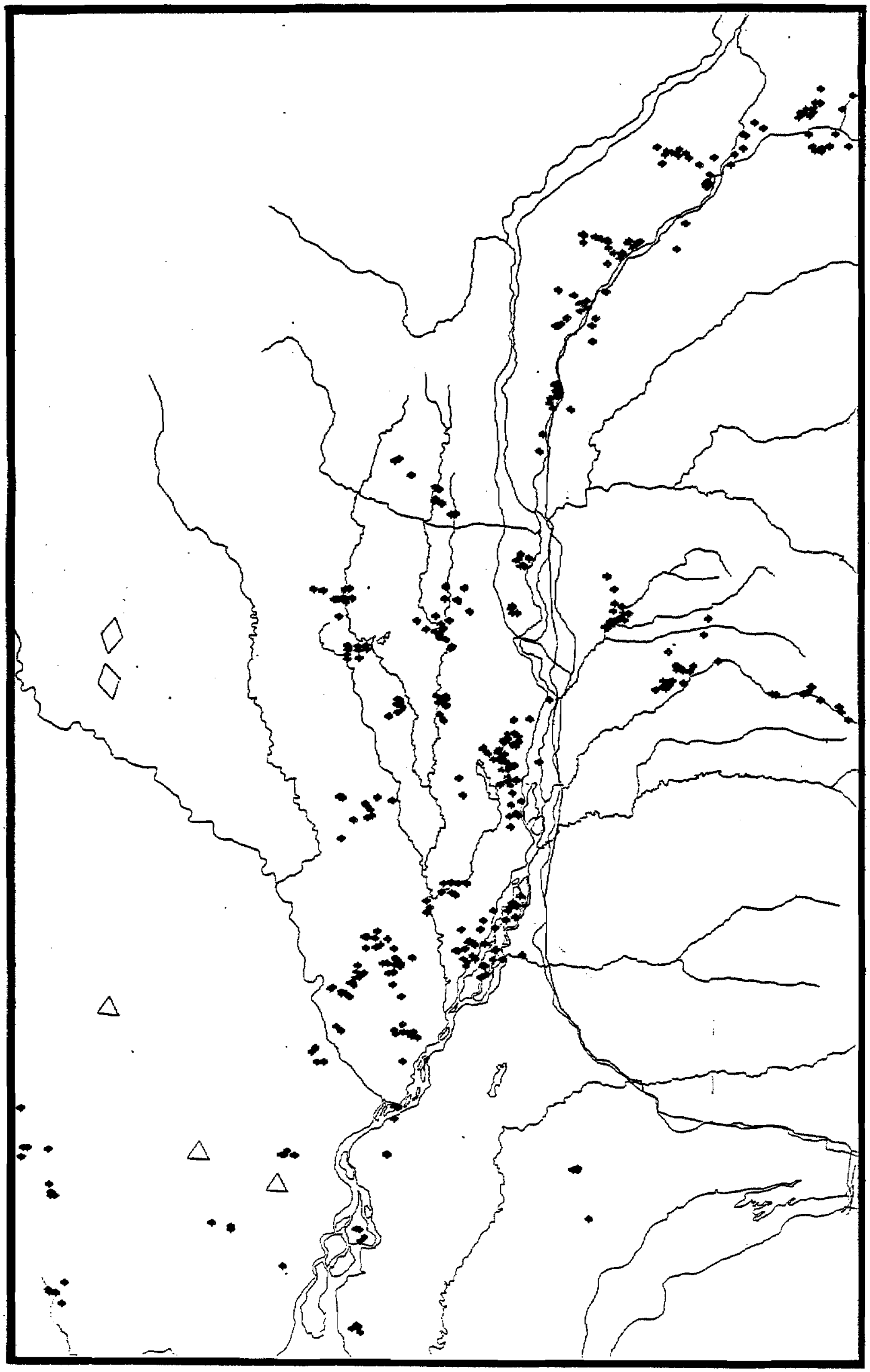

Figure 8. Locations (447) where 12 male and 39 female moose captured and radio-collared along the Susitna River between Devil Canyon and Cook Inlet, Alaska, were radio-relocated during the summer period (1 July - 31 August), 1980-82.

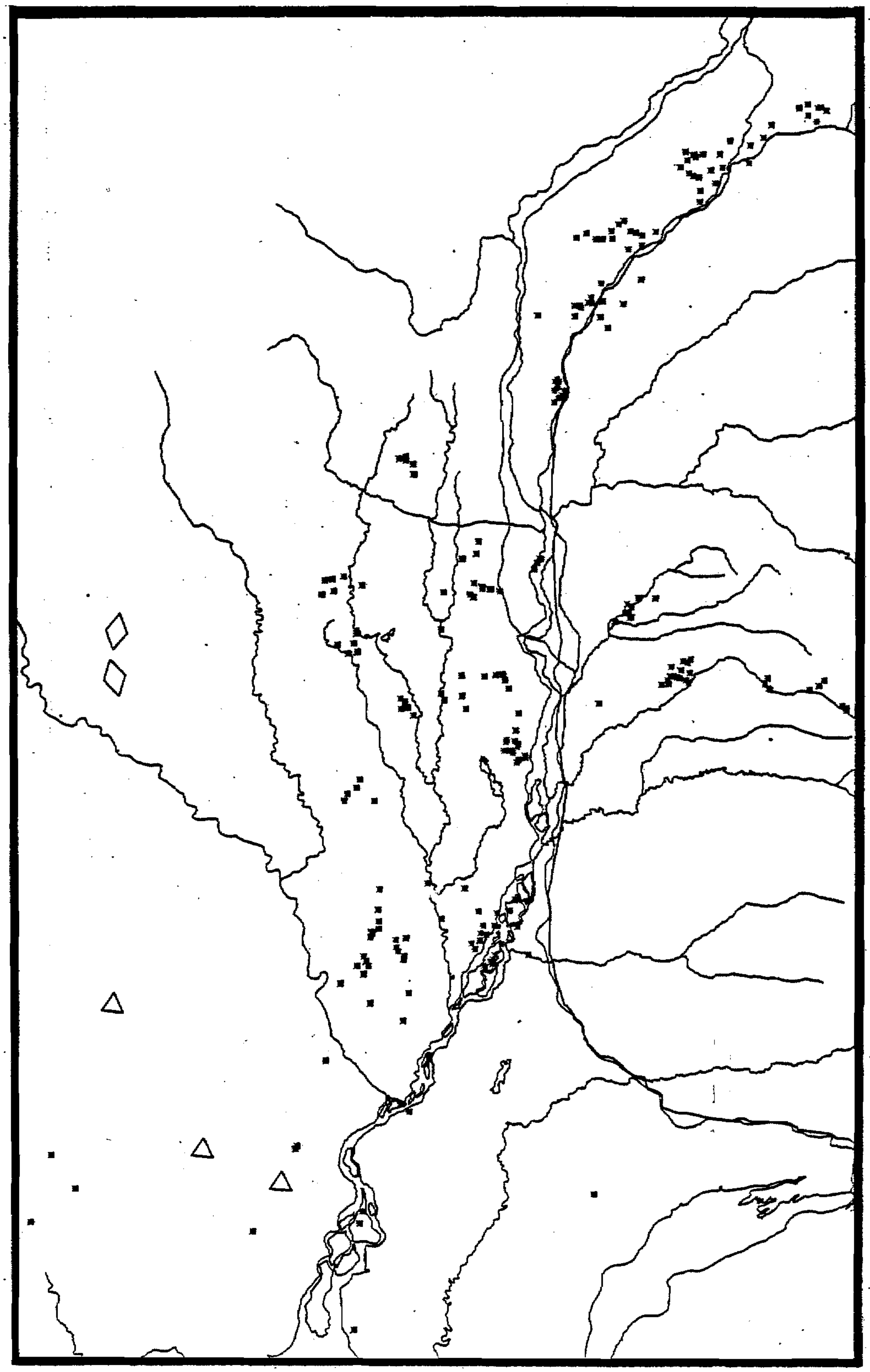

Figure 9. Locations (239) where 11 male and 38 female moose captured and radio-collared along the Susitna River between Devil Canyon and Cook Inlet, Alaska, were radio-relocated during the month of September ("hunting season"), 1980-82.

Data presented in Figs. 10 and 11 illustrate locations, where female and male moose, respectively, which wintered in Susitna River riparian habitats were subsequently relocated during the rutting period. Some moose of each sex spent the rut period in or near their winter range and others rutted up to 40 km from their winter range along the Susitna River. Impacts of hydro-electric development on moose which winter on the Susitna River, may likely affect rutting activities in these areas.

Data gathered from moose captured and radio-collared along the Susitna River in late winter and relocated during subsequent winter periods (1 January - 28 February) indicated that not all individual moose returned to riparian habitats (Fig. 12). Other data collected indicated individual and annual variation in the timing of arrival on Susitna River riparian winter range. Though most moose arrive on winter range by January, some arrive later and some may winter in entirely different and distant areas in subsequent winters. These data support the contention that winter river censuses may underestimate the numbers of different moose which seek winter range in riparian habitats. Information collected from behavior of radio-collared moose may be used in conjunction with data from river censuses to adjust for under-estimates in the numbers of different moose which may be dependent on floodplain habitats for winter range.

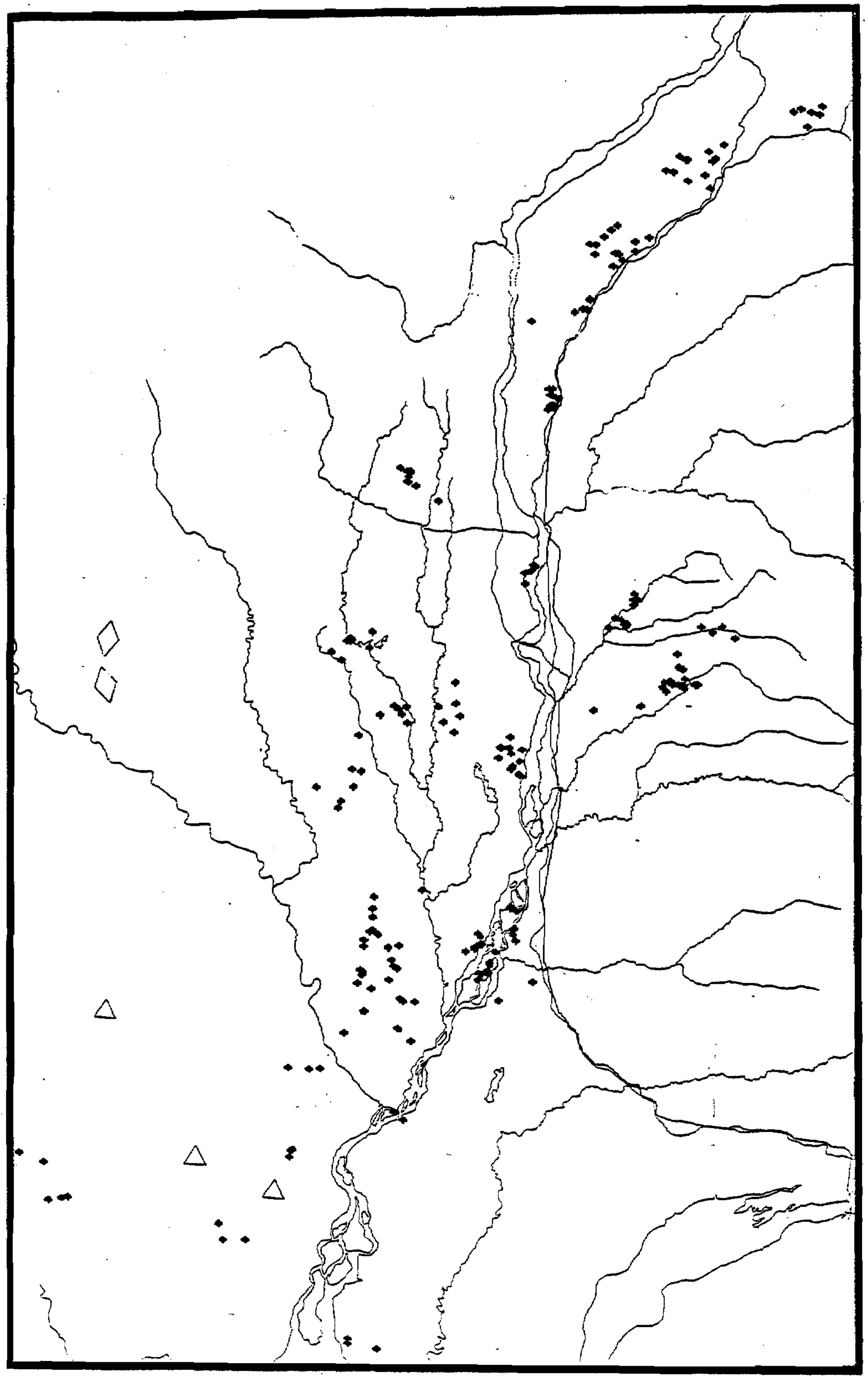

Figure 10. Locations (204) where 38 female moose captured and radio-collared along the Susitna River between Devil Canyon and Cook Inlet, Alaska, were radio-relocated during the rut period (14 September - 31 October), 1980-82.

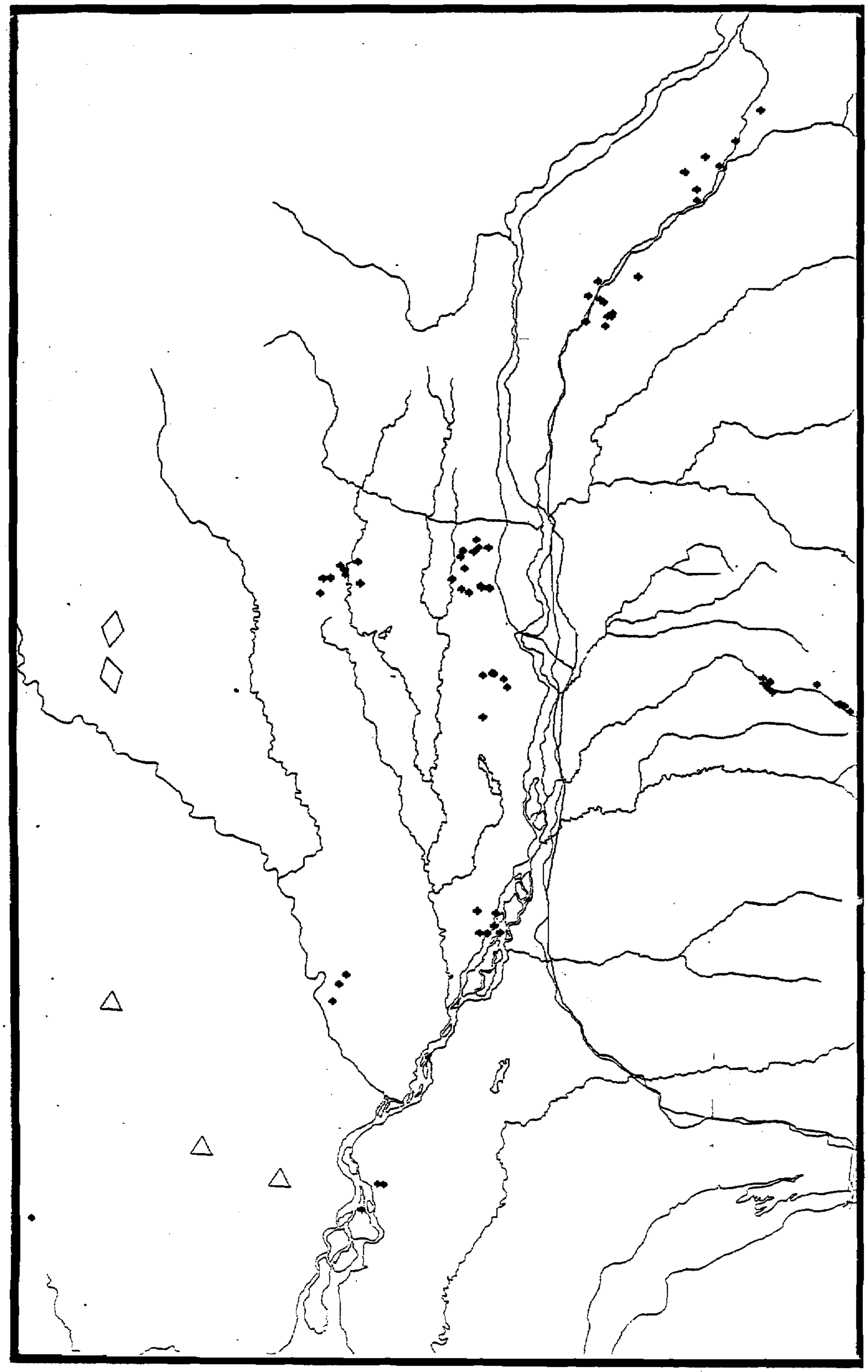

Figure 11. Locations (69) where 11 male moose captured and radio-collared along the Susitna River between Devil Canyon and Cook Inlet, Alaska, were radio-relocated during the rut period (14 September - 31 October), 1980-82.

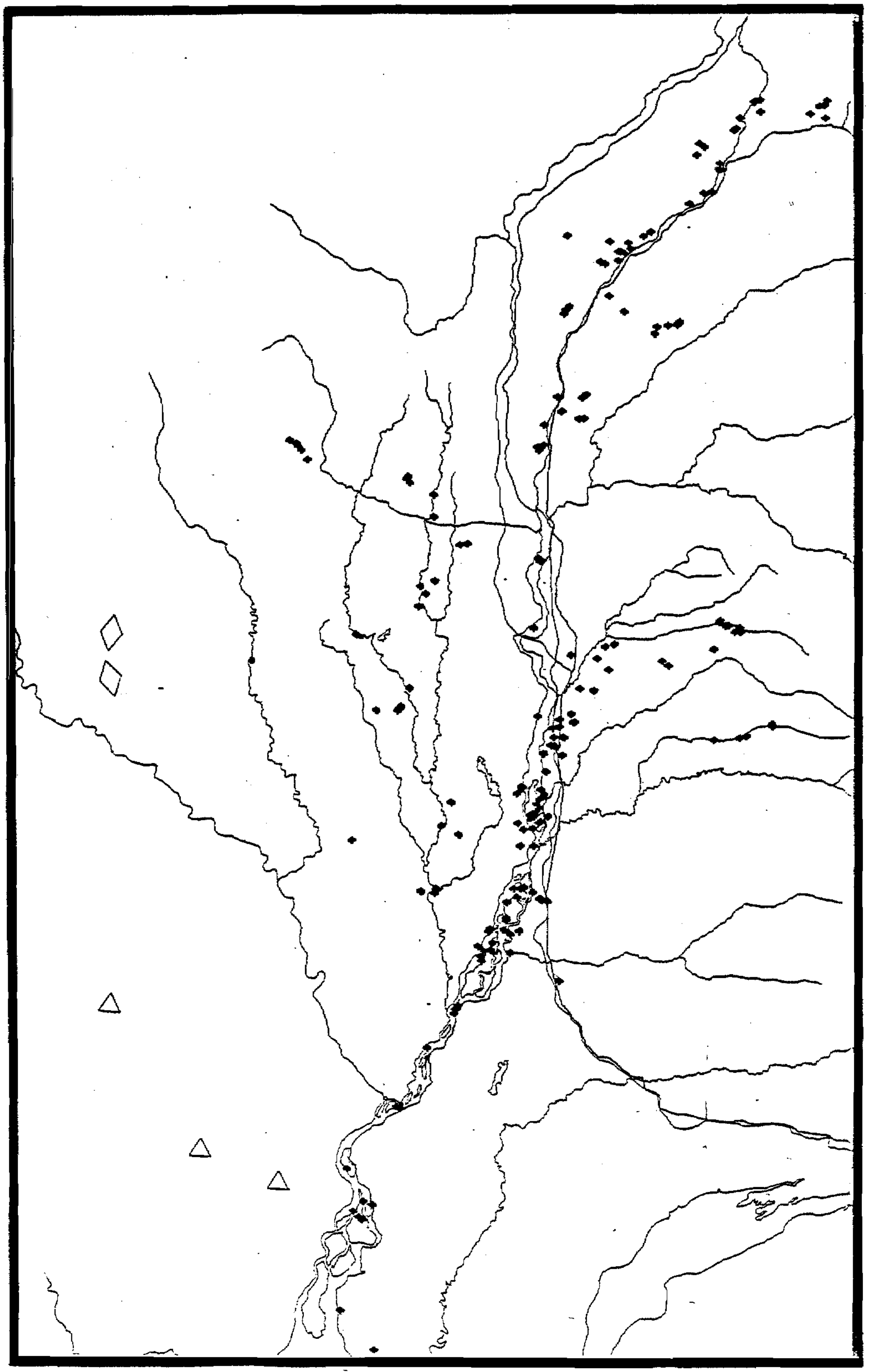

Figure 12. Locations (184) where 7 male and 40 female moose captured and radio-collared along the Susitna River between Devil Canyon and Cook Inlet, Alaska, were radio-relocated during the winter period (1 January - 28 February), 1980-82.

Information on size, shape and spatial arrangement of ranges for male and female moose is useful in assessing how individuals utilize available resources and habitat. Since previous data collected indicate that most moose are very patterned and consistent in their use of winter range along the Susitna River and appear to explore and/or exploit few areas that are not in their normal range, they would be slow to realize the presence of new winter range, which may be created as a mitigation measure, unless it were within their normal range. Likewise, with information on sizes and spatial arrangement of ranges, the aeral influence of habitat alterations may be predicted. An assessment of annual variation in range size for individual moose may be used to predict annual variation in use of Susitna River riparian habitats and to provide information on the utility of studying movements of individuals over several consecutive years. Such data also document adjustments moose make to their range in response to annual variation in climatic conditions.

Data presented in Table 17 provide information on variation in range size between individuals within sex classes, between sex classes and between consecutive years of study within individuals and sex classes. Range sizes varied greatly between individuals and within sex classes, males tended to maintain ranges of larger size than females and both sexes were found to utilize additional range in the second year they were studied.

Table 17. Array of maximum distances (km) between the capture site and a relocation site, for individual (Id) female (F) and male (M) moose, radio-collared in different areas along the Susitna River, Alaska and monitored between 0 and 3 annual cycles, 1980-82.

Area [1]	Sex	Id	Annual cycle [2] 1	2	3
T to DC	F	68	5	6	
		29	6	3	
		73	6	9	
		81	7	4	
		63	8	6	
		69	11	12	
		42	28	4	
		74	40	30	
	M	66	15	13	
		92	32	29	29
CI to F	F	39	5		
		100	10		
		97	13		
		71c	18		
		80	20		
		96	21		
		94	25		
		40	27		
		41	33		
		87	37		
		93	41		
		58b	49		
		37	7	5	
		90	7	4	
		85	10	8	
		19	17	18	
		62	17	17	
		57	21	21	
		79	24	23	
		64	24	23	
		56	26	26	
		82	37	33	
		45	38	37	
		59	41	41	
		88	43	42	
		26	18	19	15
		23	25	22	21
		22	44	46	49
	M	95	5		
		90	8		
		99	18		
		44	45		
		60	17	19	
		84	17	35	
		65	45	38	
		91	16	16	13
		27	43	42	38

1 T = Talkeetna, DC = Devil Canyon and CI = Cook Inlet.

2 Last annual cycle for each individual typically spans the 28 February - 4 April to Octobe interval. Previous cycle(s) for each individual typically spans an entire annual cycle(s from 28 February - 4 April of one year to similar dates the following year.

Within sex classes, comparisons between individual female and male moose, studied for less than 1 year, exhibited over 25 (No. 39 vs. No 58b) and 30 fold (No. 95 vs. No. 44) differences, respectively, in sizes of ranges utilized. Similar comparisons between individual female and male moose studied longer than 1 and less than 2 years, indicated individual differences in range size up to and over 35 and 4 fold, respectively. These data indicate that there are large individual differences in the size of annual ranges.

Other data presented in Table 18 indicate that some individual moose increased the size of range used the first year by over 25 percent in the second year of study (Nos. 23, 73, 82, 84, 91 and 92). Though sample sizes for individuals studied more than 2 years were small, some individuals continued to exhibit a similar but much smaller increase in annual range size.

Figs. 13 and 14 graphically illustrate annual variation in size and shape of ranges used by individual moose studied 1 year 6 months and 2 year 5 months, respectively.

Figs. 15, 16, and 17 illustrate relative size, shape and spatial arrangement for a sample of ranges from radio-collared moose monitored throughout the study. Detailed data on range size and annual alterations in range size for individuals are available in Table 16. These data exhibit a wide spectrum in method of use of Susitna River habitats by moose: from individuals with ranges

Table 18. Variation in calculated range size within and between individual (Id) female (F) and male (M) moose radio-collared in two areas along the Susitna River, Alaska and monitored different periods of time, 1980-82.

No. annual cycles[1]	Area[2]	Sex	Id	Period monitored (months)	No. relocations	Range size array (km^2)[3]	Percent change in range size[4]: Intersection year 1 & 2	Increase year 1 to 2	Intersection year (1+2) 3	Increase year (1+2) to 3
Less than 1	CI to T	F	39	9	19	10				
			71a	11	36	16				
			71c	8	18	53				
			97	9	19	57				
			96	9	19	75				
			94	9	19	75				
			40	9	18	96				
			100	9	19	98				
			80	4	10	178				
			87	9	18	242				
			71b	7	23	243				
			58b	8	17	280				
		M	95	9	19	14				
			99	9	19	87				
			44	8	17	480				
1 to 2		F	90	20	56	23	36	0.6		
			85	20	57	39	56	2.4		
			37	20	56	43	39	1.2		
			57	20	56	69	59	3.9		
			19	19	54	81	23	1.6		
			62	19	54	134	37	10		
			82	20	55	176	39	39		
			64	19	55	188	61	0.4		
			45	20	56	193	11	0.7		
			59	20	55	195	60	3.0		
			79	18	53	217	39	0		
			56	18	53	228	25	<0.0		
			88	20	57	317	57	0.2		
		M	60	18	54	143	26	0.9		
			84	19	55	430	52	30		
			65	20	55	579	58	5.8		
	T to DC	F	29	19	53	20	36	0.2		
			68	19	53	21	46	13		
			63	20	54	30	32	0		
			69	19	52	42	48	6.9		
			81	19	51	44	38	5.6		
			73	19	53	64	37	51		
			42	20	53	99	21	2.6		
			74	16	47	721	2.2	1.5		
		M	66	20	54	137	48	19		
2 to 3	CI to T	F	26	30	70	217	54	10	6.7	0
			23	30	76	268	92	34	51	1.9
			22	30	76	745	76	2.5	46	2.5
		M	91	31	78	153	67	22	34	0
	T to DC		92	31	73	483	41	27	48	8.7
	CI to T		27	30	74	650	26	5.6	15	0

1 No. of annual cycles studied from date of capture.

2 CI = Cook Inlet, T = Talkeetna and DC = Devil Canyon.

3 Area of non-overlapping, geometric union of ranges calculated for each annual cycle or part of.

4 Intersection years 1 and 2 = percent of year 1 range used in year 2, Increase year 1 to 2 = percent of range used only in year 2, Intersection years (1+2) and 3 = percent year (1+2) range used in year 3. Increase years (1+2) to 3 = percent range used only in year 3.

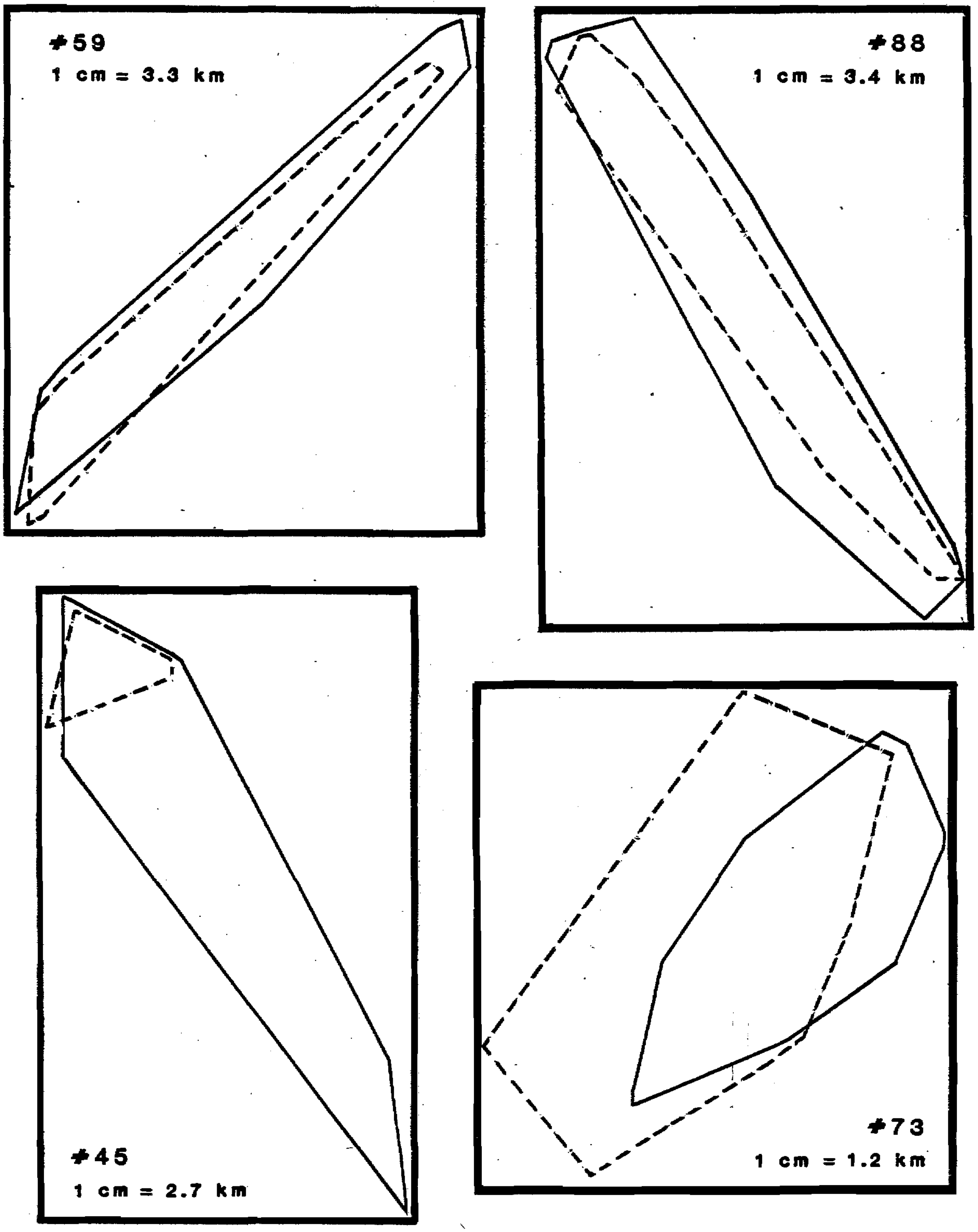

Figure 13. Variation in size and shape of ranges determined for 4 female moose captured and radio-collared along the Susitna River downstream from Devil Canyon and monitored from March 1981 through September 1982. Polygons encompass radio-relocation points for consecutive annual periods commencing from date of capture through 1981-82 (————) and 1982-83 (— — — —) annual periods.

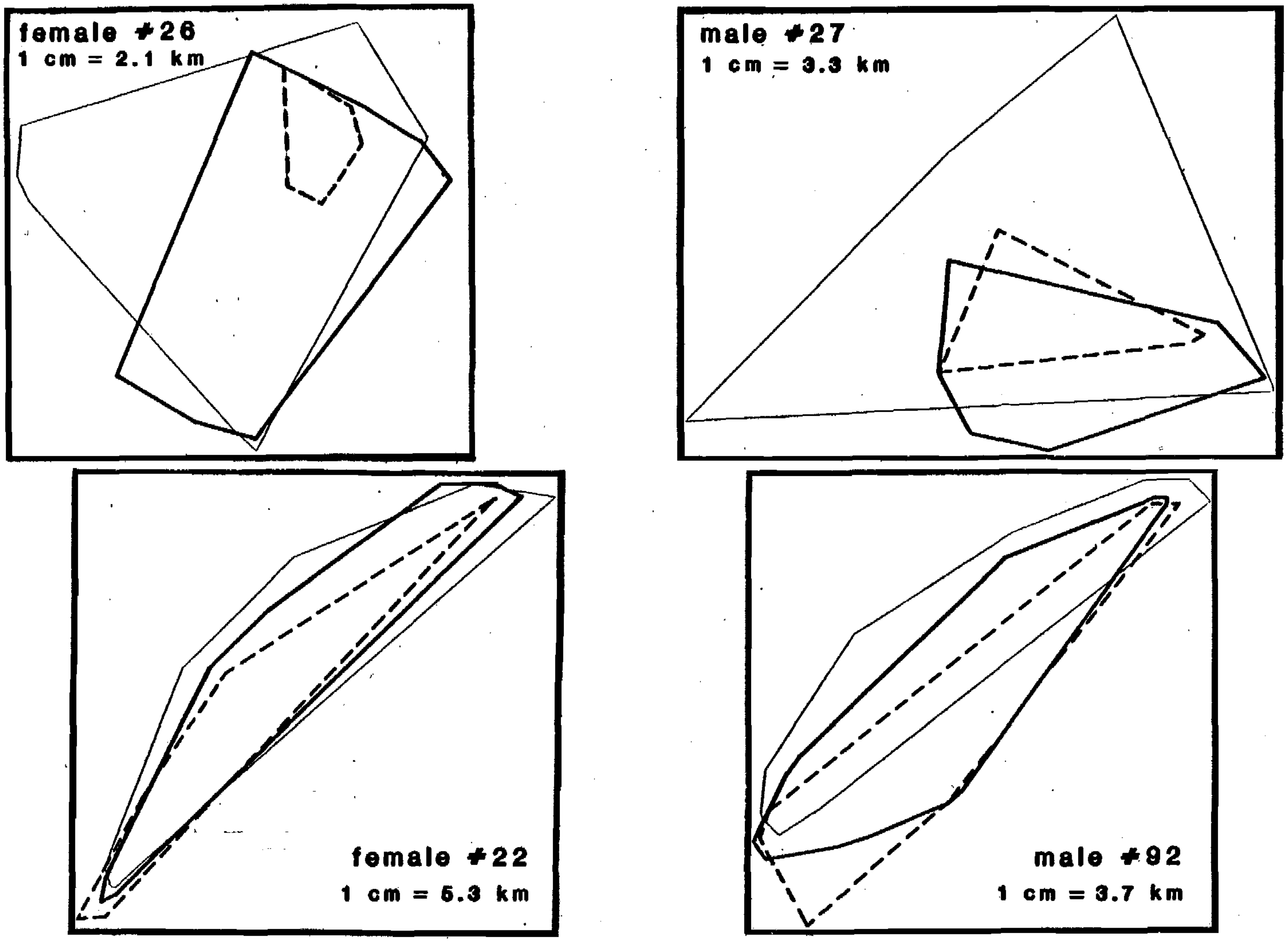

Figure 14. Variation in size and shape of ranges determined for 4 moose captured and radio-collared along the Susitna River downstream from Devil Canyon and monitored from April 1980 through September 1982. (Polygons encompass radio-relocation points for consecutive annual periods commencing from date of capture through 1980-81 (———), 1981-82 (———) and 1982-83 (- - - -) annual periods.

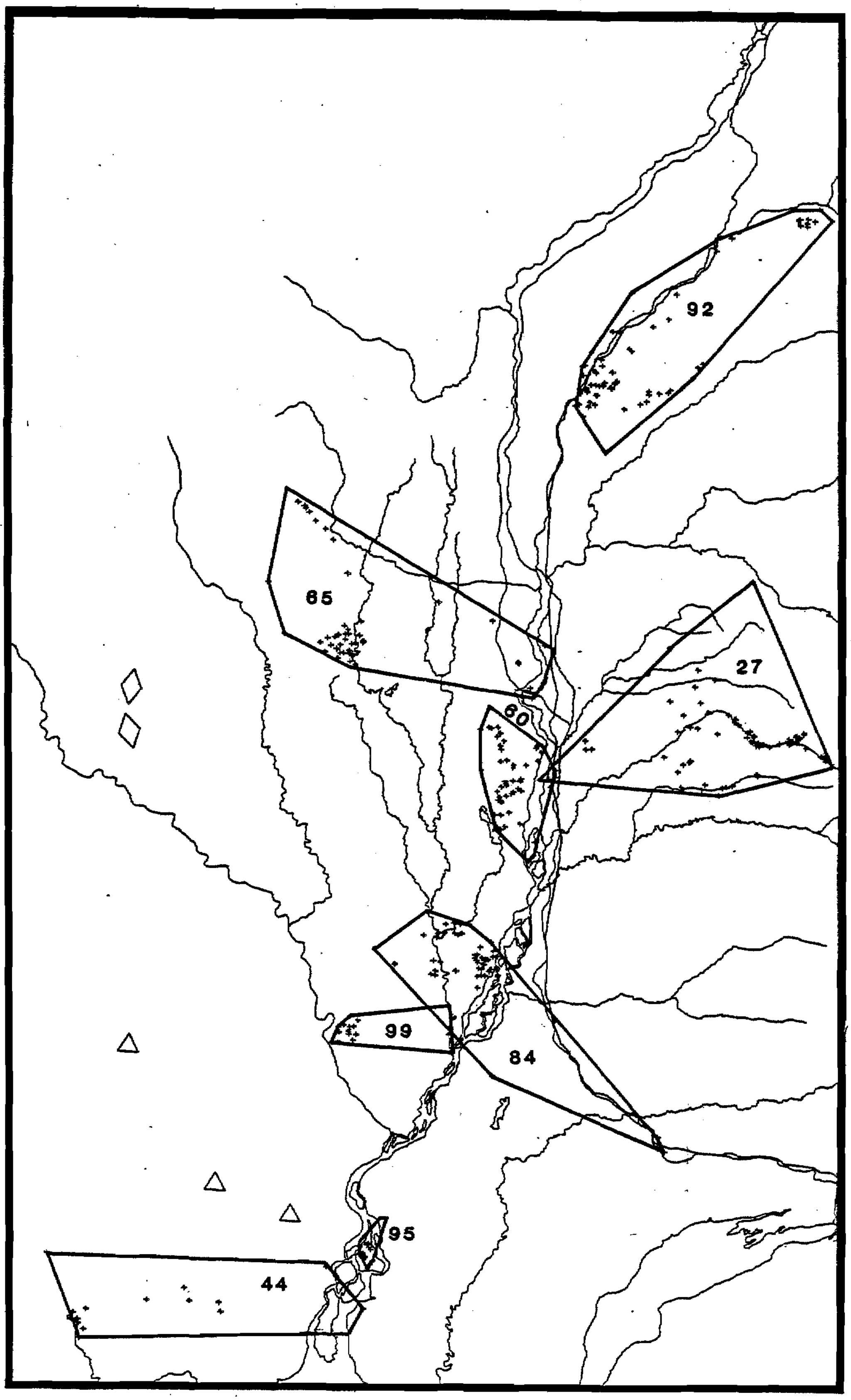

Figure 15. Shape and spatial relationships for ranges of 8 male moose captured and radio-collared along the Susitna River between Devil Canyon and Cook Inlet, Alaska and monitored during 1980-82. (Ranges depicted with polygons encompassing points of individual radio-relocations.)

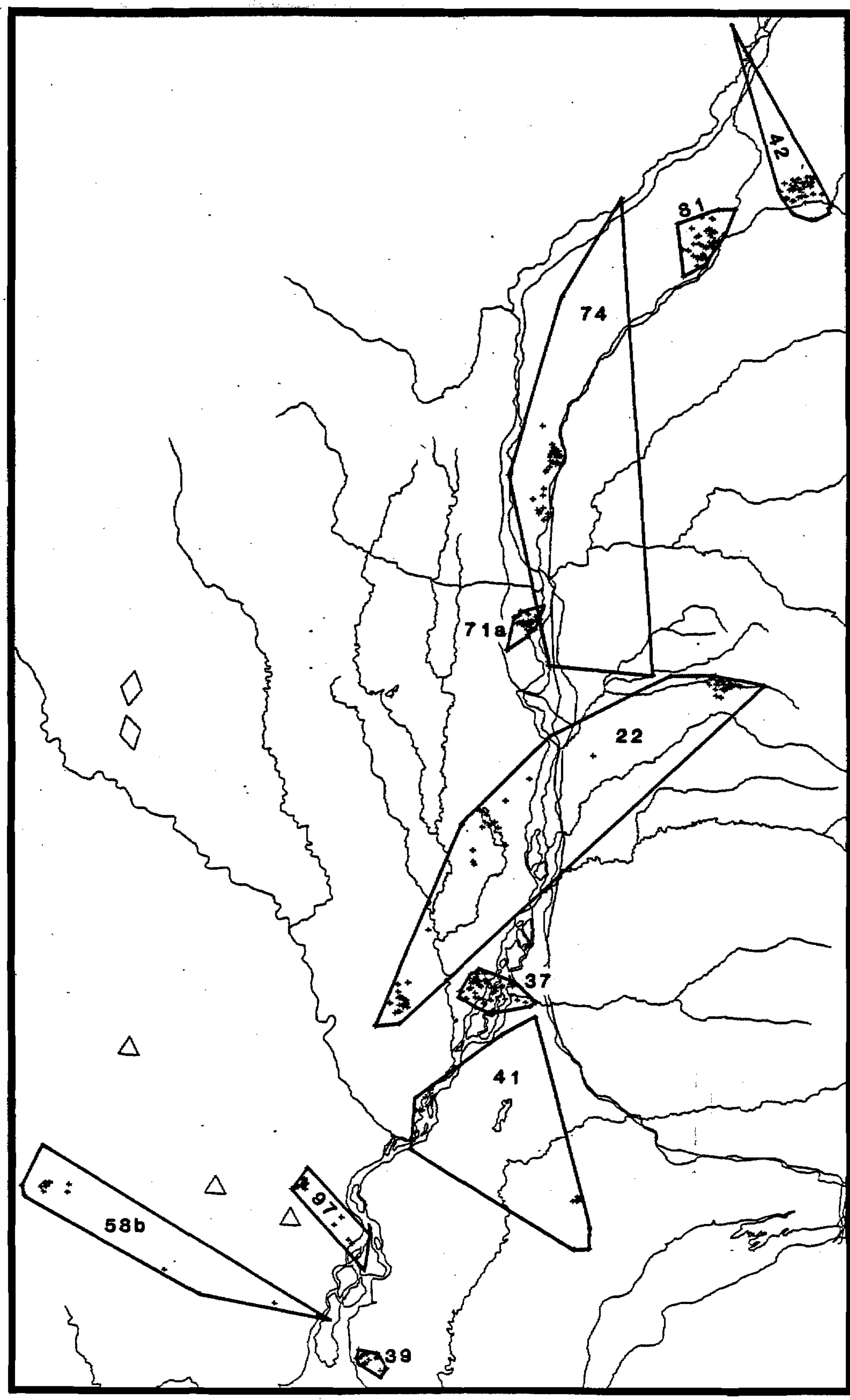

Figure 16. Shape and spatial relationships for ranges of 10 female moose captured and radio-collared along the Susitna River between Devil Canyon and Cook Inlet, Alaska and monitored during 1980-82. (Ranges depicted with polygons encompassing points of individual radio-relocations.)

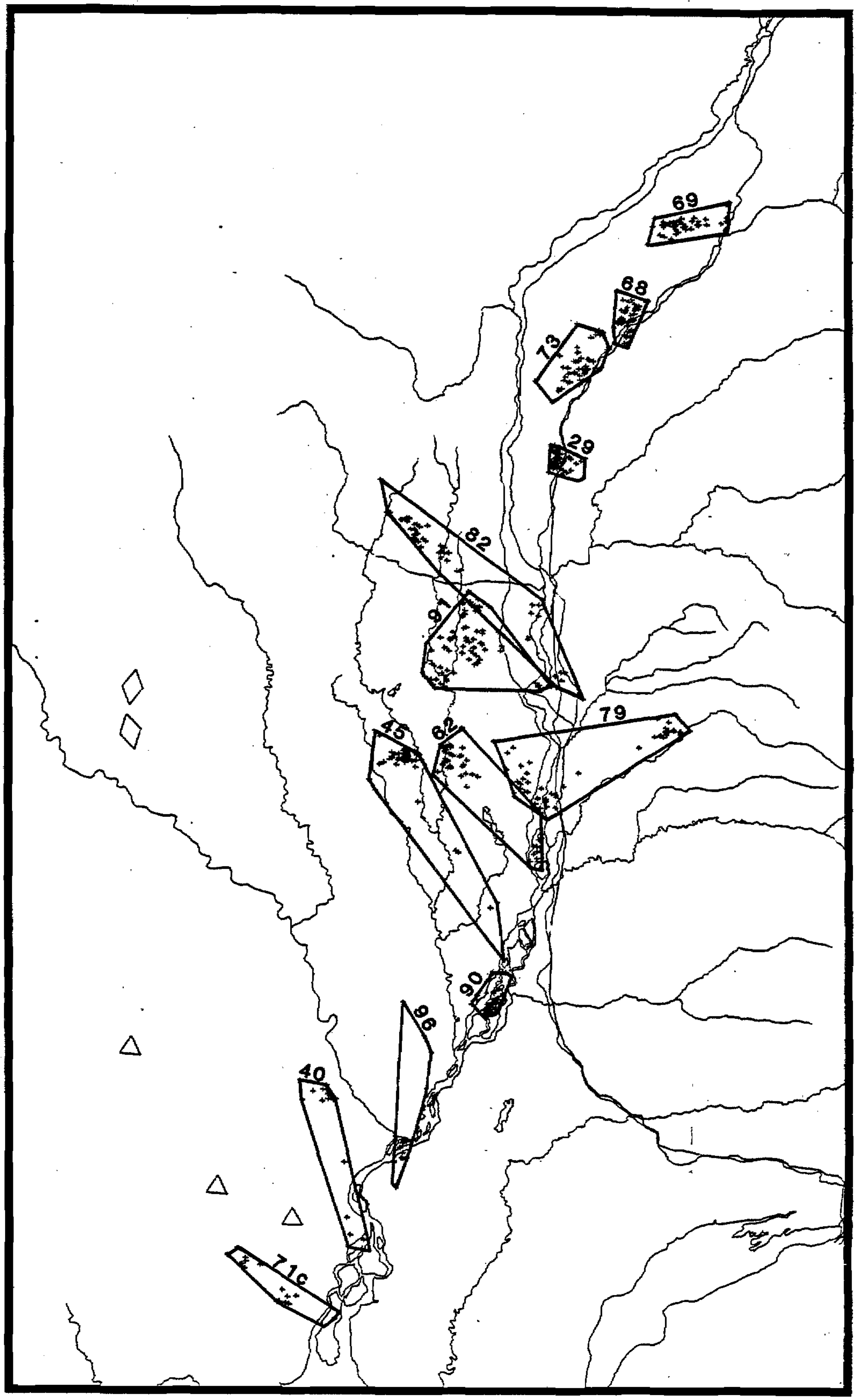

Figure 17. Shape and spatial relationships for ranges of 12 female and 1 male (#91) moose captured and radio-collared along the Susitna River between Devil Canyon and Cook Inlet, Alaska and monitored during 1980-82. (Ranges depicted with polygons encompassing points of individual radio-relocations.)

that center on riparian habitat, to those individuals with ranges that "traverse" riparian habitats and to those individuals with ranges that merely abutt riparian habitats.

PRODUCTIVITY AND SURVIVAL OF YOUNG

Productivity of female animals and survival of their newly born young are commonly used as indicators to assess the general well being of animal populations. These same parameters may be used: 1) to assess both subtle and more obvious impacts of proposed Susitna Hydroelectric development on subpopulations of moose; 2) to evaluate the results of enhancement procedures undertaken as mitigation options and/or 3) to provide options for consideration in mitigation, i.e., improvement of calving or rearing habitats or reduction of predation on calves.

Data gathered from the radio-collared samples of moose, on timing of calving, number of calves produced and survival of those calves are presented in Table 19. These data are itemized by individual female moose in Appendix A.

Data on productivity and and survival of calves in spring 1980 were obtained from a very small sample of moose and will not be treated alone.

Data provided by 27 radio-collared moose which were observed during the spring and summer of 1981, indicate that 4 had 2 calves, 18 had 1 calf and 5 had no calves. Data from 23 of these same moose indicate that 13 had 2 calves, 2 had 1 calf and 1 had no calves. The sample of 11 moose radio-collared in 1981 indicate that 7 had two calves, 4 had 1 calf and 0 had no calves.

Table 19. Monthly summaries of female radio-collared moose and associated calves observed along the Susitna River during radio-tracking flights, 1980-82.

Observation	1980 A	M	J	J	A	S	O	N	D
Total females	6	4	3	3	3	3	3	3	3
Females with calves[1]	2	1	1	1	0	0	0	0	0
Females with twins	1	1	1	1	0	0	0	0	0
Total calves	3	2	2	2	0	0	0	0	0
Calves/100 females	50	50	67	67	0	0	0	0	0

Observation	1981 J	F	M	A	M	J	J	A	S	O	N	D
Total females	3	3	27	27	27	27	26	26	25	25	25	24
Females with calves[1]	0	0	17	8	13	21	21	21	20	20	20	19
Females with twins	0	0	2	0	1	4	2	0	0	0	0	0
Total calves	0	0	19	8	14	25	23	21	20	20	19	19
Calves/100 females	0	0	70	30	52	93	88	81	80	80	76	79

Observation	1982 J	F	M	A	M	J	J	A	S	O	N	D
Total females	24	32	35	35	35	34	34	33	33	33	33	33
Females with calves[1]	17	21	18	18	30	28	24	22	22	21	20	15
Females with twins	0	1	1	1	14	11	7	7	6	6	6	1
Total calves	19	22	19	19	44	39	31	29	28	27	26	16
Calves/100 females	71	69	54	54	125	115	91	88	85	82	79	48

1 Calf moose observed with an individual female on non-sequential months were assumed to be present and alive during the interim months when they were not actually observed. Calf moose that were not observed sometime during May - December 1982 may be observed during flights in 1983.

Overall, these data indicate that in 1981 81 percent of 27 radio-collared female moose produced young, 15 percent of them produced 2 calves and an average of 1.2 calves were produced by every female with young. Similar data for 1982, indicate that 97 percent of the 34 radio-collared females observed in the spring and summer produced young, 59 per cent of those produced 2 calves and an average of 1.6 calves were produced by the 33 females observed with young.

Two possible explanations for the observed differences between productivity calculated in 1981 and 1982, where 22 and 3 percent of the females were not observed with young and 15 and 59 percent of the females were observed with single or twin calves, respectively, in those respective years are the following: 1) favorable environmental conditions in 1982 enabled females to attain and maintain a higher level of nutritive conditions then in 1981 2) environmental conditions were similar in both years but females normally do not produce twins in consecutive years and/or 3) more intensive searches for young during radio-relocation surveys. The second possibility implies that productivity in 1980 was at a level commensurate with that in 1982.

Since the high level of twin production in 1982 occurred in 2 different samples totaling 35 moose: 1) those captured in 1980 and 1981 north of the Yentna River and 2) those captured in 1982 south of the Yentna River it was probably not an artifact of sample size or local variation.

If the observations of twinning were explained by the second contention, I would expect that few of the females which produced twins in 1982 will do so in 1983.

Environmental conditions may have been worse prior to parturition in 1981 than in 1982, since in 1982 26 of 33 productive females were observed with neonatal young in May whereas in 1981 only 10 of 24 productive females were observed with neonatal young in May. Favorable environmental conditions may improve physical condition of pregnant females and result in earlier dates of parturition and higher levels of productivity. Likewise, peak numbers of calves in the population occurred in June of 1981 and in May of 1982.

The percentage of calves in the 1981 and 1982 populations declined sharply through July in 1981 and through June in 1982. By August in 1981, 84 percent of the calves produced were still alive, 16 percent had disappeared; by November 76 percent were still alive. In 1982, only 70 percent of the calves produced were alive by August; by November 63 percent of the 125 young produced were known to still be alive. By November, the ratio of calves per 100 cows was 76 and 79 for 1981 and 1982, respectively. Of course, by that time winter could also be accountable for the between year variation in calf survival.

Causes for the relatively rapid rate of loss during the first two months after the peak of parturition are not known. Newly born moose calves succumb for many reasons, but a prominent cause for neonatal death of moose calves on the Kenai Peninsula (Schwartz and Franzmann 1981) and in the Nelchina Basin (Ballard et el. 1980) is black and brown bear predation, respectively. As indicated in a previous report (Modafferi 1982), circumstances in the lower Susitna River Valley areas appear conducive to predation by black bears.

Predation on moose calves could become more prominent in riparian habitats immediately downstream from Devil Canyon, should bears displaced by post-project impoundment water levels, colonize areas downstream from the Devil Canyon damsite.

PUBLIC USE OF MOOSE RESOURCE

Impacts on the moose resource from development of the Susitna Hydroelectric project in areas downstream from Devil Canyon will secondarily impact both consumptive and non-consumptive users of that local resource. An important non-consumptive use of moose in this area is recognized but in the absence of adequate quantitive data it will not be considered specifically in the present report. Though radio-collared moose ranged into portions of subunits 16B and 14A, information on resource use in these areas will not be compiled until more complete data are available to better delineate those respective subpopulations of moose. Fig. 9 illustrate where moose which were captured and radio-collared on the floodplain of the Susitna River were distributed during September; the usual time of open hunting seasons.

Data on consumptive use of the moose resource in areas frequented by 3 identified subpopulations of moose are presented in Tables 20, 21, 22, 23, and 24. These tables summarize information on number and residency of users, quantity and type of effort, numbers and sex of moose killed and provide data on numbers of applicants for lottery permit hunts.

One prominent feature of these data is that access to and use of the resource, in both subunits 16A and 14B, is available to users through multiple types of transportation. It is not uncommon for

Table 20. Transportation type, effort (mandays), number of moose killed, number of hunters and their residence for participants in the 1979-80, 1980-81 and 1981-82 open hunting seasons in Game Management Unit 14B, Alaska.

Year	1979-80	1980-81	1981-82
No. hunters[1]	285	560	687
No. residents	270	531	651
No. moose killed	43	99	119
Transportation type (No. participants: Effort)			
Aircraft	22:111	59:291	51:272
Horse	4:25	3:18	6:27
Boat	23:114	41:205	56:266
Motorbike	1:16	6:38	6:38
Snowmachine	0:0	2:6	0:0
Offroad vehicle	54:203	97:609	125:771
Highway vehicle	108:610	218:1178	250:1593
Unspecified	73:423	134:723	193:1174
Total effort	1502	3068	4141

1 Data abstracted from the Alaska Department of Fish and Game harvest ticket master file.

Table 21. Sex and number of moose killed and number of applicants for limited entry, lottery type hunts in Game Management Unit 14B for the 1979-80, 1980-81 and 1981-82 hunting seasons.

Year	1979-80		1980-81		1981-82	
Hunt No.[1]	911	913	911	913	911	913
No. applicants	667	6011[2]	686	210	720	413
No. permits	100	50	100	50	100	50
No. moose killed	22	43	18	30	21	42
No. bulls		23[3]	4	11	0	17
No. cows		42	13	19	21	25

1 No. 911 is a fall season cow moose hunt and No. 913 is a winter season antlerless moose hunt. Data abstracted from Alaska Department of Fish and Game files.

2 In 1979-80, hunt No. 913 was announced as a separate drawing hunt open for application by any person that had not killed a moose during the regular open hunting season.

3 Data combined for hunt No. 911 and 913.

Table 22. Transportation type, effort (mandays), number of moose killed, number of hunters and their residence for participants in the 1979-80, 1980-81 and 1981-82 open hunting seasons in Game Management Unit 16A, Alaska.

Year	1979-80	1980-81	1981-82
No. hunters[1]	585	946	983
No. residents	549	912	955
No. moose killed	128	179	189
Transportation type (No. participants: Effort)			
Aircraft	57:245	77:330	88:483
Horse	2:3	2:5	0:0
Boat	85:468	127:665	126:790
Motorbike	4:17	5:12	6:30
Snowmachine	1:12	1:5	0:0
Offroad vehicle	94:604	132:757	162:1021
Highway vehicle	240:1204	456:2610	395:2141
Unspecified	102:544	146:803	206:1068
Total effort	3097	5187	5533

1 Data abstracted from the Alaska Department of Fish and Game harvest ticket master file.

Table 23. Number of moose killed and applicants for limited entry lottery type cow permit (Hunt No. 908) hunts in Game Management Unit 16A for the 1979-80, 1980-81 and 1981-82 hunting seasons.

Year[1]	1979-80	1980-81	1981-82
No. applicants	861	972	1032
No. permits	150	150	150
No. moose killed	30	38	28

1 Data abstracted from Alaska Department of Fish and Game files.

Table 24. Transportation type, effort (mandays), number of moose killed, number of hunters and their residence for participants in the 1979-80, 1980-81 and 1981-82 open hunting seasons in Game Management Unit 13E, Alaska.

Year	1979-80	1980-81	1981-82
No. hunters[1]	29	20	28
No. residents	24	19	26
No. moose killed	14	5	10
Transportation type (No. participants: Effort)			
Aircraft	1:5	2:5	1:5
Horse	3:18	1:10	0
Boat	0	1:1	2:10
Motorbike	0	0	2:5
Snowmachine	0	0	0
Offroad vehicle	20:115	4:17	8:78
Highway vehicle	3:15	2:20	2:7
Unspecified	2:28	10:50	13:105
Total effort	29:181	20:103	28:210

1 Data abstracted from the Alaska Department of Fish and Game harvest ticket master file. These data represent the following code areas: Wiggle Creek, Susitna River (Wiggle Creek to Chase), Whiskers Creek, Chase (Alaska Railroad, ARR), Susitna River (Chase to Lane), Lane Creek, Lane (ARR), Blair Lake, McKenzie Creek, Susitna River (Lane to Curry), Deadhorse Creek, Troublesome Creek, Curry (ARR), Susitna River (Curry to Gold Creek), Sherman (ARR), Gold Creek (Chunilna Hills), Gold Creek (ARR), Canyon Creek, Devil Canyon, Portage Creek, Thoroughfare Creek, Canyon (ARR), Indian River, Chulitna Pass, Summit Lake (south of Hurricane), Pass Creek (Chulitna) and Susitna River (Sherman north and south of).

wildlife resources in some areas to be commonly accessible through only one or two types of transportation. But the moose resource in subunits 16A and 14B is readily accessible to many users through highway vehicles, off-road vehicles, aircraft and boat, and therefore provides recreational opportunities for many "subgroups" of users, each associated with a type of access. The moose resource in these subunits is truly a multiple use resource utilized by a multiple of user groups.

That portion of 13E utilized by the subpopulation of moose north of Talkeetna, attracted considerably fewer hunters and appeared not to be as readily accessible as subpopulations in subunits 16A and 14B. The apparent unattractiveness of subunit 13E to hunters may in part be attributed to the fact that nearly half of that area lies in Denali State Park, an area closed to the discharge of firearms since the early 1970's. If, in the future, Denali State Park was opened to the discharge of firearms, I suspect the area would attract a considerable number of moose hunters. Access to area is available by foot, highway vehicle and off road vehicle from the Parks Highway, by float and wheel equipped aircraft, by boat via the Susitna River and by train along the Alaska Railroad.

I suspect the average "type" of person utilizing the 13E subpopulation of moose differs from that utilizing the moose resource in subunits 16A and 14B. Resources in subunits 16A and 14B are utilized by local residents but these areas also provide recreational and hunting opportunities for a large number of people resident to Anchorage and adjacent metropolitan areas; the latter no doubt predominate in overall use of the local resource.

However, the apparent small user base in subunit 13E should not diminish the relative value of that local moose resource. In the late 1960's and early 1970's property along the Susitna River in the Curry, Lane and Chase areas was made available to the public through a State of Alaska homesite land disposal program. I suspect that people who took advantage of this program and obtained that land, endeavored a subsistence type lifestyle, of which moose and moose meat probably play a dominant role. Needless to say, ready availability of moose in that area may be a very integral part in the lives of local residents.

Future state land disposals are planned in the Gold Creek and Indian River areas. I believe one of the major attractions to people for remote parcels of land is the potential for subsistence type lifestyles, and that the quality of these parcels of land is closely related to the local abundance of fish and wildlife resources, as moose.

It is well documented that substantial numbers of moose occur in subpopulations which are normally resident to relatively inaccessible areas east of the Susitna River in the western foothills of the Talkeetna Mountains (subunits 14A and B). Most moose in these subpopulations remain in the foothill regions during mild winters, but in moderate to severe winters, it is said that they exodus to "secondary" winter range in lowland areas along the Susitna River, around transportation rights of way and other sites where climax vegetation has been disturbed and more palatable winter browse of early successional species is available (Rausch 1958). Under these conditions numerous moose are killed by collisions with trains or highway vehicles, jeopardizing public safety and causing considerable monetary loss in equipment damages.

During the severe winter of 1955-56, 224 moose were killed by the Alaska Railroad train in a 70 mile stretch from Willow (milepost 160) to Sunshine (milepost 230) (Rausch 1958). It has been rumored that nearly 20 moose have been killed in one night from a single train traveling between Anchorage and Fairbanks. Similarly, during the winter of 1970-71, in subunit 14A and B, it was documented that over 100 moose were killed by vehicles in highway rights of way (Didrickson 1973).

These problems are 2-fold; not only is browse in these areas an attractant to moose but the rights of way in train and highway areas are also plowed clear of snow and afford moose easy travel. Once in these plowed areas, moose do not readily leave them for areas where snow is considerably deeper even when confronted with trains or vehicles and therefore many are killed.

The subunit 14B lottery type permit moose hunt is implemented to serve 2 main functions: 1) to harvest moose from a subpopulation that is relatively inaccessible during other times of the year and 2) to reduce the number of moose near highway and train rights of way for improved public safety. In accomplishing those objectives, additional demands for recreational opportunities and consumptive use of the moose resource are, in part, satisfied.

MORTALITY

Capture Related

Three of the 59 moose immobilized, field handled and aroused, subsequently died or were "euthanasized", within 3 days, in the immediate vicinity of their initial capture site.

In two of these instances, mortality appeared to be proximately related to injuries sustained from slipping on exposed, glare ice of the frozen Susitna River. Extensive areas of exposed glare ice is a common phenomena of the Susitna River between the Yentna River and Cook Inlet, where strong prevailing north and east winds blow snow off frozen sections of the River and polish the ice smooth with abrasive action of snow crystals and silt.

One moose was field processed and aroused in a normal manner but when the assisting helicopter approached to pick up personnel it initiated a running response in the moose. The moose fell twice while trying to flee across the ice, once in a "spread eagle" state and the other time onto a hip joint. The field crew left the moose to collect itself and recooperate in the absence of further disturbance. A reconnaissance trip to the area 3 days later revealed that the moose had died on the ice not far from where it was last observed.

The other moose which fell on the ice and apparently injured itself, had previously been immobilized and handled, and it typically departed the river bed to a forested area after being aroused. However, a brief time later, it was observed in the same general area in a prone position on glare ice. It was assumed to still be partly under anesthesia and was left to recover on its own. Three days later, the moose was found alive in the same location; it was then euthanasized.

One mortality was perhaps totally attributed to field handling technique. Subsequent to capture procedures, it was determined that an individual had not traveled far from its capture site. A reconnaissance trip, 3 days after capture revealed the individual was in the same location as when it was field processed. It had rotated itself 180°, cold move its head and neck, exhibited no sign of injury, but apparently could not get itself up. This individual was euthanasized.

Non-Hunting Mortality - Case Histories

A male moose captured and radio-collared 24 February 1982 and rated at that time in condition class 5 (7 = average) was later found dead 2.5 km from its capture site. In March, the individual was radio-relocated 800 m from the capture site and on 4 April it was relocated and observed alive in the immediate vicinity of where it was later found dead. Subsequent radio-relocations to the same area revealed no movement by the moose, indicated the collar may have been shed and lead to field inspection of the site. At the site, it was observed that remains of the moose had been scattered around the general area by bears. The actual cause of death could not be determined but since death occurred 2.5 km from the capture site and month later it was probably not related to immobilization and handling procedures.

A female moose, No. 80, captured 11 March 1981 about 5 km south of Talkeetna was relocated about 13 km south of that site in mid April and 20 km north of the capture site on 7 May. Three subsequent radio-relocations indicated the moose had not moved from that site and suggested the collar had been shed. Field inspection of the area revealed the moose intact, dead, lying on the river bank, it's hide dry and leathery in texture and covered with silt. It is probable that the moose went to this riparian area to calve, as is common for moose north of Talkeetna, but fell through overflow or got caught in an ice jam or high water during breakup where it died and remained in a relatively preserved state.

Female moose No. 71a, a relatively sedentary individual, which only once was relocated more than 5 km from its capture site and spent the majority of its time within 1 km of the Susitna River, was determined to have died between 19 and 29 January 1982. Field investigation on 10 February reveal the moose was laying on glare ice with splayed hind legs. The moose had been "picked on" by predators, the collar had been partly cut with a knife and no signs of gunshot wounds were observed. Personnel investigating the scene reasoned that the moose most likely slipped on the glare ice, where it lay, split its pelvis and or injured its hip joint, could not move and died from exposure and/or starvation; scavangers appeared after death. One would not normally expect a relatively sedentary individual, in very familiar surroundings, to succumb to an accidental death.

Apparently my experiences with moose injured on glare ice during capture procedures were not so out of the ordinary, and are probably not an uncommon natural occurrence. The pilot of the fixed-wing plane used during capture procedures, who also piloted on all river censuses, commented that in his travels during the winter of 1981-82, he had observed about a half dozen dead moose lying on glare ice of the Yentna, Skwentna and Kahiltna Rivers. Circumstances at each site, lead him to believe that those moose, too, died as a result of injuries sustained from slips and falls on glare ice.

Female moose No. 74, captured in March 1981 north of Talkeetna near Chase, traveled widely during the 16 months she was monitored, before being observed underwater and dead in a log jam of a Susitna River side channel on 16 June 1982. This individual remained quite sedentary most of the year and except during the late May to mid-June period seldom ranged farther than 8 km from her capture site. However, between 21 May and 22 June 1981, she traveled 40 km north to the Chulitna River, south 70 km to the middle Fork of Montana Creek, then north 36 km to an area on the Chulitna River only 7.7 km west of her capture site, where she resumed using familiar range. She remained in that "home" area until being radio-relocated on 26 May, 29 km to the south near a side channel of the Susitna River. It was within 1 km of this site, that she was observed dead under water near the log jam. I presume, somehow she had drowned in the River, perhaps after getting carried into the log jam while attempting to cross the river; though she may well have been killed further upstream in another manner and was carried by river currents into the log jam.

The long excursions from the relatively confined "home" range near the capture site were probably to areas where she intended to bear calves. Several other radio-collared females (No. 22, 23 and 42) were known to make long excursions immediately prior to calving. It is interesting to note that this individual was commonly observed but was only seen with a calf when she was initially captured. It seems reasonable, that moose which travel frequently or over great distances would have a higher probability of encountering "chance circumstances" which could result in "accidental" death or loss of calves.

Female moose No. 79, captured and radio-collared 10 March 1981 between Goose Creek and Sheep Creek Slough, behaved more like female moose (No. 22, 23 and 26) captured in 1980 than her counterparts captured in 1981; except for her calving activities which took place northeast of Trapper Lake, she usually ranged east of the Susitna River near Sheep Creek, about 17 km northeast of her capture site. In 1982, she departed the Trapper Lake area with 1 calf and returned to her summer and fall range in the Sheep Creek area. On 23 September, the transmitted signal from this individual's radio-collar came from a 5 m diameter disturbed area in which a brown bear was lying. The bear was obviously at the site where this female moose had been killed. It is possible that the bear killed the moose, but since several hunter tent camps were also observed in the vicinity, one camp was only 1 mile away, it is equally possible that the moose was killed by a hunter during the open female moose season. The hunter may have thought his activities were illegal when he saw the radio collar, salvaged the meat but left the collar at the kill site. The brown bear may have located and consumed the remains of the moose which were located near the neglected radio-collar. Fresh snow soon covered the site and precluded recovery efforts but next spring I will helicopter to the site and attempt to reconstruct the exact circumstances of death.

Hunting Mortality - Case Histories

Four of the radio-collared moose, 3 males and 1 female, have been legally killed by hunters during the open hunting season. Brief case histories and details of their movements which lead to those confrontations will follow.

Male moose No. 93, captured and radio-collared in April 1980, was killed by a hunter 5 months later about 7 km southwest of the capture site. This individual commonly ranged near the Parks Highway just north of the Sunshine Bridge; an area traversed by many hunters.

Female moose No. 71b, captured and radio-collared in March 1981, traveled with a calf to the Deshka River area west of Amber Lake, 41 km northwest of her capture site and was subsequently killed on the bank of Moose Creek by a hunter "floating" the creek. This moose and her calf were frequently relocated along Moose Creek south of its confluence with Ninemile Creek. Moose hunters commonly "float" down streams in subunit 16A during the open hunting season.

Male moose No. 92, captured and radio-collared in April 1980 along the Susitna River near Sherman, was killed by a hunter in September 1982, near Curry. This particular male commonly ranged along the south side of the Susitna River from McKenzie Creek to Devil Canyon and wintered in the Lane or Chunilna Creek drainages. Each year this individual would travel from that wintering area north and to be near Devil Canyon by July or August and then return along the south bank of the Susitna River to its wintering area near Lane Creek. It was during this return trip in the third consecutive year, that he was killed by a hunter. Though this individual traveled extensively, he appeared to move between

3 distinct and seasonally used areas: a summer area near Devil Canyon, a winter area in Lane Creek and a spring/fall area between Lane and Curry.

Male moose No. 84, captured and radio-collared in March 1981 just north of the Delta Islands was killed about 7 km from that site by a hunter in September 1982. This individual was commonly relocated along the Deshka River, Trapper Creek and the Susitna River; all popular hunting areas, but he did travel about 38 km south west of the capture site to the Pittman area between February and April of 1982; a movement not detected in March or April of 1981.

<u>Quantified By Sex, Subunit and Study Area</u>

Data on mortality of individual radio-collared moose are summarized for sex and subunit occupied during open hunting season (Table 25). Because, these data represent incomplete years and more than 1 year for most individuals, hunting mortality is related to the number of hunting seasons each individual was exposed to and non-hunting mortality is related to the number of months each individual was monitored. Though these values may roughly approximate overall average mortality regimes for respective populations of moose; one must realize that hunting mortality rates for individual moose as No. 84 and 90, which commonly ranged near readily accessible and popular hunting areas, as the Deshka and Susitna Rivers and Parks Highway, respectively, would

Table 25. Hunting (K) and non-hunting (D) mortality for individual (Id) male (M) and female (F) moose captured and radio-collared along the Susitna River between Devil Canyon and Cook Inlet and resident in Alaska Game Management Subunits 13E, 16B, 16A, 14A and 14B while monitored 1980-82.

13E				16B				16A				14A				14B			
Sex	Id	Hs[1]	Mths[2]	Sex	Id	Hs	Mths	Sex	Id	Hs	Mths	Sex	Id	Hs	Mths	Sex	Id	Hs	Mths
M	66	1	20	M	44	1	8	M	60	2	18					M	27	3	30
	92	3K	31		95	1	9		65	2	20								
Total	2	4(1K)	51	Total	2	2	17		84	2K	19								
									90	1K	6								
									91	3	31								
									99	1	9								
								Total	6	9(2K)	103								
F	29	-	19	F	40	1	9	F	19	2	19	F	39	-	9	F	22	3	30
	42	-	20		58b	1	8		37	2	20		41	-	9		23	3	30
	63	-	20		71c	1	8		45	2	20		96	-	9		26	3	30
	68	-	19		93	1	8		56	2	18		100	-	9		79	1	18M
	69	-	19		97	1	9		57	2	20					Total	4	10	108(1M)
	73	-	19	Total	5	5	42		59	2	20								
	74	-	16M						62	2	29								
	80	-	5M						64	2	19								
	81	-	19						71a	1	11M								
Total	9	-	156(2M)						71b	1	7K								
									82	2	20								
									85	2	20								
									87	1	9								
									88	2	20								
									90	2	20								
									94	1	9								
								Total	16	28	271 (1K and 1M)								

1 Hs = number of hunting seasons individual was exposed to, (-) = hunting season not open for females.

2 Mths = number of months individual was observed and susceptible to non-hunting types of mortality. Capture and handling related mortalities not included.

vary greatly from that of individual No. 65 which ranged near Amber Lake and Peters Creek, a less accessible and more remote area. Sample sizes for all but subunit 16A are extremely small and may lead to erroneous conclusions.

In view of aforementioned shortcomings, these data indicate that 25, 0, 22 and 0 percent of the male moose which wintered on the Susitna River in an average winter and were exposed to a hunting season in subunits 13E, 16B, 16A and 14B, respectively, were killed by hunters. Similarly, the average male moose in subunits 16B and 14B, probably survives at least 2 open hunting seasons. Overall, the data imply that 17 percent (3 males killed in 18 moose-seasons of vulnerability) of the male moose that wintered on the Susitna River and are exposed to a hunting season are probably killed by hunters.

Subunits 16A and B have open hunting seasons for female moose. In the former subunit, a limited number of permits are issued by lottery drawing. In the later subunit, the season is open to all hunters. None of the 5 female radio-collared moose which utilized subunit 16B during the open hunting season were killed by hunters. One of 16 female radio-collared moose vulnerable to hunting for an aggregate total of 28 seasons in subunit 16A was killed by a hunter. These data imply that less than 4 percent of the female moose which range on the Susitna River in an average winter and are available to hunters during open season in subunit 16A, are killed.

None of 2, 1 of 4 , 0 of 6 and 0 of 1 male radio-collared moose observed for a cumulative total of 51, 26, 103, 36 and 108 months, respectively, in subunits 13E, 16B, 16A and 14B, respectively, died from non-capture related, non-hunting mortality. This individual (moose No. 76), as previously reported, was discovered dead on Bell Island 3 months after its capture. It is possible that this moose was killed by a brown bear. This island is located less than 10 km from Mt. Susitna, an area in which brown bears commonly occur. Because of the proximity of this area to Mt. Susitna and Little Mt. Susitna, brown bears are probably more abundant in riparian habitats along the Susitna River south of the Yentna River than from the Yentna to Talkeetna.

Considering data collected in all subunits, only this 1 of 17 radio-collared males monitored over 324 months was known to die from non-hunting (predation or accidental) mortality.

Data gathered from female radio-collared moose indicate that 2 of 9, 0 of 5, 1 of 16, 0 of 4 and 1 of 4 individuals monitored for 156, 42, 271, 36 and 108 cumulative months, respectively, in subunits 13E, 16B, 16A, 14A and 14B, respectively, died from non-hunting causes of mortality. Most probable causes of their death were brown bear predation, 2 drownings and 1 injury from slipping on ice. The cumulative total for all subunits indicates that a "natural" mortality occurred in 4 of 38 radio-collared female moose individually studied for various lengths of time. In total, these 38 moose provided 613 months of observation and yielded 1 death for every 153 moose-months.

Data obtained from this radio-collared sample of moose indicate that under present management schemes male moose throughout the area studied are about 9 times as likely to be killed by hunters as females (3 male moose:18 moose-seasons vs. 1 female moose:55 moose-seasons) and that females are more than 2 times as likely as males (4:613 moose-months vs. 1:324 moose-months, respectively) to die from non-hunting causes of mortality.

POPULATION PHENOMENA

Forty-six moose captured and radio-collared late in the winters of 1979-80, 1980-81 and 1981-82 along the Susitna River from Portage Creek to Cook Inlet, a linear river distance of approximately 215 km, had by 20 October 1982 ranged over more than 8900 km^2 of habitat adjacent to the Susitna River. Apparently, riparian habitats along the Susitna River serve as winter range for moose which are very widely distributed at other times of the year. It is not uncommon for several populations of moose to share a common winter range (LeResche 1974 and Van Ballenberghe 1977).

Considering general patterns of movement documented for radio-collared moose, large geographical units where radio-collared moose were never relocated and areas along the Susitna River where data have yet to be collected, Modafferi (1982) hypothesized the existence of 9 geographical units which contain moose that utilize the Susitna River riparian habitat at some time during an "average" year (Fig. 18). Moose within each geographical unit: 1) behave similarly in their use of riparian habitats; 2) have peculiarities in their life history and/or environment which distinguish them from moose in other units and/or 3) may not necessarily visit those riparian habitats every year.

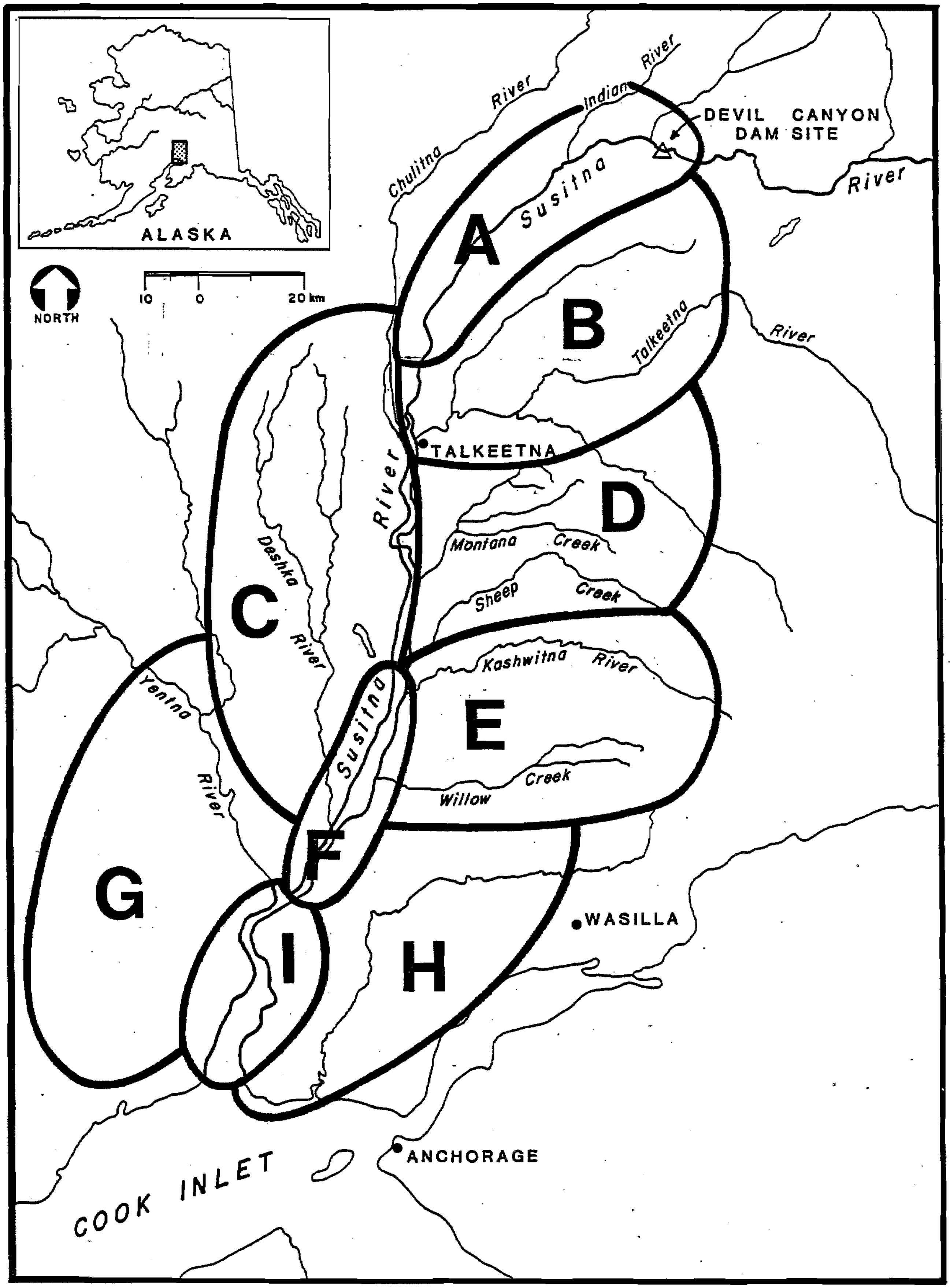

Figure 18. Spatial relationships for hypothetical subpopulations of moose in the Susitna River watershed between Devils Canyon and Cook Inlet, Alaska (from Modafferi 1982).

It may be appropriate to consider all moose which winter along the Susitna River as a single population unit but local differences in movement patterns and environmental conditions documented in this study indicate that particular life history strategies must also vary to accommodate specific local environmental conditions. Since patterns of movement for individual moose are extremely traditional (Van Ballenberghe 1977) and may be subsequently learned by offspring (Gasaway *et al.* 1980), they can rapidly become characteristic and fixed for individuals in specific local areas through processes of natural selection, if they prove to be of survival value and individual fitness is increased. It therefore appears that subpopulation distinction is most appropriate to account for the behavioral variation observed in moose along the Susitna River.

Sampling in different years, at different locations and at different times in the winter has yielded representatives from several different subpopulations of moose along the Susitna River. The sample of moose captured and radio-collared in 1980 conformed to characteristics of subpopulation D (Montana Creek/ Sheep Creek). Moose characterizing subpopulations A (Upper Susitna River), C (Deshka River/Trapper Lake) and F (Delta Island complex) were captured and radio-collared in the 1981 sample of moose. Moose captured in the 1982 sample generally conformed to specifications for G (Yentna River/Mt. Susitna) and I (Big Island/Bell Island complex) subpopulations. This sampling scheme has failed to capture moose representing subpopulations B (Talkeetna River/Sheep River) and E (Kashwitna River/Willow Creek). This observation along with the fact that few representatives from subpopulation H have been captured indicates that most moose which use Susitna River riparian habitats in a "average" winter are resident to areas west of the Susitna River. The possibility also exists that moose from subpopulations B and E do use riparian habitats in "average" winters but depart before March when samples of moose were captured.

Since representatives from subpopulation G did not appear to come from very great distances down the Yentna or Kahiltna Rivers, I suspect that riparian habitats in those respective river drainages provide adequate winter range for locally resident moose. However, to the contrary, moose from the southern part of area G (south of Mt. Susitna), even in a relatively mild winter, traveled extensive distances to winter on the Susitna River. Apparently, sufficient or adequate winter range is not locally available in the latter area.

It is not known, from which subpopulation(s) the large numbers of moose counted in the 20, 21 and 22 December river census originated. They may have come from within subpopulations that are represented in "average" winters, they may have originated from subpopulations farther to the west than subpopulations C and G and/or they may have been moose from subpopulations D, E and H which are resident in areas to the east. In any event, data gathered from subsequent river censuses indicated that they only remained in floodplain habitats for a short period of time. It is unfortunate, that more than two times the number of moose used Susitna River riparian habitats in the winter of 1982-83 as did in the winter of 1981-82 and their origin remains unknown.

HABITAT REHABILITATION

Because major mitigation strategies, to compensate for impacts of the proposed Susitna River hydroelectric development on subpopulations of moose, will be through maintenance, replacement and/or creation of new habitats to augment those presently used by moose for winter range, periodic censuses, paralleling the timing of river censuses, were conducted on 6 sites where vegetative complexes had been altered by man.

Conditions, causes and timing of disturbances to these specific sites are not presently known but could probably readily be researched, if necessary.

All sites monitored were immediately adjacent to floodplain habitats of the Susitna River except for the Kashwitna Lake site, which was located about 1.5 km east of the Susitna River. Because of such close proximity of these sites to floodplain habitats, they may possibly compete with or compliment winter range presently available to and used by moose wintering along the Susitna River.

Though close to floodplain habitats, numbers of moose counted in these disturbed sites, were not included in talleys for river censuses. However, it seems likely that moose using these sites are not discrete groups from those using adjacent floodplain habitats; a flux of individuals between both habitats probably exists.

Data presented in Table 26 demonstrate intensive use of some sites and variability in use between different sites. In part, variation may be attributable to differences in size of individual sites, but it may also be related to factors as plant species composition, age of plants, proximity to other sites and location with respect to general movement patterns of subpopulations of moose. Differences between years in numbers of these moose using sites are probably mostly related to snow conditions and winter severity. Differences in sex composition of moose observed between areas (Talkeetna west vs. other sites) appeared to occur; biological reasoning or significance for these observations are at present unclear.

I plan to continue study of moose use of these disturbed sites in the future, as information provided will be necessary for knowledgeably considering mitigation options.

Table 26. Numbers, sex and age of moose[a] observed in areas adjacent to the Susitna River floodplain[b] where vegetation and plant succession have been altered by activities of man, Alaska 1981-83.

Winter period	Montana west							Montana middle							Talkeetna west						
	Lm	Sm	FO	F1	F2	Lc	Tm	Lm	Sm	FO	F1	F2	Lc	Tm	Lm	Sm	FO	F1	F2	Lc	Tm
1981-82																					
2 Dec	15	14	6	3	0	0	41	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 Dec	0	1	2	1	1	0	8	8	3	0	6	0	0	23	1	0	0	1	0	1	4
14 Dec	15[c]		8	-	-	-	23	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28 Dec	6	2	4	5	1	0	25	1	0	6	2	0	0	11	0	0	7	0	0	0	7
29 Dec	3	1	7	1	0	0	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6 Feb	0	0	1	0	0	0	1	0	0	9	0	0	0	9	0	0	2	1	0	0	4
1 Mar	0	0	14	5	0	0	24	0	0	2	0	0	0	2	0	0	1	0	0	0	1
24 Mar	-	-	-	-	-	-	-	0	0	2	1	0	0	4	0	0	1	0	0	0	1
12 Apr	0	0	1	0	1	0	4	0	0	0	0	0	0	0	0	0	1	0	0	0	1
1982-83																					
29 Oct	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	1	3	2	0	11
6 Nov	7	0	4	5	0	1	22	0	1	1	0	0	0	2	-	-	-	-	-	-	-
10 Nov	16	10	24	9	0	0	68	3	1	8	1	0	0	12	1	2	3	1	0	0	8
18 Nov	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2 Dec	12	11	25	9	1	0	69	19	3	16	2	1	0	43	0	0	3	4	3	1	21
6 Dec	7	9	20	10	0	0	56	17	3	15	3	2	0	47	-	-	-	-	-	-	-
21 Dec	1	4	15	6	1	1	36	7	5	15	6	1	0	40	0	2	5	5	2	2	23
22 Dec	6	4	19	4	1	1	41	6	5	21	5	0	0	41	-	-	-	-	-	-	-
5 Jan	4	18	6	0	0	0	28	5	2	25	3	1	0	41	0	0	7	1	0	0	9
1981-82																					
2 Dec				-							-							-			
10 Dec	0	0	0	0	0	0	0				-				8[c]	-	5	0	1	0	16
14 Dec				-							-							-			
28 Dec				-							-							-			
29 Dec				-							-							-			

Table 26 Continued.

Winter period	Montana north							Kashwitna Lake							Montana south						
Date	Lm	Sm	F0	F1	F2	Lc	Tm	Lm	Sm	F0	F1	F2	Lc	Tm	Lm	Sm	F0	F1	F2	Lc	Tm
6 Feb				-							-							-			
1 Mar	0	0	1	0	0	0	1				-				0	0	4	1	0	0	6
24 Mar	0	0	0	0	0	0	0	0	0	5	1	0	0	7				-			
12 Apr	0	0	0	0	0	0	0				-				0	0	1	0	0	0	1
1982-83																					
29 Oct				-							-							-			
6 Nov				-				0	0	3	0	0	0	3				-			
10 Nov				-				2	6	4	1	0	0	14				-			
18 Nov				-				0	0	1	1	0	0	3				-			
2 Dec	0	0	1	0	0	0	1	3	1	6	2	1	0	17				-			
6 Dec	1	0	2	0	0	0	3	3	2	14	1	0	0	21				-			
21 Dec	0	0	8	0	0	0	8	1	0	12	3	0	0	19				-			
22 Dec	0	0	2	0	0	0	2	1	0	3	3	0	0	10				-			
5 Jan	0	0	6	0	0	0	6	0	0	17	1	1	0	22				-			

a Lm = males with large antlers; Sm = males with small antlers, mostly yearlings, probably males; F0 = females without young; F1 = females with one young; F2 = females with 2 young Tm = total moose.

b Specific location of areas illustrated in Fig. 2.

c Includes Sm moose too.

LIMITATION OF SAMPLES AND SAMPLING EFFORT

Concern has been expressed about the relationship between subpopulations of moose represented by individuals in the samples captured for radio-collaring and subpopulations of moose which are ecologically affiliated with floodplain habitats along the Susitna River (Modafferi 1982).

Since the magnitude of use of the Susitna River floodplain habitats by moose as a winter range is related to the amount of snowfall and its persistence as ground cover into early spring, the lack of a severe winter and the occurrence of relatively mild winters in 1979-80, 1980-81, 1981-82 and 1982-83 in spite of record early snowfall in October and November of the latter winter, must be weighed when considering results presented in this report.

Theoretically, moose sampled in late winter of 1979-80, 1980-81 and 1981-82 should not be representative of subpopulations of moose which only seek floodplain habitats during more severe winters.

Circumstantial evidence gathered in the winter of 1982-83 appears to support this theoretical contention. The largest number of moose observed in floodplain habitats of the Susitna River between Cook Inlet and Devil Canyon in the winter of 1981-82 occurred on the 1-2 March 1982 census when 369 moose were counted. In 1982, following early and heavy snowfall, 171 moose were counted in the same area in late October.

In the same sample area and following continued above average snowfall 476 moose were observed in mid-November and 826 in early December. By late December, 934 moose were observed utilizing winter range in floodplain habitats along that same stretch of the Susitna River. At that time, most all of the moose captured and radio-collared in previous winters had returned to utilize winter range in floodplain habitats. Following a relatively dry and warm December 1982 and January 1983 many moose had departed from Susitna River floodplain habitats. Three separate censuses between January and early February revealed between 450 and 525 moose; about 400 of the moose which sought floodplain habitats in early winter in response to heavy snowfall "promptly" departed from winter range along the Susitna River when weather conditions ameliorated. However, despite this apparent exodus of nearly half of the moose, most radio-collared moose remained distributed in floodplain areas. These data strongly suggest that a large portion of the moose which were utilizing floodplain habitats in December were a behaviorally distinct group (subpopulation?) from those which were captured in samples from the previous years.

It may be hypothesized that those additional moose which utilized floodplain habitats in December 1982 were: 1) a behaviorally distance sub-set of individuals from within subpopulations A, C, D and/or G already delineated (Fig. 18, and Modafferi 1982), 2) individuals from subpopulations (B, E and/or H) not yet represented in the radio-collared samples and/or 3) individuals from subpopulations resident to areas more remote than those hypothetically delineated.

This circumstantial evidence demonstrates several facts about relationships between present samples of moose, sampling methods and subpopulations which utilize Susitna River floodplain habitats: 1) samples presently being monitored do not adequately represent all subpopulations, 2) the importance of maintaining independent and parallel sampling schemes (radio-collaring and river censuses) which when integrated provide information neither method could have provided alone and 3) additional information is needed to predict annual variation which might be expected in utilization of floodplain habitats.

More intensive and site specific sampling of moose must be conducted on sites where vegetative succession has been altered by man. Present observations are gross oversimplifications of their interface with moose ecology. Enumeration of 50 moose on a site on successive surveys, provides no indication of individual turnover, ie., whether 50 or 100 different moose used the site. Knowledge of other ecological factors which might be required by moose and are provided by peripheral habitats are entirely unknown. Behavioral (social) interactions which may place density restrictions below energetic carrying capacity of sites are not known. Moose appear to congregate at some sites earlier in the winter than other sites (Montana west vs. Montana middle). Some sites appear to be more acceptable to cows with calves than other sites (Talkeetna west vs. Montana north).

Numbers of male moose providing information on movements and population identity throughout the study area are small.

Sample size of moose radio-collared north of Talkeetna, where post project impacts are expected be be greatest is small. To represent males in that subpopulation, data are presently being collected from a single individual. For these reasons, I believe the sample size available for delineation of this subpopulation of moose is inadequate.

Because of the imperative need to obtain a sample of moose in floodplain habitats during a severe winter, equipment and finances should be set aside for sampling activities (river censuses, carcass counts, additional radio-collaring and monitoring) during a severe winter. Perhaps a severe winter may be characterized as one when about 1300+ moose are observed in floodplain habitats along the Susitna River.

POTENTIAL MAJOR IMPACT MECHANISMS: And Associated Effects

Altered Seasonal River Flow Patterns and Loss of Annual Variation in River Flow: soil erosion and deposition, inundation, drought, ice jams, ice scouring (influence through destruction of vegetation and influence on main channel erosion and redistribution of soil), fertilizing effects of inorganic and/or organic nutrient loads, water or ice surface area, redistribution of debris, terrestrial floodplain surface area, floods, effects on beavers, bears or other subpopulations of moose, composition, distribution and/or abundance of plant species or plant communities.

Altered Water Temperature: ice fog/fog (physical, physiological, visual, insolation and insulation); frosting of vegetation; plant phenology; composition, distribution and/or abundance of plant species or communities; ice scouring; ice jams; open water in winter.

Alteration of Habitat: transmission corridors, railway and vehicle rights of way; project facilities, attractant for predators and conspecific competitors.

Increased Access: transmission corridors; railway and vehicle rights of way; winter boating.

Human Encroachment: construction and maintenance employees; hunters; visitors; recreators.

Increased Railway and Vehicular Traffic: disturbance, interference with movement, direct mortality.

Impoundment: inundation displaces predators and conspecific competitors.

Altered Turbidity: composition, distribution and/or abundance of aquatic plant species.

Salt Water Encroachment at Cook Inlet: composition, distribution and/or abundance of aquatic and riparian plant species.

Altered Ecosystem: secondary and tertiary effects from impacts on plant and other wildlife species as salmon, beaver, bears, wolves and other subpopulations of moose.

RECOMMENDATIONS FOR FUTURE RESEARCH

Until specifics and limits of seasonal and annual variation in post-project flow regimes and water levels of the Susitna River are known and secondary responses of plant communities are projected, it is not possible to assess their subsequent impacts on subpopulations of moose which are ecologically affiliated with the Susitna River. Before such data are available, I recommend continuation of a general, broad based research study of the ecology of subpopulations of moose which are known to interface with environments influenced by the Susitna River in its present state.

General studies of individual moose and of subpopulation behavior will always continue to provide data useful for knowledgeably assessing impacts or predicting responses of moose to any type of hydroelectric development on the Susitna River. As limits of expected variation in hydraulics and plant communities are further refined, research on moose may likewise be directed to investigate particular impacts in finer detail. At the present time, it seems inappropriate to become too specific in addressing potential impacts on moose while disregarding other more general impacts.

To date, it seems that the extent and magnitude of expected hydraulic changes and their influence on vegetative communities between Talkeetna and Cook Inlet remain uncertain. Until potential changes are more clearly outlined, general information on behavior of these subpopulations of moose should definitely not be discontinued. If at a later date, it is learned that impacts in this reach of the river will be negligible on moose, data collected on behavior of these subpopulations may at worse form a basis for assessing and recommending various mitigation options. Relocation of radio-collared moose should continue through the winter of 1983-84.

Periodic winter censuses for moose in floodplain habitats along the Susitna River should be continued through the winter of 1983-84. These censuses document variation within and between winters in the distribution and intensity of use for all stretches and habitat types along the river downstream from Devil Canyon.

Continuation of relocation of radio-collared moose and winter censuses over a number of years provide information an annual variation in use of Susitna River riparian habitats. Ideally, these sorts of data should be collected in a relatively severe winter.

Since rehabilitation of plant communities to favor moose may be a prime mitigation option for loss of moose or their habitat, surveys to assess moose use of sites where vegetative communities have been altered by man, should be continued. To more fully learn about ecology of those sites and their interface with moose, I strongly recommend that samples of moose be radio-collared in the Talkeetna West, Montana West, Montana Middle and Kashwitna Lake sites which were surveyed during the winters of 1981-82 and 1982-83.

Because large alterations in riparian habitats are expected between Talkeetna and Devil Canyon, an additional samples of moose should be radio-collared in that area, to increase the that sample size and our data base. Islanded areas appear important for moose during calving and decreased post project river flows will possibly eliminate many of the islands. Since behavior patterns for male moose differ greatly from those of females and presently only one male is providing data from area, efforts should be made to radio-collar additional males in that subpopulation.

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APPENDIX A

Individual visual collar number, radio transmitter and ear tag numbers, date of capture, sex and maternal status for moose radio-collared in February and March on the Susitna River between the Delta Islands and Cook Inlet, Alaska, 1982.

Visual collar No.	Radio trans.	Ear tag [1]	Capture date	Sex	Maternal status
39	10596	-/-	2/26/82	F	2 calves
40	10595	8489/-	2/24/82	F	0 calves
41	6494	16998/-	2/24/82	F	0 calves
44	6503	-/-	2/26/82	M	---
58	6412	16855/-	3/10/82	F	0 calves
71	6419	16985/-	3/10/82	F	0 calves
75	10594	16944/16986	2/24/82	M	---
76	10592		2/24/82	M	---
78	10606	-/16701	2/24/82	M	---
87	10593	-/16937	2/24/82	F	1 calf
93	10590	16721/	3/10/82	F	1 calf
94	10597	16984/-	2/24/82	F	1 calf
95	10598	-/16710	2/24/82	M	---
96	10599	16702/-	2/24/82	F	1 calf
97	10601	18405/-	2/24/82	F	1 calf
98	10603	16987/-	2/24/82	M	---
99	10591	16856/-	2/24/82	M	---
100	16704	16704/-	2/24/82	F	0 calf
1M [2]	---	-/-	2/24/82	F	0 calf
2M [2]	---	-/-	2/24/82	F	0 calf
3M [2]	---	-/-	2/24/82	F	0 calf

1 Ear tag = left ear tag/right ear tag.

2 M = Mortality, individual found dead at a later date.

APPENDIX B

History of maternal status indicated by the presence of calves for individual female moose radio-collared along the Susitna River from Cook Inlet to Devil Canyon, Alaska and subsequently radio-relocated, 1980-82 [1].

	1980									1981												1982											
Sample Individual	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
1982																																	
58b																								1	1	0	0	0	2	0	2	2	0
71c																								0	0	2	1	1	0	0	0	0	0
93																								1	1	0	0	0	2	0	2	2	0
39																							2	2	2	2	1	1	1	1	1	1	1
40																							0	0	0	2	2	0	2	0	2	2	0
41																							0	0	1	0	0	1	2	0	0	0	0
87																							1	0	0	2	2	0	2	0	2	2	0
94																							1	1	1	1	0	0	0	0	0	0	0
96																							1	1	0	1	0	0	0	0	0	0	0
97																							1	1	0	1	0	0	0	0	0	0	0
100																							0	0	0	0	1	0	0	0	1	0	0
1981																																	
80												1	0	0	0	M																	
71b												0	1	1	2	0	1	K															
71a												1	1	0	1	0	0	0	0	0	M												
74												1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	M						
79												2	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1	M				
42												0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29												2	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0
63												0	0	0	0	1	1	1	0	1	1	1	1	1	1	2	2	2	0	2	1	2	0
68												1	0	1	2	2	1	1	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0
69												1	1	1	1	0	1	1	0	0	1	0	0	0	0	1	2	2	1	0	0	1	1
73												0	0	0	1	1	1	1	1	1	1	1	1	1	1	2	1	0	0	0	0	0	0
19												0	0	2	2	1	0	1	0	1	1	1	1	0	0	1	0	0	0	0	0	1	1
37												0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
45												0	1	0	1	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1	1
56												1	1	1	0	1	0	0	0	1	1	1	0	0	0	1	2	0	0	0	0	0	0
57												0	0	1	1	0	0	0	1	1	1	1	0	1	1	2	0	2	2	0	2	2	0
59												1	0	1	0	1	1	0	1	1	1	1	1	1	1	2	2	2	0	1	1	2	1
62												1	1	1	1	0	0	0	0	0	0	0	0	0	0	2	0	2	0	0	0	1	1
64												1	0	0	0	0	0	0	0	0	1	0	1	0	0	2	2	0	0	0	0	0	0
81												1	0	0	1	0	1	1	0	1	1	1	1	1	1	1	1	0	0	1	0	0	0
82												1	0	1	0	0	1	1	0	1	1	1	0	0	0	2	0	0	0	0	0	1	1
85												1	1	0	0	1	1	1	1	1	1	0	1	1	1	1	2	2	0	0	2	2	2
88												0	0	0	0	0	1	0	0	1	1	0	1	1	1	2	1	0	0	0	1	0	1
90												1	0	0	0	1	0	0	0	0	1	0	0	0	0	2	2	0	1	0	0	1	1
1980																																	
20	0	S																															
24	0	S																															
28	1	S																															
22	1	0	2	2	0	0	0	0	0	0	0	0	0	0	2	2	0	0	1	1	1	1	1	1	1	2	2	0	0	0	0	0	1
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	1	1	1	1	1	1	1	1	1	0	0	1	1
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0

1 Highest number of calves observed with individual female on any survey during indicated monthly period; (_) = newly born calves and/or first time an individual was observei with new calves of the year. S = moose shed collar; M = non-hunter kill mortality; K = hunter kill mortality, underline = first observation of newly born calf or calves.