2321

SUSITNA HYDROELECTRIC PROJECT
1983 ANNUAL REPORT

BIG GAME STUDIES

VOLUME II MOOSE - DOWNSTREAM

Ronald D. Modafferi

ALASKA DEPARTMENT OF FISH AND GAME
Submitted to the Alaska Power Authority
April 1984

DOCUMENT No. 2321

SUSITNA HYDROELECTRIC PROJECT

BIG GAME STUDIES

1983 ANNUAL REPORT

VOLUME II. MOOSE - DOWNSTREAM

Ronald D. Modafferi

ALASKA DEPARTMENT OF FISH AND GAME

Submitted to the Alaska Power Authority

July 1984

NOTICE

ANY QUESTIONS OR COMMENTS CONCERNING THIS REPORT SHOULD BE DIRECTED TO THE ALASKA POWER AUTHORITY SUSITNA PROJECT OFFICE

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 began in order 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. In these annual or final reports, we are narrowing the focus of our studies to evaluate specific impact mechanisms, quantify impacts and evaluate mitigation measures.

This is the second 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 through 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 causative mechanisms, ultimate impacts of direct or indirect effects of hydroelectric development on migratory species of wildlife may occur distant, in both time and space, 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 Susitna River floodplain as wintering habitat for moose is unsurpassed by riparian habitats elsewhere in the State.

The general objective of this study was 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 utilize habitats on the Susitna River floodplain (i.e., what is the ecological value of these habitats to moose?). Only after ecological values of floodplain characteristics to moose are assessed, and subsequently, integrated with hypothetical post-project conditions, can one knowledgeably evaluate impacts of hydroelectric development on moose.

Primary objectives of this study were 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 hydroelectric project may affect subpopulations of moose; and 7) to determine and suggest potential options for mitigating actions.

This report is primarily based on data from relocations of radio-collared moose collected between 15 October 1982 and

6 October 1983, and from supplemental moose censuses and surveys conducted through March 1984, but also includes pertinent findings from the Phase I study progress report (Arneson 1981) and final report (Modafferi 1982) and a Phase II study progress report (Modafferi 1983).

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 to average winters between 1979 and 1984. Though not as severe as winters can be (i.e. 1970-71), the variable nature of weather conditions in the later two winters exhibited the influence snowfall can have on moose behavior and winter use of the Susitna River floodplain and further substantiated the importance of this concern. The 1982-83 winter was characterized by large amounts of snowfall through December, followed by mild conditions and a recession of snowcover by mid-January. The 1983-84 winter was characterized by an early snowfall, continued extensive accumulations of snowcover through February and an abrupt amelioration of conditions in early March.

In the mild winter of 1981-82, a maximum of 369 moose were observed in 6 censuses of floodplain habitats. Maxima of 934 and 819 moose were observed in 11 and 7 similar censuses conducted in winters of 1982-83 and 1983-84, respectively. Though within and between year variation in moose use of floodplain habitats were primarily associated with affects of winter weather conditions on moose behavior, possible effects of winter mortality in 1982-83 on subsequent population levels in winter of 1983-84 and of other factors, which historically may affect long term population levels, should not be overlooked.

Data on patterns of movement, habitat use, productivity, survival and identity of moose subpopulations ecologically affiliated with the Susitna River, presented in this report, were primarily synthesized from 3,184 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 3 October 1983. Five moose initially captured 17 April 1980, were recaptured 27 March 1983 and collared with new radio-transmitters.

Radio-collared moose were relocated at intervals of 16 days through 16 March 1981 and at about 9 day intervals from March 1981 through 3 October 1983. This schedule provided 11, 16, 14, 9, and 9 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. These data illustrate where impacts to subpopulations of moose which winter on the Susitna River floodplain will be realized during other seasonal periods.

Most data collected from radio-collared individuals were analyzed relative to these periods in moose life history. Effects of the variables sex, subpopulation and year were considered in interpretive analyses. Radio-relocations dated outside of the life history periods were grouped within spring, summer, autumn and post-breeding transitory intervals.

To assess magnitude of seasonal and regional moose use of riparian habitats along the Susitna River from to Devil Canyon to Cook Inlet radio-relocation data were integrated with information collected on 6, 11 and 7 aerial censuses for moose conducted on the floodplain between 9 December 1981 and 12 April 1982 and between 29 October 1982 and 22 February 1983, and between 17 November 1983 and 15 March 1984, respectively.

During the study period, a maximum of 934 moose were observed on the lower Susitna River floodplain, but other data, which demonstrated that moose do not use the floodplain everyday within a winter and that some moose do not use the floodplain every year, suggested that this value may underestimate the true value by a minimum of 41 percent.

Numerically, moose winter use of the Susitna River floodplain was greatest south of Talkeetna. Highest moose densities were recorded for large islanded areas near Cook Inlet. Age composition of observed moose appeared related to habitat type; calves were most commonly observed in low relief, relatively open floodplain habitats. For the third consecutive year, female moose north of Talkeetna exhibited an affinity for riparian habitats near the time of parturition. Hypothetical explanations for these observations are provided.

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 latter area. Though moose north of Talkeetna did not range far from riparian habitats, some did travel great 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 and larger areas than females. Though many individual moose were found to range over similar areas during their third year of study, some individuals continued to add different areas to their annual range.

Some data collected from radio-collared individuals suggested that several moose subpopulations which may choose to winter in the foothills of the Talkeetna Mountains, only seek winter range on the Susitna River floodplain when confronted with severe winter conditions in those alpine areas.

To more completely assess the relative importance of Susitna River floodplain habitats (vs. adjacent nonfloodplain habitats) as winter range for moose subpopulations in the Susitna River Valley downstream from Devil Canyon, studies on sites where "natural" vegetation had been altered by activities of man ("disturbed" sites) were intensified and studies involving winter moose surveys conducted in forested and riparian habitats adjacent to the Susitna River floodplain were initiated. These types of studies are of importance since mitigation actions may potentially involve selection and procurement of lands (primarily nonfloodplain) and alteration (enhancement) of habitats on those lands for the benefit of moose populations.

Like the Susitna River floodplain, other riparian areas appeared to be the most heavily used nonfloodplain winter range. However, some nonriparian, heterogenous, relatively open mixed forest habitats also appeared to support substantial numbers of wintering moose. Dense extensive, homogenous, forest habitats contained few moose. Because of early spring movements of moose from floodplain areas in 1984, it was not known if moose had occupied those habitats all winter. These preliminary observations require further study before nonfloodplain, forested habitats are altered as a mitigation action for moose habitat enhancement.

Very dense concentrations of moose were observed at "disturbed" sites. Data on timing and magnitude of their use by moose is provided and their roles in interacting with Susitna River floodplain winter range and in moose winter ecology are evaluated.

One nonfloodplain alpine area in the southwestern foothills of the Talkeetna Mountains, which contained high densities of wintering moose, was visited to determine what food sources were attracting moose to the area. It was found that moose wintering in this alpine area were "cratering" to feed on rhizomes and immature fronds of ferns. Chemical composition of these non-browse food items indicated they contained higher concentrations of essential nutrients and lower concentrations of the less digestible components than apical shoots of browsed willows which occurred in the same area. Ferns may be a critical food item for moose which winter in similar alpine areas.

To understand factors which may limit growth of moose subpopulations associated with the lower Susitna River floodplain, data on productivity and calf survival were collected from radio-collared moose. The latter data when supplemented with information gathered during river censuses indicated that the moose subpopulations studied had very high rates of productivity, but that calves probably sustained early summer predation by black bears and winter weather conditions affected both productivity and calf survival.

Data available on present and historic moose population levels were provided for areas along the Susitna River downstream from

Devil Canyon. Similar data must be considered in assessing the potential value of the Susitna River floodplain habitats to moose, since numbers of moose using those habitats are probably related to moose population levels and the latter can vary over time. Likewise, mitigation plans should not be limited to the present status or use of habitats but more appropriately, they should be based on the potential value of those habitats to moose.

Probable and potential inadequacies of moose samples and sampling effort in this study are listed and discussed.

A list, summarizing preliminary considerations for reviewing, selecting, creating and/or maintaining "enhanced" land areas for the benefit of moose populations was developed.

An annotated summary of potential impact mechanisms and their associated effects is provided. 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.

It was recommendated that research studies investigating: 1) moose use of "disturbed" sites; 2) moose subpopulations north of Talkeetna; 3) moose use of nonfloodplain habitats; 4) ecology of floodplain areas where high moose densities occurred; 5) annual variation in moose movements and productivity; and 6) effects of "severe" winter weather conditions on moose use of the Susitna River floodplain, be continued.

ACKNOWLEDGEMENTS

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

K. Schneider, Alaska Department of 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 Department of Fish and Game, for willing and able assistance and suggestions and comments in all aspects of this study.

C. Allen, Charlie Allen Flight Service, and L. Rogers, 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 Department of Fish and Game, for assistance on radio-relocating surveys, efforts in scheduling and coordinating numerous project activities, and in preparation of this report.

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 and his willing attitude to get the job done, as if the project were his own.

D. Anctil, T. Otto and S. Miller, all Alaska Department of Fish and Game employees, for assistance in management and analysis of data. D. Anctil also provided excellent, "draft ready" computer graphics of most figures presented in this report.

C. Riedner, Alaska Department of Fish and Game, for promptly drafting the figures.

J. Lewis, B. Taylor, and C. Riedner, all Alaska Department of Fish and Game employees for occasional assistance on radio-relocation surveys.

E. Goodwin, Alaska Department of Fish and Game, for processing samples of marrow fat from moose and for providing laboratory supplies whenever they were needed.

G. Couey and R. Lund, Acres American, for logistical support when capturing moose at the Montana West "disturbed site."

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

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES

LIST OF TABLES

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES

LIST OF FIGURES

LIST OF FIGURES

LIST OF FIGURES

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 reevaluate the feasibility of developing the hydroelectric potential of the upper Susitna River. Environmental studies were of particular importance 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.

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.

Though proposed 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.

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 bury 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, such as beaver activity, periodic flooding, ice scouring, riparian erosion, and alluvial 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, 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 hydroelectric 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 and the First Annual Phase II reports (Modafferi 1982 and 1983, respectively) and was initially intended to largely address studies continuing from 20 October 1982 through 3 October 1983.

However, due to unusual variability in 1983-84 winter weather conditions and to recent resurgence in interest, concern and questions pertaining to the planning of a contingency habitat enhancement program for moose as a mitigation option, that reporting period was protracted to include data gathered through the 1983-84 winter. In consideration of the above factors, the extended reporting period facilitated a more meaningful overall assessment of observed moose behavior.

Additional data contained in this report are: moose surveys conducted through 5 April 1984 at "disturbed sites," moose surveys conducted through 15 March 1984 in areas removed from the Susitna River floodplain, periodic moose surveys conducted through 15 March 1984 in the Susitna River floodplain, and general observations from a 23 December 1983 field trip to the western foothills of the Talkeetna Mountains near Little Willow Creek.

In this report, the terminology "disturbed sites" is used loosely in reference to any parcel of ground where human activities have altered climax vegetation and resulted in establishment of seral stages of vegetation which moose utilize as winter browse.

Though this report is based primarily on information obtained since completion of the Phase I Final Report and the First Annual Phase II report, where appropriate, all available data sets were integrated to provide a more meaningful and current description and 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 the First Annual Phase II (Modafferi 1983) reports. However, portions of those reports particularly salient to data herein, are reiterated.

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 most 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 for assessing impacts of Susitna hydroelectric development 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.

Data on several more specific aspects of moose ecology were collected from smaller geographical areas located within the general, overall study area.

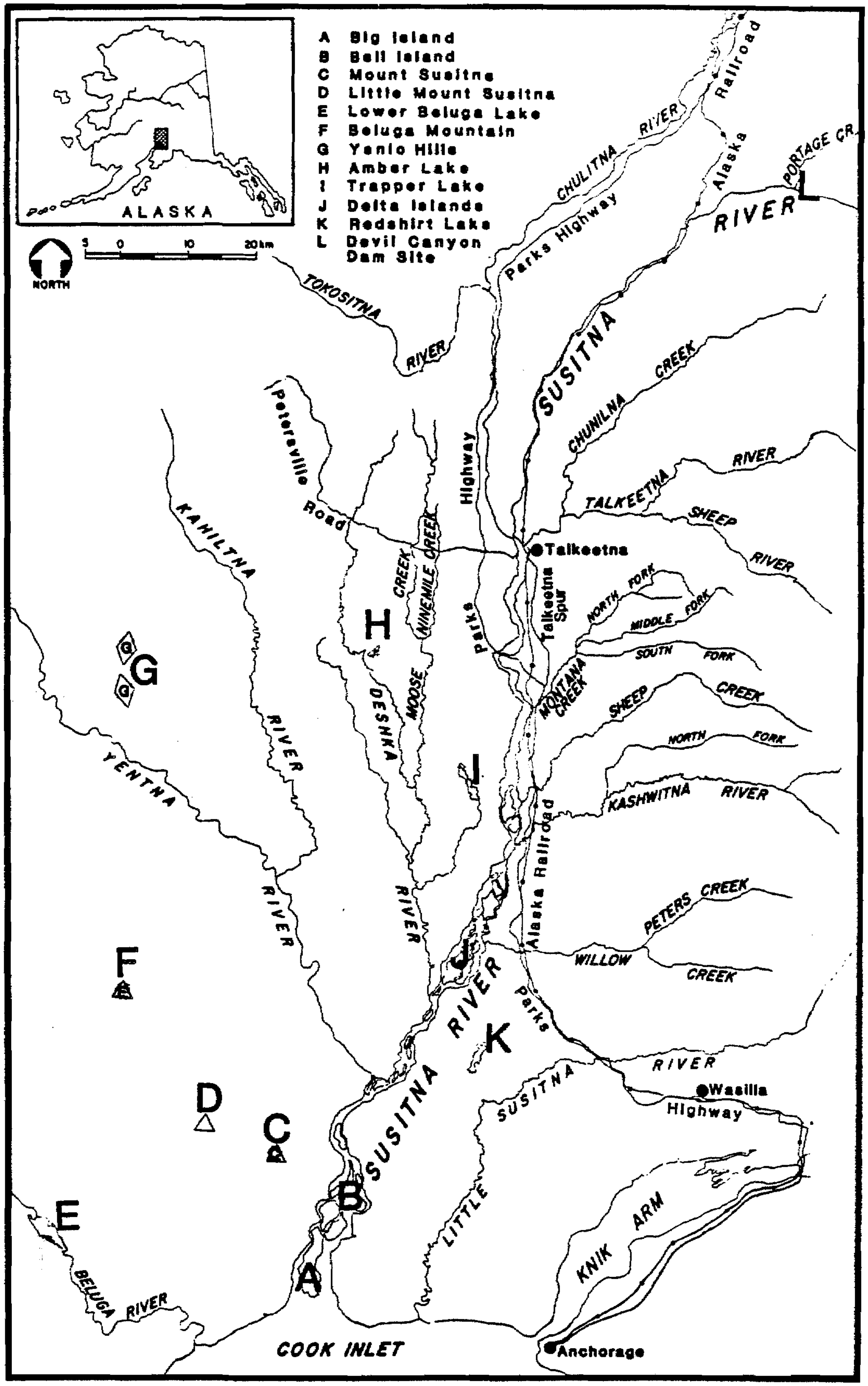

Figure 1. Map showing location of the study area in Alaska with names listed for rivers, lakes and other prominent landscape features.

Data for comparing densities and age composition of moose wintering in different areas and habitats were collected from 2 predominantly small islanded, low relief, floodplain areas and 4 higher relief, large islanded habitats located on the Susitna River floodplain south of Talkeetna (Fig. 2).

Data for determining moose use of habitats where "natural" plant succession had been altered by man, were collected from 13 sites located adjacent to the Susitna River floodplain south of Talkeetna (Fig. 3).

Data for assessing moose use of areas, other than the Susitna River floodplain but within the overall area of study, as winter range were gathered from 3 predominantly riparian habitats and 8 predominantly nonriparian habitats located west of the Susitna River floodplain and south of Talkeetna (Fig. 4).

Data for assessing recent and historic moose population levels in the hypothetical impact zone, were obtained from Alaska Department of Fish and Game files on moose composition counts and from a stratified random census conducted in game management subunits located along the Susitna River corridor south of Devil Canyon (Fig. 5).

METHODS

To identify subpopulations of moose that are ecologically affiliated with Susitna River floodplain habitats downstream from Devil Canyon, to assess the ecological importance of these habitats to individual subpopulations of moose, and to determine timing, location, duration, magnitude, type and seasonal and annual use patterns for those floodplain habitats within and between individual moose subpopulations, it was necessary to periodically locate and observe individually identifiable moose.

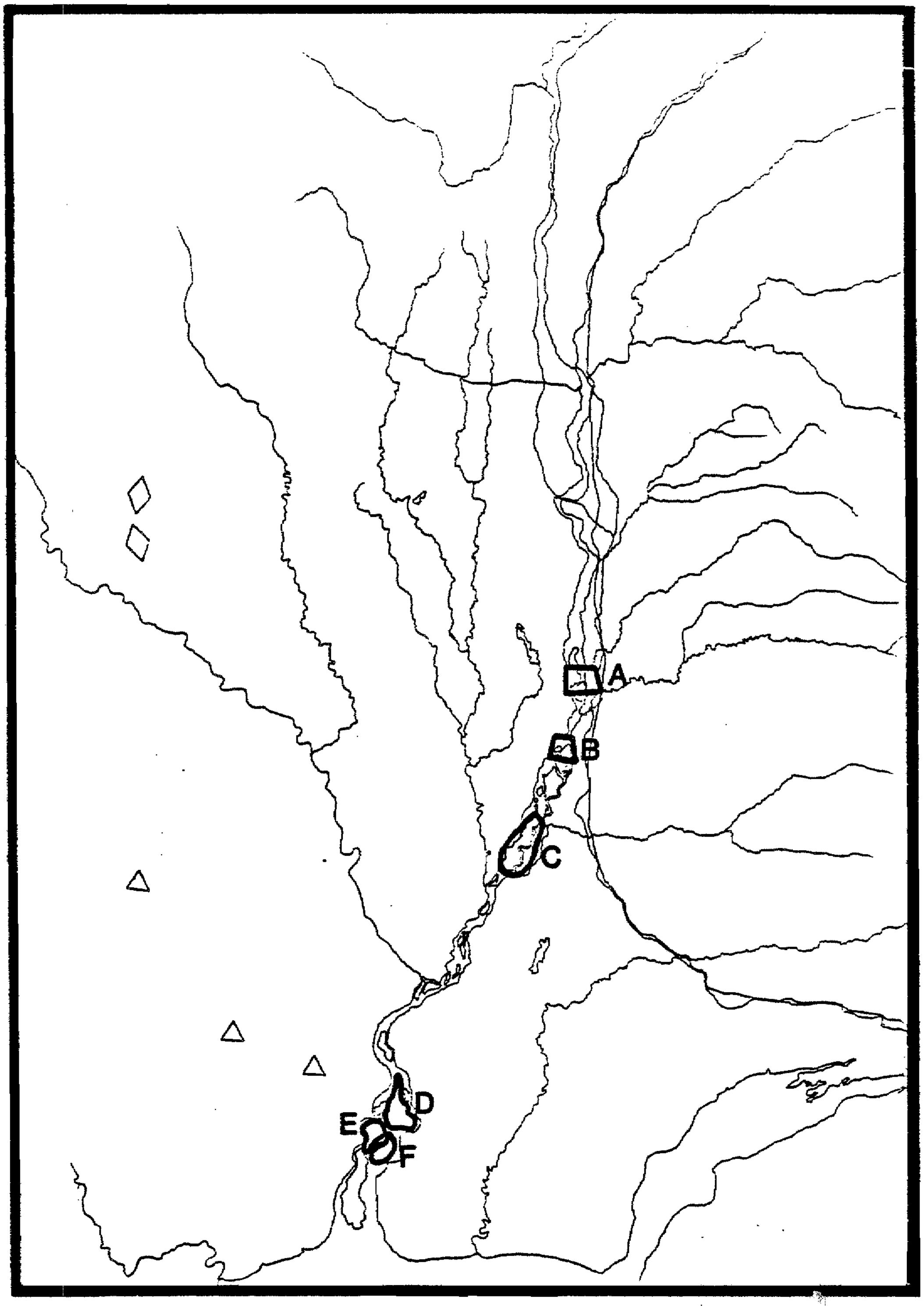

Figure 2. Location of floodplain and islanded areas along the Susitna River, Alaska, where densities and calf composition were determined for wintering moose, 1981–83.
(A = Caswell floodplain, B = Kashwitna floodplain, C = Delta Island, D = Bell Island, E = Alexander Island, F = Beaver Island)

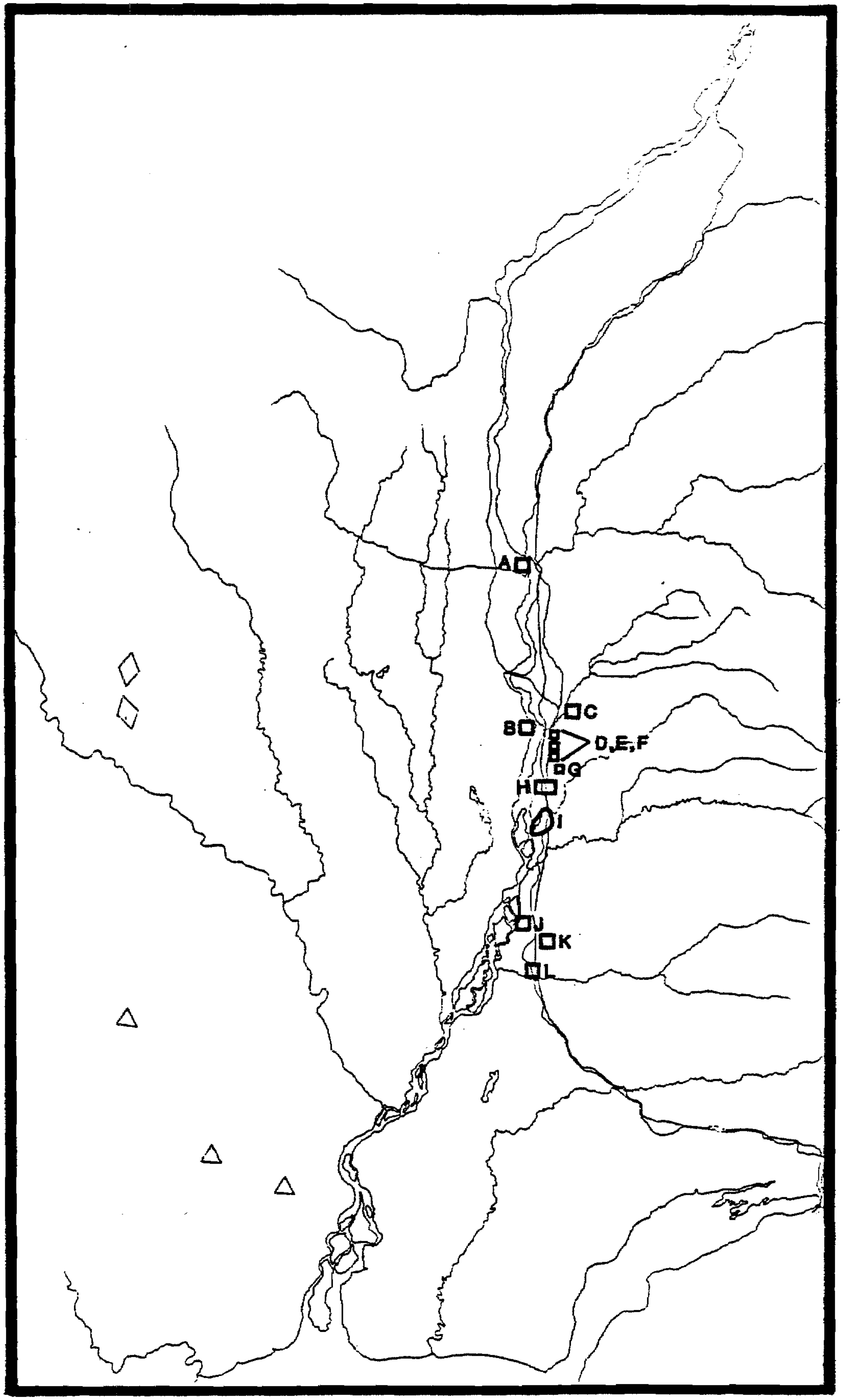

Figure 3. Location of sites adjacent to the Susitna River, Alaska, where climax vegetation has been altered by man and numbers of moose were counted periodically during the winter, 1981-84. (A = Talkeetna West, B = Montana West, C = Montana East, D = Montana North, E = Montana Middle, F = Montana South, G = Goose Creek, H = Chandalar East and West, I = Kashwitna Bluff, J = Kashwitna Lake, K = Kashwitna East and L = Willow Creek)

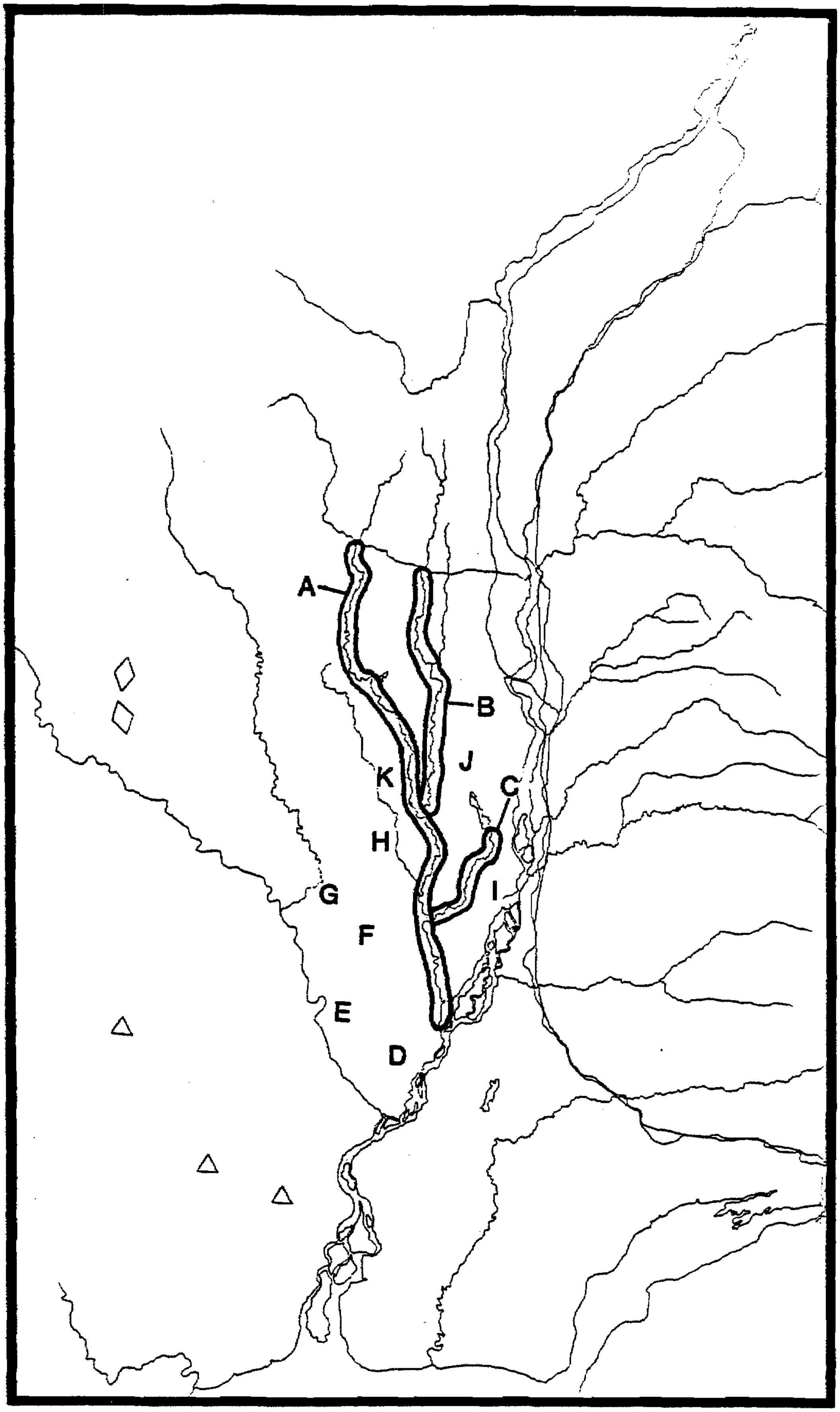

Figure 4. Geographic locations for moose surveys conducted in areas removed from the Susitna River floodplain, Alaska. (A = Deshka River, B = Moose Creek, C = Trapper Creek, D = Whitsol Lake, E = Swede, F = Lockwood Lake, G = Kahiltna/Moose Creek, H = Neil Lake, I = Kashwitna Knobs, J = Trapper Lake and K = Parker Lake)

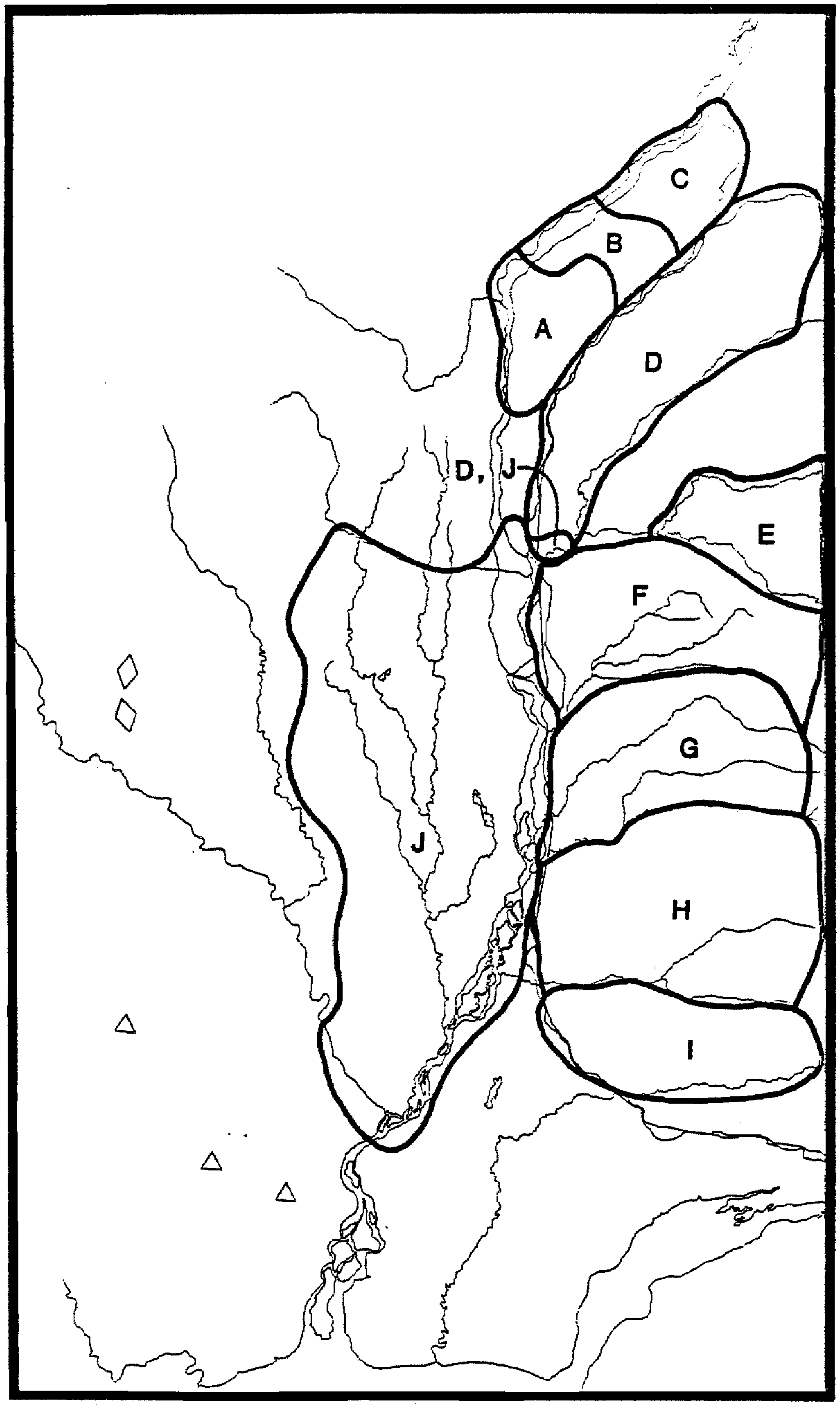

Figure 5. Geographical areas (A - J) along the Susitna River, Alaska, downstream from Devil Canyon, where numbers and sex and age composition of moose have been assessed by aerial survey techniques. (See Table 19 for survey data.)

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

Moose were collared during the winter on the ice and snow covered Susitna River floodplain between Sheep Creek and Sherman in 1980 (Arneson 1981), between the Delta Islands and Portage Creek in 1981 (Modafferi 1982) and between the Delta Islands and Cook Inlet in 1982 (Modafferi 1983). Due to the relative unavailability of moose on the floodplain north of Talkeetna, some individuals were captured up to 400 m on either side of the river proper.

Five moose (No. 22, 23, 26, 27 and 91) originally captured and radio-collared in April 1980 were relocated, recaptured, and retagged with new radio-transmitting collars on 27 March 1983. Original radio transmitters on these moose were expected to expire within several months.

Relocation flights with Cessna 172, 180 or 185 aircraft-equipped with a yagi antenna on each wing were conducted at intervals of about 2-3 weeks in 1980 and about every 1-2 weeks thereafter. Inclement weather occasionally altered this schedule.

Locations (audio-visual or audio) of radio-collared moose were noted on 1:63,360 scale USGS topographic maps and later transferred to mylar overlays for computer digitization. Data on elevation, vegetation, snow cover and other moose at the relocation sites were also recorded. For more complete details of data management, see Miller and Anctil (1981).

Three subsamples of moose were used to provide 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.

To relate these findings to moose ecology and to illustrate the relative magnitude of 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 range use periods 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 range location, a very narrow spread of inclusive dates was selected to describe locations for respective life history activity periods. Perhaps determination of areal extent of these ranges would suffer at the expense of determining 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. Data provided from this methodology may be interpreted to illustrate how and where impacts of Susitna River hydroelectric development will most likely be realized in relation to both moose population ecology and subpopulation geography (i.e., habitat or moose lost in hydroelectric development may impact hunters in a particular area, affect results of fall moose composition surveys in another area and affect spring and winter calf composition surveys in yet other geographical areas, etc.)

Moose were known use the Susitna River floodplain year-round; however, a previous study indicated that the magnitude (time and numbers) of use was significantly greater during the winter and

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	------------	---

particularly so during winters characterized by deep snows which persist late into early spring (Rausch 1958). In consideration of this *a priori* knowledge, a series of periodic aerial moose censuses were conducted within the floodplain of the Susitna River from Cook Inlet to Devil Canyon, to assess the magnitude of river use, to delineate the timing of use and to determine the location and spatial distribution of use.

No periodic river census was conducted in the winter of 1980-81, because when 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. Within the winters of 1981-82, 1982-83 and 1983-84, 6, 11, and 7 aerial moose censuses, respectively, were conducted on the Susitna River floodplain. In 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; 7 and 9 February; 22 and 23 February; 7 and 8 March; 22 and 23 March and 7, 8, and 13 April. In winter of 1983-84, censuses were conducted on 17 and 18 November; 9, 14, and 16 December; 29 and 30 December; and 5 January; 3, 8, and 9 February; 21 and 28 February and 1 March; and 15 March.

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. Though limitations of aerial surveys of moose were known (LeResche and Rausch 1974), the object of each aerial river census was to count all moose within the banks of the Susitna River floodplain and any of its interconnecting sloughs.

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. 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 2 calves, and lone calves.

Location of each moose observed was recorded on USGS 1:63,360 scale topographic maps. Weather and numbers of moose counted affected duration of individual censuses. Inclement weather and inadequate snowcover for counting moose frequently interrrupted continuity within and between censuses. Characteristics of the Susitna River and adjacent floodplain habitats change greatly between Devil Canyon and Cook Inlet. To reflect these obvious ecological changes, data from each river census was presented for each of 4 physiographic zones. Detailed descriptions for physiographic zones appear in Modafferi (1982, p. 5-15).

To facilitate calculation of relative densities of moose which were observed wintering in habitats within each of the 4 riparian zones on each census of Susitna River floodplain within or between years, one may utilize surface area calculations that I determined for each zone, by making visual estimates of 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, respectively, of aquatic and terrestrial habitats, respectively.

After conducting numerous aerial river censuses over a period of several years, it became apparent that moose were not distributed evenly throughout the course of the Susitna River. To examine this contention, densities and age composition of moose observed on periodic river censuses were calculated and compared between 2 low relief, predominantly floodplain areas (Caswell and Kashwitna) and 4 higher relief predominantly large islanded areas (Delta, Bell, Alexander and Beaver). These areas were selected because they represented different types of riparian habitat and numbers of moose observed on surveys appeared to differ greatly between them. Study of geography, physiography and habitat types within each area could provide baseline data for appraising relative values of different habitats to moose and for secondarily assessing the role of river flow hydraulics in creating and maintaining those habitats.

Since mitigation actions may potentially involve selection and procurement of lands and alteration of habitats on those lands for the benefit of moose populations, studies were initiated in areas downstream from Devil Canyon and off the Susitna River floodplain, to obtain information on moose winter use of 1) sites where "natural" vegetation had been altered by man ("disturbed sites"), and 2) sites where "natural" vegetation occurred in non-Susitna River floodplain habitat.

Preliminary studies on moose use of "disturbed sites" were initiated in 1981 and continued through winter of 1982-83 (Modafferi 1983). In 1983-84, periodic aerial censuses for moose were conducted on the 6 original sites studied in 1981-83 and on 7 additional sites. Eight, 14 and 17 moose censuses were conducted on "disturbed sites" during the 1981-82, 1982-83 and 1983-84 winters, respectively.

To census moose on "disturbed sites," aerial surveys were conducted by flying low-level transects over the area in a PA-18. A 100 m band around the disturbed area was also surveyed to include moose which may be using the site but were "bedding down" in denser vegetative cover along the perimeter of the site. Moose observed were categorized into sex and age classes utilized in river censuses.

To obtain more definitive baseline data on moose use of "disturbed sites," 3 male and 4 female moose were captured and tagged with radio-transmitting collars on 31 January and 1 February, 1984 at the Montana West "disturbed site," located opposite Montana on the west side of the Susitna River (Fig. 3). This sample of moose will be relocated periodically along with other samples of radio-collared moose.

Immobilization and field procedures for capture, tagging and radio-relocating were described in Modafferi (1982 and 1983).

To assess moose use of nondisturbed ("natural"), nonfloodplain habitats, aerial censuses were conducted in March 1984 on 11 sites removed from the Susitna River floodplain. In general, sites surveyed contained either riparian successional or "climax" type, forested habitats. Information from these studies will be used to evaluate the absolute value of such areas and habitats to moose as winter range, will assist in appraising the relative winter range value of Susitna River floodplain habitats, and will provide data on moose winter use of "climax" type habitats. Since the latter type habitats are likely to be selected for enhancement, it is important that their overall value to moose be well understood before they are altered in favor of other more seral, vegetative associations.

Surveys in nonfloodplain areas were conducted in a manner similar to river censuses (Modafferi 1983) and procedures resembled those recommended by Gasaway (1981) for counting moose in sample units of standard statified random moose surveys.

Information obtained from these aspects of downstream moose studies were intergrated with other baseline data on moose ecology to formulate a listing of facts and procedures to be considered in selection of lands and alteration of habitats for the benefit of moose. This listing is preliminary and may be updated as new data become available.

Censuses in nonfloodplain areas were planned to be conducted when seasonal moose use of Susitna River floodplain habitats was greatest and annual winter conditions were rated as "severe." By early February, winter conditions in 1984 appeared destined to satisfy both stipulations and censuses in nonfloodplain areas were initiated. Harsh winter conditions continued through early March, but subsequently, ameliorated tremendously, as record warm and dry weather conditions occurred in mid-March. The aforementioned, unanticipated change in pattern of weather conditions must be considered when evaluating results of these censuses.

To relate present moose population levels to historic levels, data from recent Alaska Department of Fish and Game moose composition surveys were compared to record high, historical counts available from Alaska Department of Fish and Game moose composition survey data files. These data may be used to place present moose population levels and associated moose use of Susitna River floodplain habitats into perspective, historically. Count areas considered were those utilized by the Alaska Department of Fish and Game to reflect composition and status of moose subpopulations in areas which parallel the Susitna River downstream from Devil Canyon, Game Management Subunits 13E, 14B and 16A.

Data from previous moose composition surveys indicated that particularly dense winter concentrations of moose occurred in alpine areas between Little Willow Creek and the Peters Creek fork of Willow Creek ("Willow Mountain"). Observations incidental to routine radio relocating surveys, confirmed these reports and indicated that most moose were actively "cratering" for food. On 3 January 1984, the area was visited to determine what foods initiated the "cratering" behavior and to collect samples of those foods for chemical analyses. Chemical analyses were conducted at the University of Alaska, Agricultural Experiment Station, Palmer, Alaska.

Data obtained from radio-collared female moose during routine aerial relocation surveys and from aerial river censuses were used to document calf production and survival for moose populations which winter on the Susitna River floodplain. These data were also used to assess and rate factors which may be limiting growth of those moose populations.

LIMITATIONS OF SAMPLES AND SAMPLING EFFORT

Samples are only representative of the population from which they were drawn. Since moose subpopulation use of the Susitna River floodplain is greatly influenced by winter conditions, photo period (seasonal time) and location, samples of radio-collared moose are winter, season and location specific subpopulation samples. As a result, radio-collared samples of moose probably do not contain representatives from all moose subpopulations which winter on the Susitna River floodplain. For a more detailed discussion see Modafferi (1982, 1983).

The sample of moose radio-collared north of Talkeetna, where impacts from hydroelectric development are expected to be greatest, was small and data were collected from only two males. For these reasons, I believe data presently available to identify and assess habitat use for moose subpopulations which use this portion of the Susitna River floodplain are inadequate.

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).

Moose use Susitna River floodplain habitats throughout the year, but greatest use occurs in winter, when snow and foraging conditions become unfavorable in adjacent habitats (Rausch 1958). Though timing, duration and magnitude of moose use is strongly influenced by occurrence and extent of snowfall in the Susitna River valley, I believe that activities and movements associated with rutting and calving would override any extreme effects of weather on the timing of moose movements. With these constraints, the winter period, would be bounded by late October, in the fall, and by late April, in the spring.

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 24 censuses for moose in floodplain habitats along the Susitna River downstream from Devil Canyon to

Cook Inlet (Modafferi 1982 and Tables 2-13) substantiate beliefs of Rausch (1958) and others (Chatelain 1951 and LeResche 1974) about affects of weather on 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, 11 censuses were conducted from 29 October through 9 February during the relatively inclement winter of 1982-83, and 7 censuses were conducted from 17 November through 15 March during the highly variable seasonal and area weather conditions in winter of 1983-84.

Maximum numbers of moose observed (minimum numbers of moose using the area) annually on the Susitna River floodplain varied from 369 in Census No. 4, to 934 in Census No. 10 to 819 in Census No. 23, respectively, for the winters of 1981-82, 1982-83 and 1983-84 (Table 14). These peaks in total numbers of moose occurred in early March, mid-December and late February for the 3 respective winter periods. Though these particular censuses yielded maximum numbers for all censuses within a year, greater hypothetical values are obtained, if one calculates an aggregate annual total by summing the maximum numbers of moose observed for each zone within each year. Considering these annual maxima values within zones, their aggregate annual sum, and the fact that moose interchange between zones was probably minimal, then a minimum of (36 + 25 + 236 + 123) 420, (84 + 94 + 460 + 412) 1,050, and (88 + 107 + 325 + 403) 923 different moose utilized the Susitna River floodplain during the respective winters of 1981-82, 1982-83 and 1983-84. These data may also be interpreted to indicate maxima values for moose use (moose days) which occurred on the floodplain in each of these winters.

The winter of 1981-82 was mild and resulted in a subtle increase and low, early March peak in moose use (369 moose) of floodplain areas.

Table 2. Sex, age composition and zone of location for moose observed on the 7 and 9 February aerial censuses of the Susitna River from Devil Canyon to Cook Inlet, Alaska, 1983.

	Census No. 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	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. May be underestimates (see footnote 3).

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 becomes prevalent by mid-December.

Table 3. Sex, age composition and zone of location for moose observed on the 22 and 23 February aerial censuses of the Susitna River from Devil Canyon to Cook Inlet, Alaska, 1983.

	Census No. 14									
River zone [1]	Males [2]		Females [3]			Lone calves	Total		
	Ad	Im	W/O	W/1	W/2		Ads	Calves	Moose
I	0	0	17	5	0	0	22	5	27
II	0	0	28	16	1	2	45	20	65
III	0	0	146	58	2	1	206	63	269
IV	0	0	133	38	1	0	172	40	212
Total	0	0	324	117	4	3	445	128	573

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. May be underestimates (see footnote 3).

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 becomes prevalent by mid-December.

Table 4. Sex, age composition and zone of location for moose observed on the 7 and 8 March aerial censuses of the Susitna River from Devil Canyon to Cook Inlet, Alaska, 1983.

	Census No. 15								
River zone [1]	Males [2]		Females [3]			Lone calves	Total		
	Ad	Im	W/O	W/1	W/2		Ads	Calves	Moose
I	0	0	24	4	0	0	28	4	32
II	0	0	38	10	1	1	49	13	62
III	0	0	161	46	2	1	209	51	260
IV	0	0	124	31	1	1	156	34	190
Total	0	0	347	91	4	3	442	102	544

[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. May be underestimates (see footnote 3).

[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 becomes prevalent by mid-December.

Table 5. Sex, age composition and zone of location for moose observed on the 22 and 23 March aerial censuses of the Susitna River from Devil Canyon to Cook Inlet, Alaska, 1983.

	Census No. 16								
	Males [2]		Females [3]			Lone	Total		
River zone [1]	Ad	Im	W/O	W/1	W/2	calves	Ads	Calves	Moose
I	0	0	13	2	0	0	15	2	17
II	0	0	26	13	1	0	40	15	55
III	0	0	158	56	2	1	216	61	277
IV [4]	-	-	-	-	-	-	-	-	-
Total	0	0	197	71	3	1	271	78	349

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. May be underestimates (see footnote 3).

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 becomes prevalent by mid-December.

4 Snow cover in this zone insufficient for counting moose.

Table 6. Sex, age composition and zone of location for moose observed on the 7, 8 and 13 April aerial censuses of the Susitna River from Devil Canyon to Cook Inlet, Alaska, 1983.

	Census No. 17								
River zone [1]	Males [2]		Females [3]			Lone calves	Total		
	Ad	Im	W/O	W/1	W/2		Ads	Calves	Moose
I	0	0	2	1	0	0	3	1	4
II	0	0	21	4	0	1	25	5	30
III	0	0	82	22	1	1	105	25	130
IV [4]	0	0	80	16	0	0	96	16	112
Total	0	0	185	43	1	2	229	47	276

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. May be underestimates (see footnote 3).

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 becomes prevalent by mid-December.

4 Due to insufficient snow cover, on 7 and 8 April, census in this zone could not be conducted until 13 April.

Table 7. Sex, age composition and zone of location for moose observed on the 17 and 18 November aerial census of the Susitna River from Devil Canyon to Cook Inlet, Alaska, 1983.

	Census No. 18								
River zone [1]	Males [2]		Females [3]			Lone calves	Total		
	Ad	Im	W/O	W/1	W/2		Ads	Calves	Moose
I	1	0	5	6	1	0	13	8	21
II	0	0	3	2	2	2	7	8	15
III	7	6	27	26	1	1	67	29	96
IV [4]	-	-	-	-	-	-	-	-	-
Total	8	6	35	34	4	3	87	45	132

1 I = Devil Canyon to Talkeetna, II = Talkeetna to Montana Creek, III = 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. May be underestimates (see footnote 3).

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 becomes prevalent by mid-December.

4 Snow conditions in Zone IV not suitable for counting moose.

Table 8. Sex, age composition and zone of location for moose observed on the 9, 14 and 16 December aerial censuses of the Susitna River from Devil Canyon to Cook Inlet, Alaska, 1983.

	Census No. 19								
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	10	3	0	18	16	34
II	1	0	7	1	1	1	10	4	14
III[4]	7	1	33	27	2	2	70	33	103
IV	8	2	43	28	6	0	87	40	127
Total	16	3	88	66	12	3	185	93	278

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. May be underestimates (see footnote 3).

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 becomes prevalent by mid-December.

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

Table 9. Sex, age composition and zone of location for moose observed on the 29-30 December 1983 and 5 January 1984 aerial censuses of the Susitna River from Devil Canyon to Cook Inlet, Alaska, 1983-84.

	Census No. 20								
	Males [2]		Females [3]			Lone	Total		
River zone [1]	Ad	Im	W/O	W/1	W/2	calves	Ads	Calves	Moose
I [4]	-	-	-	-	-	-	-	-	-
II	0	0	17	9	2	0	28	13	41
III	9	1	53	33	5	0	101	43	144
IV	7	3	52	29	3	0	94	35	129
Total	16	4	122	61	10	0	223	91	314

[1] I = Devil Canyon to Talkeetna, II = Talkeetna to Montana Creek, III = 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.
May be underestimates (see footnote 3).

[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 becomes prevalent by mid-December.

[4] Weather conditions in Zone I not suitable for conducting survey.

Table 10. Sex, age composition and zone of location for moose observed on the 13, 17 and 19 January aerial censuses of the Susitna River from Devil Canyon to Cook Inlet, Alaska, 1984.

	Census No. 21								
	Males [2]		Females [3]			Lone	Total		
River zone [1]	Ad	Im	W/O	W/1	W/2	calves	Ads	Calves	Moose
I	0	0	9	6	2	0	17	10	27
II	5	1	14	8	2	1	30	13	43
III	6	1	78	37	3	1	115	44	159
IV	10	3	122	67	7	0	209	81	290
Total	21	5	223	118	14	2	381	148	529

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. May be underestimates (see footnote 3).

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 becomes prevalent by mid-December.

Table 11. Sex, age composition and zone of location for moose observed on the 3, 8 and 9 February aerial censuses of the Susitna River from Devil Canyon to Cook Inlet, Alaska, 1984.

	Census No. 22								
River zone [1]	Males [2]		Females [3]			Lone calves	Total		
	Ad	Im	W/O	W/1	W/2		Ads	Calves	Moose
I	1	1	46	20	0	0	68	20	88
II	0	0	52	26	1	0	79	28	107
III	0	1	180	46	4	1	231	55	286
IV[4]	1	6	160	59	6	1	232	72	304
Total	2	8	438	151	11	2	610	175	785

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. May be underestimates (see footnote 3).

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 becomes prevalent by mid-December.

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

Table 12. Sex, age composition and zone of location for moose observed on the 21 and 28 February and 1 March aerial censuses of the Susitna River from Devil Canyon to Cook Inlet, Alaska, 1984.

	Census No. 23									
River zone [1]	Males [2]		Females [3]			Lone calves	Total		
	Ad	Im	W/O	W/1	W/2		Ads	Calves	Moose
I	0	0	35	3	0	0	38	3	41
II	0	0	40	5	0	0	45	5	50
III	0	0	214	52	2	1	268	57	325
IV	0	1	232	70	10	0	313	90	403
Total	0	1	521	130	12	1	664	155	819

[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. May be underestimates (see footnote 3).

[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 becomes prevalent by mid-December.

Table 13. Sex, age composition and zone of location for moose observed on the 15 March aerial census of the Susitna River from Devil Canyon to Cook Inlet, Alaska, 1984.

	Census No. 24								
River zone [1]	Males [2]		Females [3]			Lone calves	Total		
	Ad	Im	W/O	W/1	W/2		Ads	Calves	Moose
I[4]	0	0	9	0	2	0	11	4	15
II	-	-	-	-	-	-	-	-	-
III	-	-	-	-	-	-	-	-	-
IV	-	-	-	-	-	-	-	-	-
Total	0	0	9	0	2	0	11	4	15

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. May be underestimates (see footnote 3).

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 becomes prevalent by mid-December.

4 Snow cover in Zones I - III not suitable for counting moose.

Table 14. Percent of calves (numbers of moose) observed on each of 24 censuses for moose in floodplain habitat along 4 zones of the Susitna River between Devil Canyon and Cook Inlet, Alaska 1981-84.

Winter period	No. census	Date	River Zone[1] I	II	III	IV	Census total
1981-82	1	9 and 10 Dec	22 (36)	31 (16)	31 (147)	28 (123)	29 (322)
	2	28 Dec 81, 4 Jan	22 (18)	26 (19)	26 (191)	28 (96)	26 (324)
	3	2 and 6 Feb	0 (8)	20 (5)	25 (134)	21 (92)	23 (239)
	4	1 and 2 Mar	0 (7)	24 (17)	16 (236)	20 (107)	17 (369)
	5	23 and 24 Mar	20 (25)	36 (25)	20 (166)	20 (41)	22 (257)
	6	12 Apr	14 (7)	17 (18)	32 (57)	-[2]	27 (82)
1982-83	7	29 Oct and 6 Nov	22 (14)	25 (4)	32 (60)	29 (89)	29 (171)
	8	10 and 18 Nov	18 (57)	36 (28)	25 (232)	26 (159)	25 (476)
	9	1, 2 and 6 Dec	17 (76)	24 (46)	31 (292)	18 (412)	23 (826)
	10	20-22 Dec	20 (76)	34 (86)	28 (460)	21 (312)	25 (934)
	11	5 and 6 Jan	21 (84)	28 (94)	29 (345)	-	27 (523)
	12	20 and 24 Jan	34 (56)	19 (62)	29 (329)	-	29 (447)
	13	7 and 9 Feb	38 (26)	23 (44)	30 (251)	22 (206)	27 (527)
	14	22 and 23 Feb	19 (27)	31 (65)	23 (269)	19 (212)	22 (573)
	15	7 and 8 Mar	13 (32)	21 (62)	20 (260)	18 (190)	19 (544)
	16	22 and 23 Mar	12 (17)	27 (55)	22 (277)	-	22 (349)
	17	7, 8 and 13 Apr	25 (4)	17 (30)	19 (130)	14 (112)	17 (276)
1983-84	18	17 and 18 Nov	38 (21)	53 (15)	43 (96)	-	51 (132)
	19	9, 14 and 16 Dec	47 (34)	29 (14)	32 (103)	31 (127)	33 (278)
	20	29 and 30 Dec and 5 Jan	-	31 (41)	30 (144)	27 (129)	29 (314)
	21	13, 17 and 19 Jan	37 (27)	30 (43)	28 (159)	28 (290)	28 (529)
	22	3, 8 and 9 Feb	23 (88)	26 (107)	19 (286)	24 (304)	22 (785)
	23	21 and 28 Feb and 1 Mar	7 (41)	10 (50)	17 (325)	22 (403)	19 (819)
	24	15 Mar	27 (15)	-	-	-	27 (15)

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 - = Zone not censused because of insufficient snow cover or inclement flying weather.

In 1982, following an early snowfall in October, relatively few moose (171 moose) were observed on the floodplain. Extensive snowfall later in that winter precipitated a rapid, early (mid-December) and high peak in moose use (934 moose) of floodplain habitats. However, in response to a relative scarity of snowfall after December and melting of the existing snowcover, moose numbers decreased sharply, but remained at a relatively high level (550 moose) through March, as the snow cover persisted, until subsequently decreasing to a lower level by mid-April (276 moose).

Winter in 1983-84, was characterized by average early winter weather conditions. Mild weather conditions prevailed through December and moose use of the Susitna River floodplain was correspondingly low (about 300 moose). Heavy snowfall during January and frequent snowfall and increasing accumulations of snow through February, apparently triggered a gradual movement of moose toward the Susitna River riparian habitats and ultimately resulted in a large concentration of moose (819) on the river's floodplain by late February/early March (Census No. 23). However, one of the warmest and driest months of March on record followed. Because of the rapid decrease in snow cover inadequate survey conditions occurred and aerial moose censuses were not done. Consequently, information on moose use of the floodplain in late March-early April 1983-84 is not available.

Data gathered from river censuses demonstrate that moose use of Susitna River floodplain habitats is closely related to winter weather conditions, particularly snowfall and resultant depth of the snowcover. Within years, mild weather conditions may preclude movements of large numbers of moose (1981-82), early snows may initiate early moose movements (1982-83) and late snows may delay moose movements to floodplain areas (1983-84). Moose movements to floodplain areas may be rapid (1982-83) or gradual (1983-84). High levels of moose use may be sustained for long periods of time (1982-83) or may be relatively short-lived (1983-84). Abrupt decreases in moose numbers associated with ameliorating weather conditions, occurred in all winters. Even in mild winters, moose from some subpopulations apparently still move to floodplain habitats (1981-82).

Data gathered from Census No. 7, indicates that approximately 171 moose may be closely associated with Susitna River floodplain habitats throughout the year. If this is true, then the floodplain moose population may double during a mild winter (369 moose in 1981-82) and even increase by 5 times during a more severe winter (934 in 1982-83). Apparently, the numbers of moose which move to floodplain habitats is related to severity of the winter; as winter severity increases more moose seek forage in floodplain habitats. If winter in 1982-83 had ended harsh like the 1983-84 winter, there probably would have been many more moose on the floodplain then were present in either winter separately.

It was very interesting that large numbers of moose which moved to floodplain habitats in winter 1982-83 (Census No. 10) did not remain in those areas through the winter (at least through early March) but departed by at least early February. Several of the possible explanations for this occurrence are: 1) that habitats from which they came are much more desirable and 2) the floodplain could not support them and other transient moose for the remainder of the winter. It is still unknown whether these highly mobile moose were a part of a subpopulation already present on the river or a part that came from greater distances or different areas or were from a completely different moose subpopulation. It is also not known whether moose which immigrated <u>early</u> in winter 1982-83 are the same groups of individuals which moved to floodplain areas <u>late</u> in 1983-84 (i.e., Does timing of snowfall affect likelihood of specific subpopulations to move to floodplain habitats?). If different subpopulations are involved, then, numbers of <u>different</u> moose which use floodplain habitats would be significantly greatly than simply considering the maximum numbers of moose within years (1982-83 and 1983-84) but would also involve adding some early winter moose of 1982-83 to the late winter moose of 1983-84.

Numbers of moose utilizing floodplain habitats in 1983-84 may have been depressed by winter mortality sustained by moose populations in the previous winter. Percent calves observed in floodplain habitats in 1983-84 on Census No. 23 (Table 14) indicates that calf moose sustained a higher rate of mortality in the 1983-84 winter than in previous winters.

Percent of calf moose observed on the Susitna River floodplain decreased dramatically in 1982-83. The decrease in percent calf moose observed on floodplain censuses became apparent by late February and early March (Census No. 14 and 15), when 22 and 19 percent of the moose observed were calves. The percent calves observed on the previous 7 censuses conducted by early February in 1982-83 averaged 26 percent. Decreases in percent calves in 1982-83 did not become apparent until several months after peak moose numbers were attained (Census No. 10 vs. 14).

Similar comparisons for the winter of 1983-84 indicated that decreases in numbers of calves became apparent a month prior to appearances of maximum numbers of moose (Census No. 22 vs. Census No. 23).

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 moose subpopulations will ultimately be realized; and

4) propose various mitigation plans and determine the overall positive effects of those plans 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. 6 illustrate the spatial distribution of all radio relocations (3184) for all moose captured and radio-collared along the Susitna River between Devil Canyon and Cook Inlet. Generally, these data may be interpreted to indicate the minimum area or zone within which impacts incurred by moose that utilize Susitna River riparian habitats, may 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 headwaters of Sheep Creek, Pittman and Big Lake; an area covering approximately 10,380 km^2. The impact zone broadens widely in areas south of Talkeetna (Fig. 6)and it is apparent that impacts to moose, from Susitna River hydroelectric development are likely to be realized in areas quite distant from the river's floodplain.

Likewise, positive effects of mitigation efforts undertaken in riparian habitats may be realized throughout this same area or may be directed at locations distant from the floodplain and still benefit moose subpopulations which utilize floodplain habitats.

Figures 7 and 8 illustrate points of relocation for female and male radio-collared moose, respectively. These data indicate that the 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 individuals, appeared to range more widely.

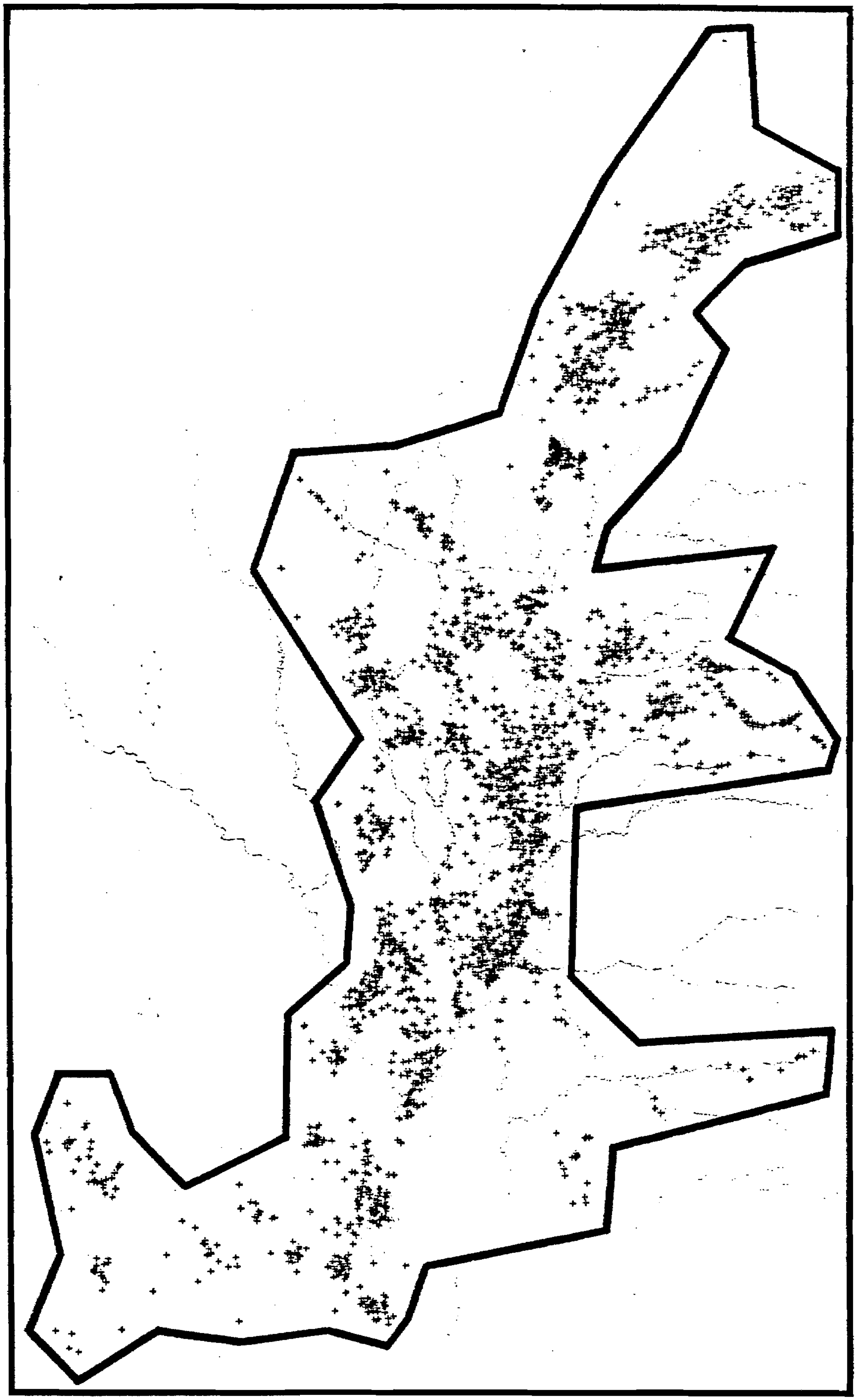

Figure 6. Polygon encompassing 3184 relocation points for 10 moose radio-collared 17 April, 1980, 29 moose radio-collared 10-12 March, 1981 and 17 moose radio-collared 26 February - 10 March, 1982 along the Susitna River between Devil Canyon and Cook Inlet, Alaska and monitored through 3 October, 1983. (Inclusive area = 10380 km^2)

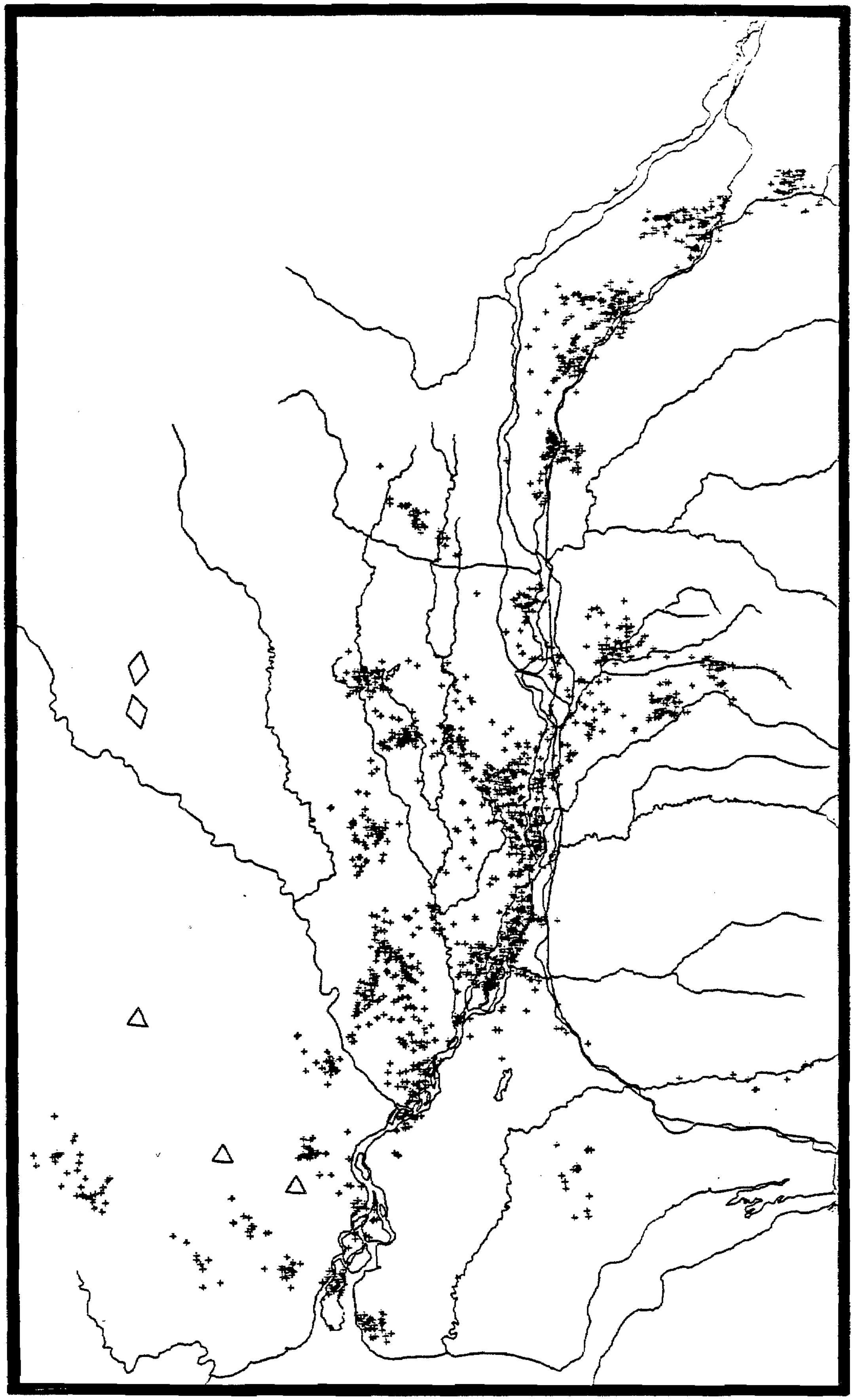

Figure 7. Radio-relocations (2462) for 40 female moose captured and radio-collared along the Susitna River between Devil Canyon and Cook Inlet, Alaska, 1980-83.

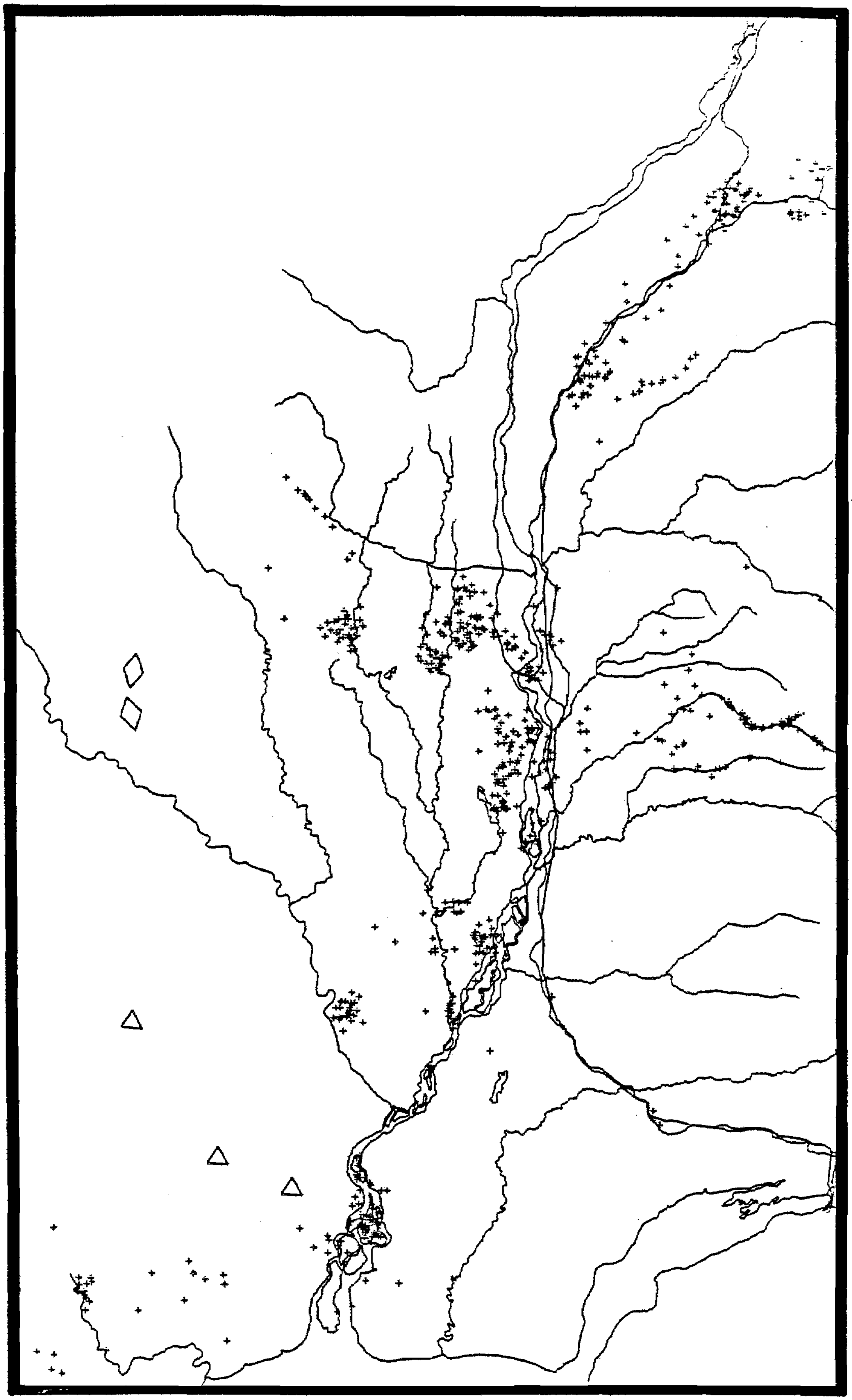

Figure 8. Radio-relocations (722) for 15 male moose captured and radio-collared along the Susitna River between Devil Canyon and Cook Inlet, Alaska, 1980-83.

In areas south of Talkeetna, individual males tended to range annually over larger areas than individual females (Modafferi 1983) but bounds of overall impact zones between "populations" of sexes may be quite similar.

Changes in environmental conditions along the Susitna River as a result of hydroelectric development may affect productivity of some subpopulations of moose directly by elimination of females through changes in carrying capacity or indirectly, by affecting productivity of subpopulations through alteration of female nutritive condition. In either case, effects may be realized locally or distant from floodplain habitat. Likewise, mitigation measures which improve the calving environment or winter range in riparian habitats may increase productivity of moose subpopulations in those particular areas and result in higher population levels. However, enhancement of environments for moose in riparian areas which do result in greater subpopulation productivity, may subsequently place additional stress on environments used by those moose subpopulations during other seasonal periods. Figure 9 illustrates where female moose captured and radio-collared in winter on the Susitna River floodplain were relocated during the calving period (10 May-17 June). These data illustrate that most female moose south of Talkeetna leave the floodplain to calve, but that female moose north of Talkeetna return to, and those females in large islanded areas south of Talkeetna may remain in, floodplain areas for calving.

For a period of time after calving, females with calves remain relatively sedentary, but by July moose have generally started to move to summer range areas where they will remain until rutting activities start. Relocations for radio-collared female and male moose, respectively during the summer period (1 July-31 August) appear in Figs. 10 and 11. These data show that by the summer period, female moose north of Talkeetna have again departed from floodplain areas and only females in larger islanded areas south of Talkeetna remain on the Susitna River floodplain.

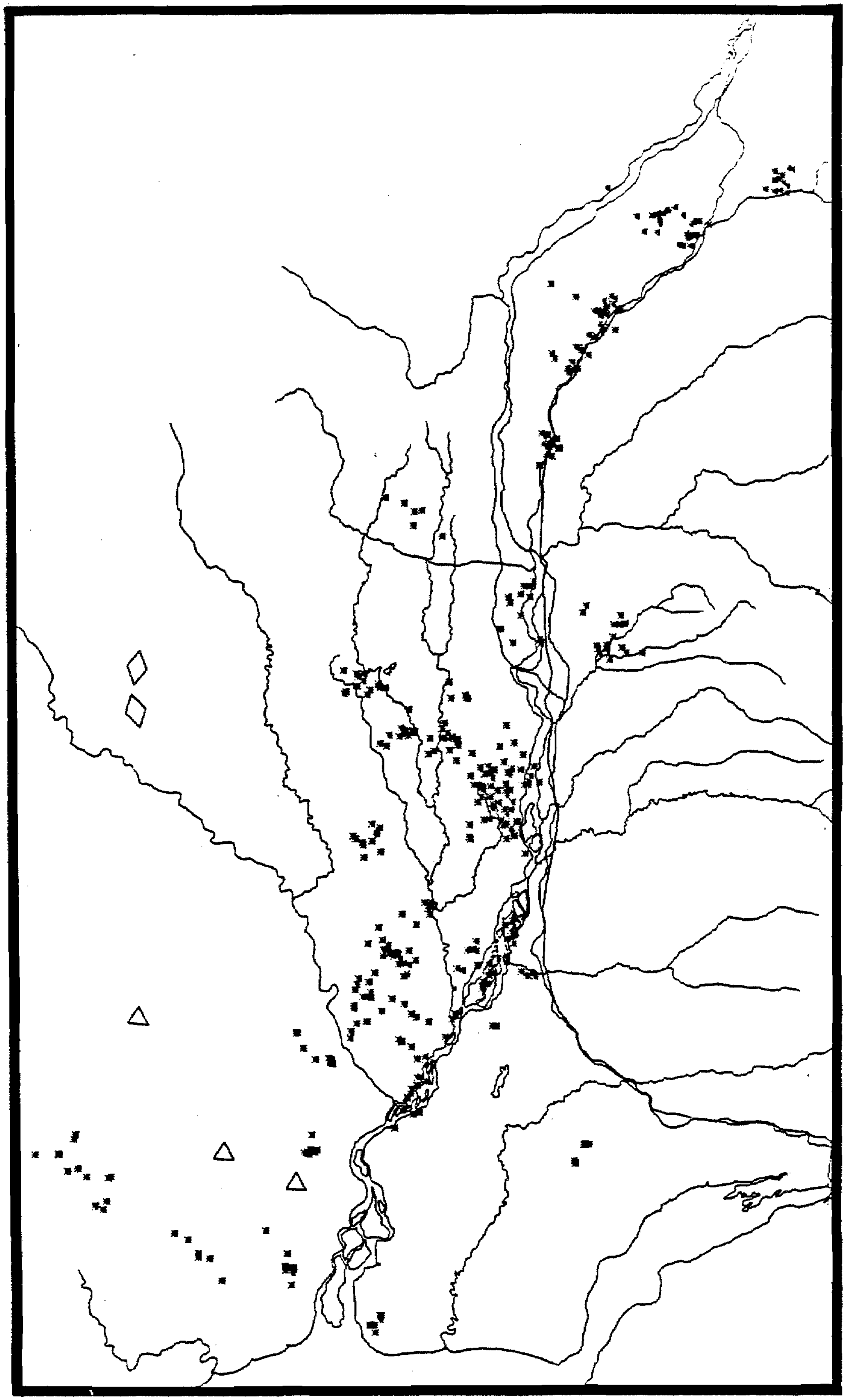

Figure 9. Locations (506) where 40 female moose captured and radio-collared along the Susitna River between Devil Canyon and Cook Inlet, Alaska were radio-relocated during the calving period (10 May-17 June), 1980-83.

It is probably during the summer period, when many people are traveling, picnicking, camping, fishing, boating and recreating in the outdoors, that nonconsumptive values of moose are greatest. Impacts of the proposed Susitna hydroelectric project on moose, may be expected to influence summer distribution and abundance of moose in areas similar to those illustrated in Figs. 10 and 11, and affect nonconsumptive use of the moose resource in those areas.

Consumptive use of the moose resource by hunters occurs primarily during the month of September. Figures 12 and 13 illustrate where female and male radio-collared moose, respectively, were relocated during that time period. Those sorts of data indicate where hunters may realize impacts of Susitna hydroelectric development on moose. These data demonstrate that moose which winter on the Susitna River floodplain may provide opportunities for consumptive use throughout an extensive area, including areas far from the Susitna River floodplain.

Data presented in Figs. 14 and 15, respectively, illustrate locations where female and male moose, which were captured in winter on the Susitna River floodplain, were subsequently relocated during the rutting period (14 September to 31 October). Few moose of either sex spent the rut period in or near their winter range on the Susitna River. Most rutted to the west of the floodplain and some individuals occurred in areas up to 40 km from the Susitna River. Impacts of hydroelectric development to moose which winter on the Susitna River may likely affect rutting activities in subpopulations throughout this large area.

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 had returned to floodplains habitats during the later winter period (Fig. 16). Other data collected indicated

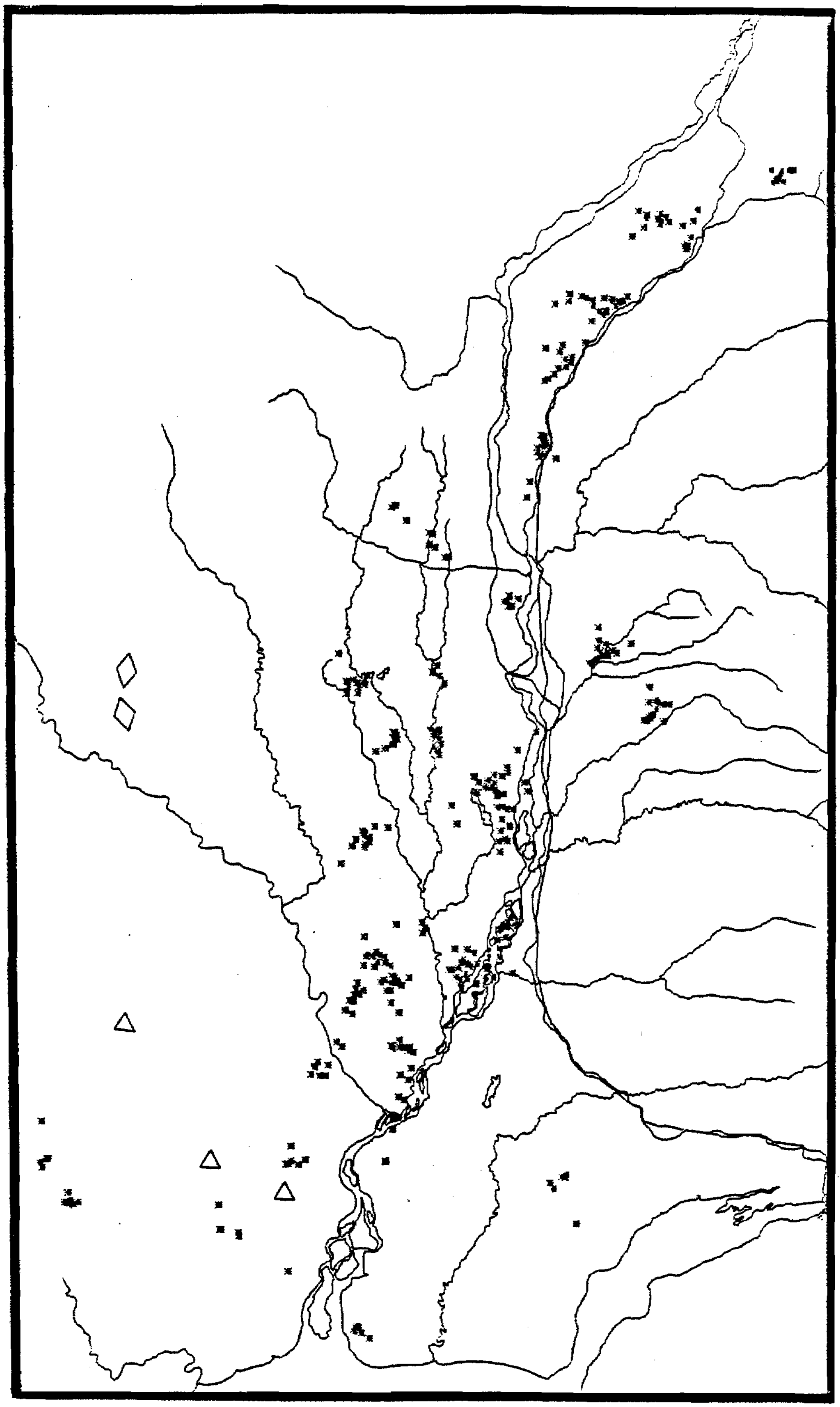

Figure 10. Locations (393) where 39 female moose captured and radio-collared along the Susitna River between Devil Canyon and Cook Inlet, Alaska, were radio-relocated during the summer period (1 July - 31 August), 1980-83.

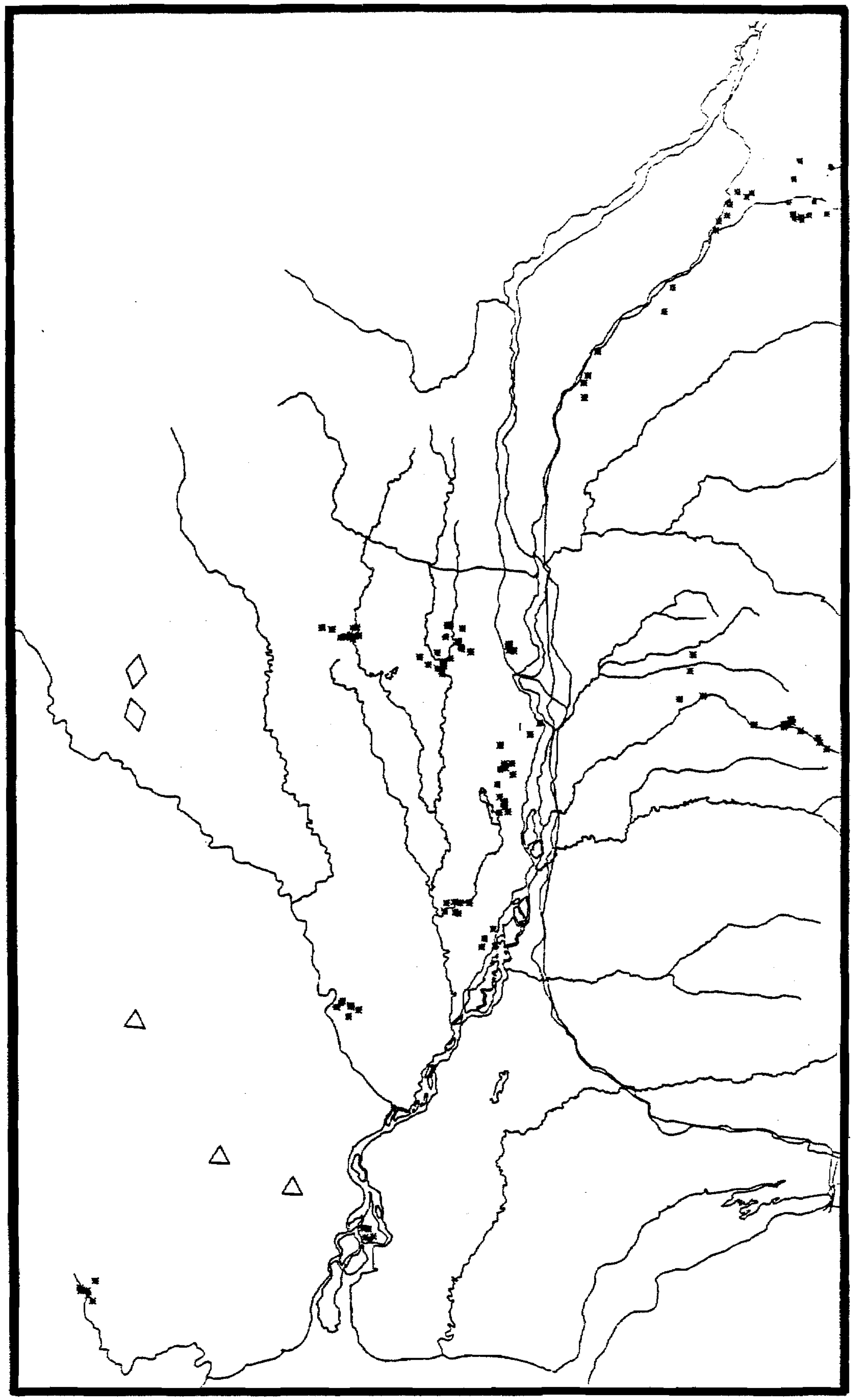

Figure 11. Locations (129) where 12 male moose captured and radio-collared along the Susitna River between Devil Canyon and Cook Inlet, Alaska were radio-relocated during the summer period (1 July-31 August), 1980-83.

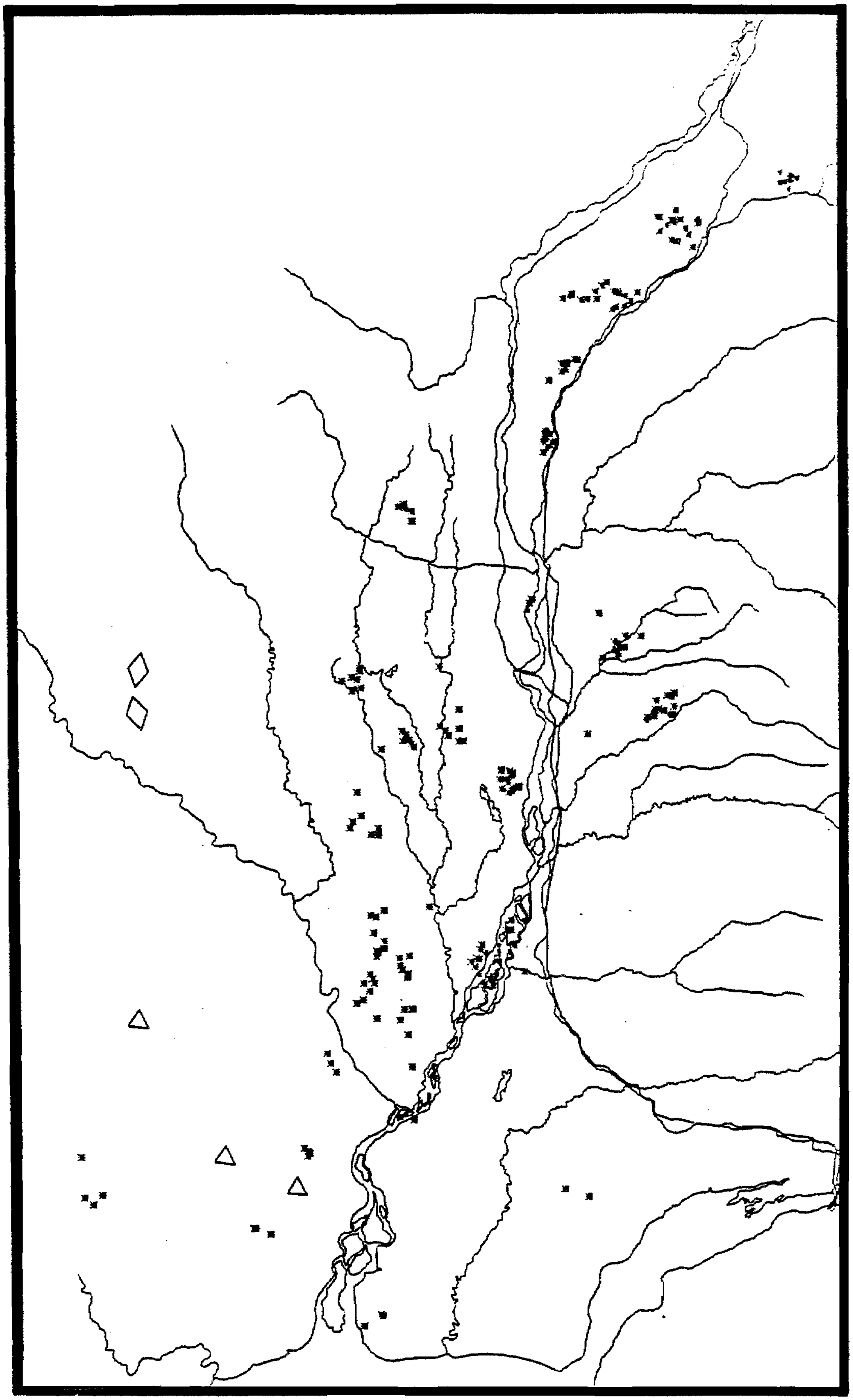

Figure 12. Locations (242) where 38 female moose captured and radio-collared along the Susitna River between Devil Canyon and Cook Inlet, Alaska were radio-relocated during the month of September ("hunting season"), 1980-83.

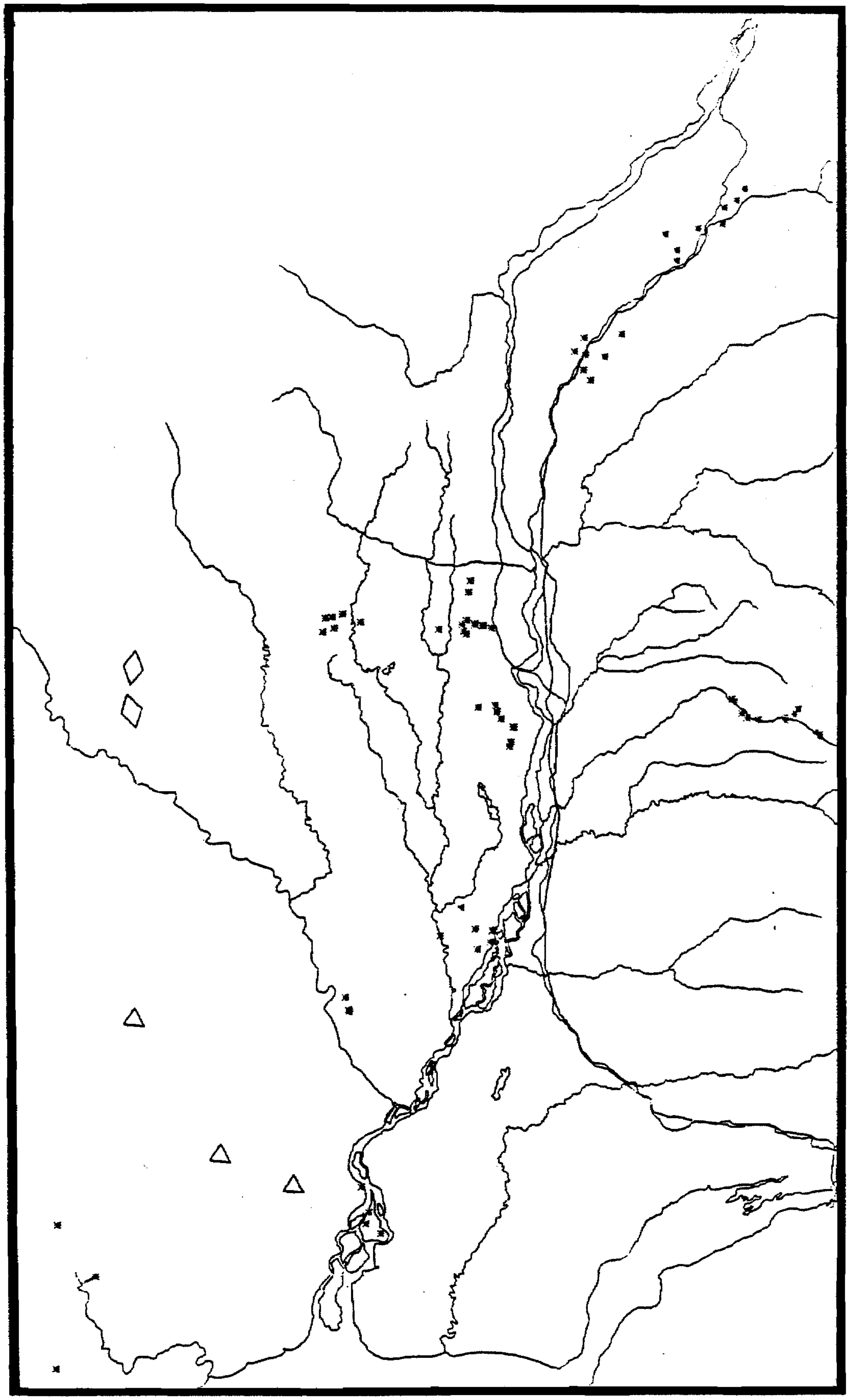

Figure 13. Locations (72) where 11 male moose captured and radio-collared along the Susitna River between Devil Canyon and Cook Inlet, Alaska were radio-relocated during the month of September ("hunting season"), 1980-83.

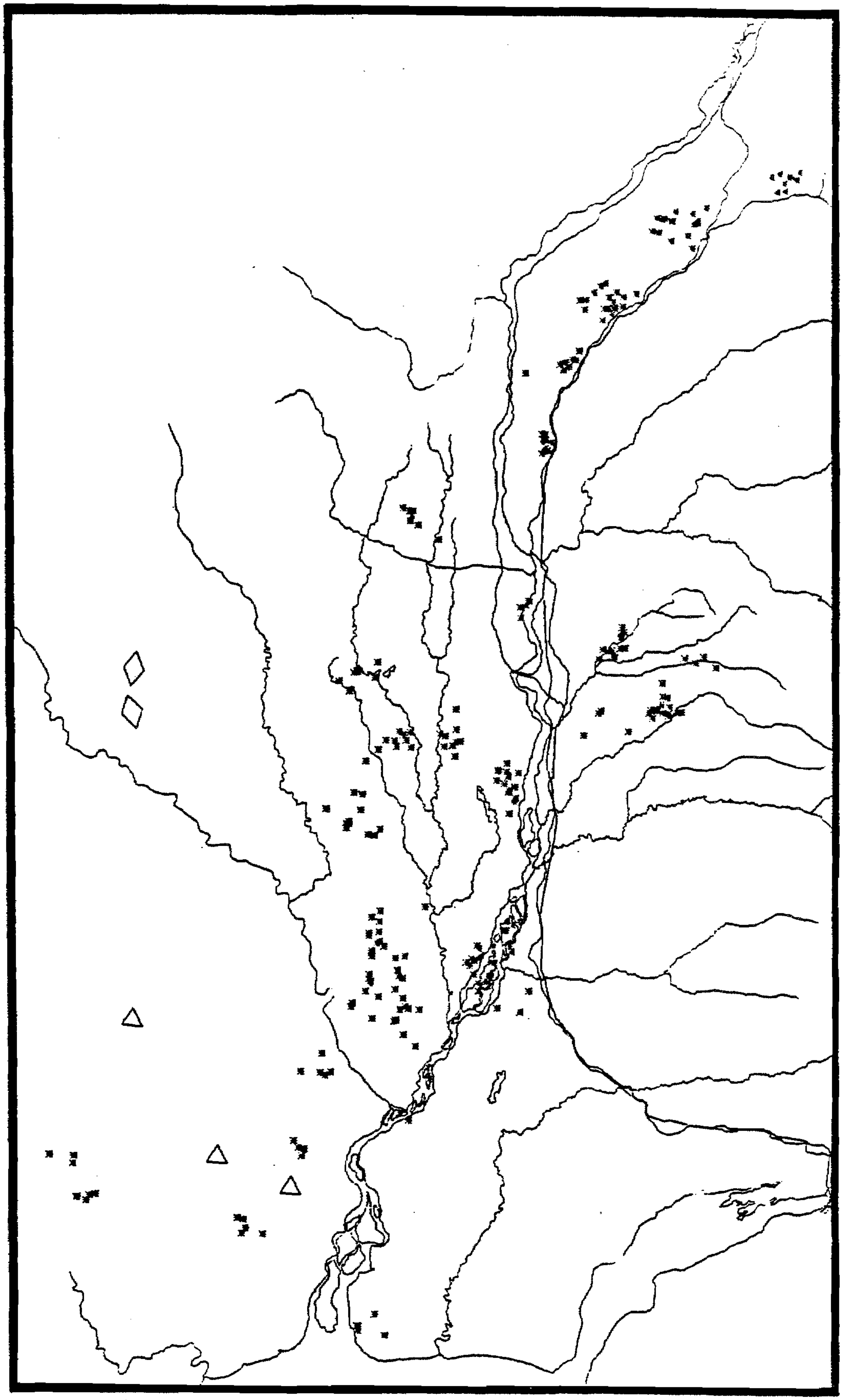

Figure 14. Locations (286) where 38 female moose captured and radio-collared along the Susitna River between Devil Canyon and Cook Inlet, Alaska were radio-relocated during the rut period (14 September-31 October), 1980-83.

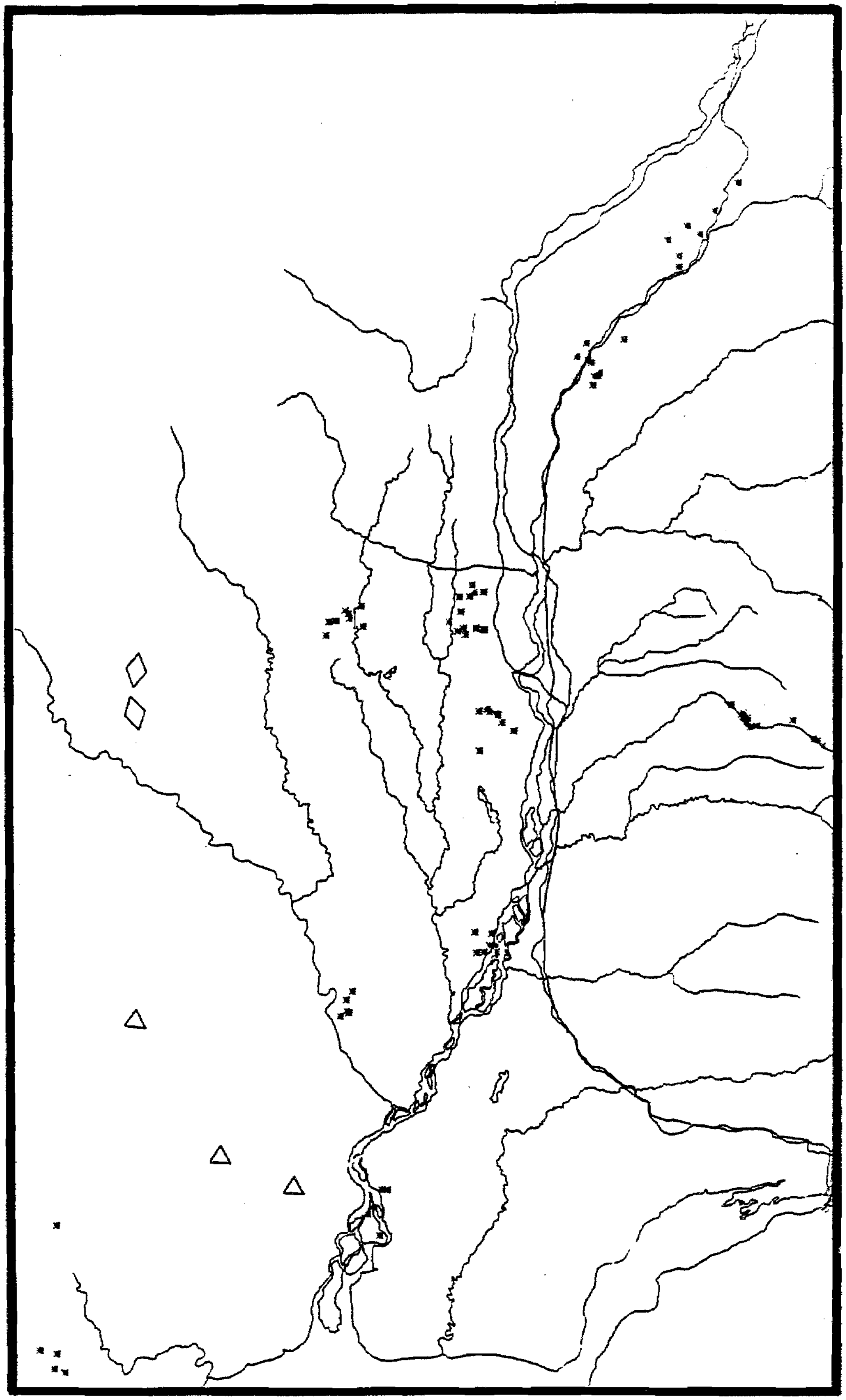

Figure 15. Locations (86) where 11 male moose captured and radio-collared along the Susitna River between Devil Canyon and Cook Inlet, Alaska were radio-relocated during the rut period (14 September-31 October), 1980-83.

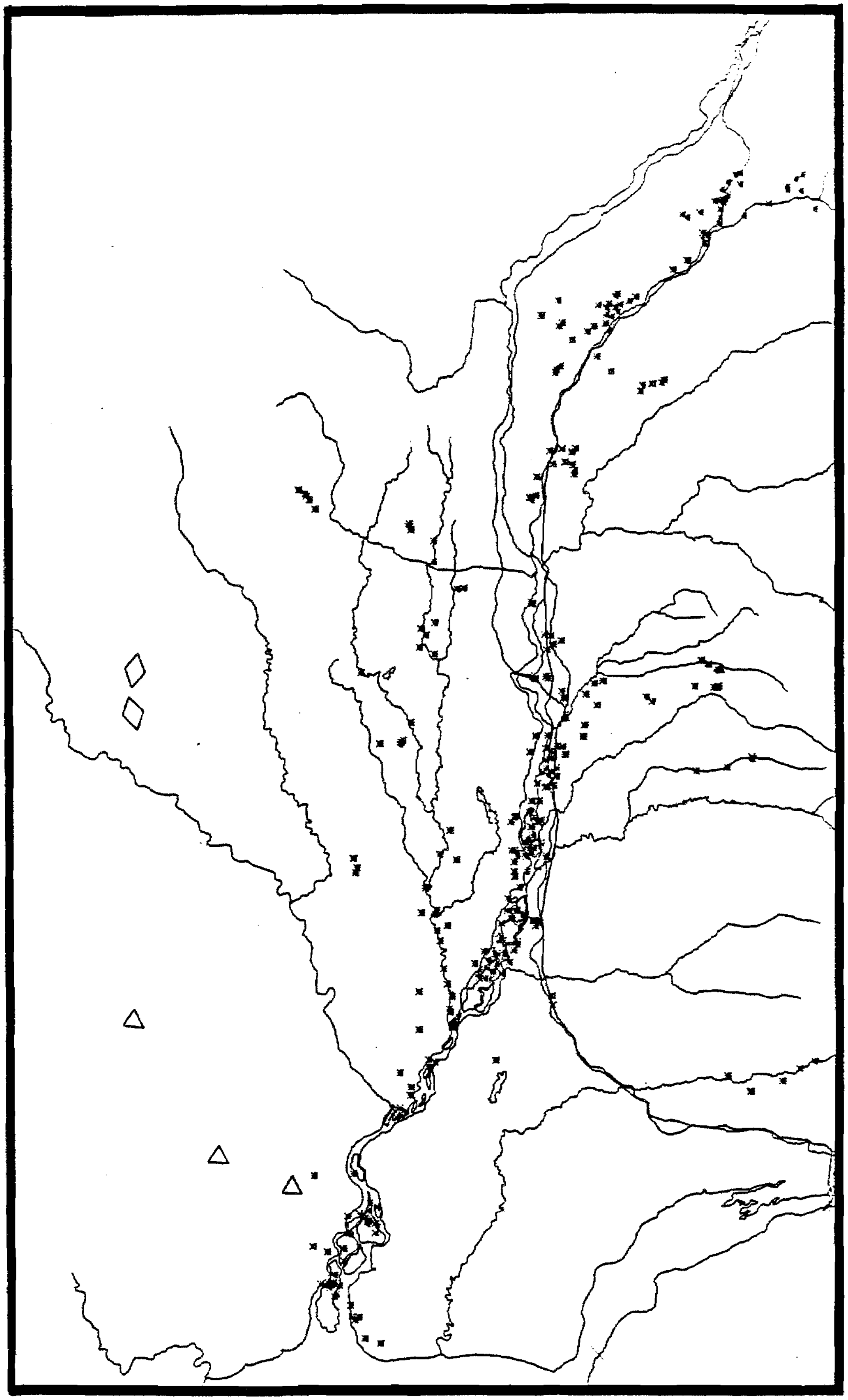

Figure 16. Locations (348) where 7 male and 40 female moose captured and radio-collared along the Susitna River between Devil Canyon and Cook Inlet, Alaska were radio-relocated during the winter period (1 January-28 February), 1980-83.

individual and annual variation in the timing that moose arrived on the Susitna River floodplain winter range. Though most moose arrived on the winter range by January, some arrived later and some individuals even wintered in entirely different and distant areas in subsequent years. These data support the contention that winter river censuses may underestimate the numbers of different moose which seek winter range in Susitna River floodplain habitats. Information collected from behavior of radio-collared moose may be used in conjunction with data from river censuses to adjust for underestimates in the numbers of different moose which may be dependent on floodplain habitats for winter range. Since timing and location of sampling (capturing moose) as well as winter conditions are critical to obtaining representatives from all moose subpopulations, only very intensive radio-collaring and careful review of collected data will identify numbers of moose and all moose subpopulations which are ecologically affiliated with the Susitna River floodplain in winter.

AFFINITIES FOR FLOODPLAIN 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 and between year variation which may be expected in those patterns of use, so long-term behavioral patterns for those subpopulations may be adequately "bounded."

Data on timing and frequency of use of riparian habitats and on variation in affinities for those habitats obtained from radio-collared moose are presented in Tables 15 and 16, respectively.

Table 15. Variation in and general affinities for floodplain habitats of the Susitna River exhibited by moose radio-collared and relocated periodically, 1980-83.

			No.		Percent of relocations at distances (mi) from floodplain (F)							
Area[1]	Sex[2]	Treatment[3]	Moose[4]	Relocations[5]	F	0-1	1-3	3-5	5-10	10-15	15-20	20+
Upstream	F	Min	1	79	11	29	48	8	4	0	0	0
		Max	1	79	16	61	23	0	0	0	0	0
		Total	8	597	10	41	43	5	1	0	0	0
	M	Min	1	73	1	47	34	3	15	0	0	0
		Max	1	61	2	30	51	18	0	0	0	0
		Total	2	134	2	39	42	10	8	0	0	0
Downstream												
	F	Min	1	43	26	0	0	2	7	9	14	42
		Max	1	81	90	9	1	0	0	0	0	0
		Total	29	1,823	25	11	14	9	24	12	3	3
	M	Min	1	98	1	2	7	2	2	20	30	36
		Max	1	80	8	25	50	18	0	0	0	0
		Total	8	520	6	16	20	7	21	10	12	8

[1] Upstream = north of Talkeetna, Downstream = south of Talkeetna.

[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 = mean affinity calculated for respective population.

[4] Moose = numbers of different individuals which provided data; same individuals provided data for more than three years.

[5] Relocations = number of relocations; sampling intensity relatively similar throughout year.

Table 16. Dates indicating chronology of arrival and departure from Susitna River riparian habitat for female and male moose radio-collared in habitats downstream from Talkeetna, 1980-83.

Date	Females		Males	
	Riparian [a]	Non-riparian	Riparian	Non-riparian
1980				
Apr.	3 [b]	0	3	0
May	ND [c]	ND	ND	ND
Jun.	0	3	0	3
Jul.	0	3	0	3
Aug.	0	3	0	3
Sep.	0	3	0	3
Oct.	0	3	0	2
Nov.	0	3	0	2
Dec.	0	3	0	3
1981				
Jan.	0	3	0	2
Feb.	ND	ND	ND	ND
Mar. [d]	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.	9	8	0	5
Feb. [e]	18	6	7	4
Mar. [f]	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	1	5
Oct.	3	23	0	6
Nov.	10	15	1	5
Dec.	15	10	2	4
1983				
Jan.	17	8	3	3
Feb.	19	6	3	3
Mar.	15	10	3	2
Apr.	15	10	2	3
May	8	17	2	3
Jun.	5	19	1	4
Jul.	ND	ND	ND	ND
Aug.	6	17	1	4
Sep.	6	17	0	4

[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.

Data gathered from individual moose north of Talkeetna indicated that for 3 consecutive years their greatest affinity for use of riparian habitats occurred during May and June, but even that affinity appeared reduced in 1983 (Table 15). Since radio-collared female moose throughout the study area calved between mid-May and mid-June, riparian habitats may likely be important to this moose subpopulation 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 Edwards 1983).

Wolves are not common along the Susitna River downstream from Devil Canyon; but brown and black bears occur commonly in the area and are known to utilize mid-elevations on south facing slopes during this seasonal period (Sterling Miller, per. comm.), and could be responsible for female moose moving from ridges and mid-slopes to lower elevations along the floodplain, as was hypothesized by Edwards (1983) for female moose in association with wolves at Isle Royale. High rates of predation by brown and black bears on neonatal moose calves have been documented for a moose population in an area several miles upstream from Devil Canyon (Ballard et al. 1982a). Coyotes are abundant throughout the entire study area and may also be involved in prompting female moose to move to floodplain areas near parturition.

Edwards believed that diet diversity was inversely related to diet quality (i.e. increased diversity in dietary constituents decreased overall diet quality). However, it may be that understory vegetation in riparian habitats provides a variety of nonbrowse plant species which each at any given time occur at different stages of phenological development, but when considered over time they could, in combination, provide a continuous supply of young, tender, highly digestible and nutritious phenological stages of vegetation. Collins (pers. comm.) has observed in late May and early June that ferns on some floodplains islands north of Talkeetna were heavily browsed by moose. He also believed that ferns (particularly at the fiddlehead stage) were an excellent source of nitrogen (see pg. 109, this report, for chemical composition of fern rhizomes collected alpine areas in January).

The apparent "unattractiveness" of floodplain habitats (from January through April in 1981-82) to the moose subpopulation north of Talkeetna may have in part been related to the relatively mild weather conditions that winter, since in the much earlier and harsher winter of 1982-83, moose from that same subpopulation appeared to utilize riparian habitats from November through February.

Data presented in Table 17 indicate that radio-collared moose, in winter 1981-82, started to move to floodplain habitats in December, were most frequently relocated in those habitats in February and March, and proceeded to depart from the floodplain areas during April.

However, in winter of 1982-83, heavy, early snowfall apparently stimulated moose to move to floodplain habitats in November, and as in the previous winter, moose numbers built up to a peak in February. But apparently, the persistence of snowcover and wintery conditions late into the spring of 1983 caused more moose to remain in floodplain areas through April and into May.

In spite of the relatively harsh winter conditions in 1982-83, 1 male and 1 female moose which were previously captured on the Susitna River floodplain, were not known to return to those areas that winter. These data, along with the former, indicate that many more moose may utilize riparian habitats than are present at

Table 17. Timing and frequency of use of Susitna River riparian habitats by individual radio collared female moose, between Talkeetna and Devil Canyon, Alaska 1981-1983.

Individual	1981					1982						1983				
	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 Oct.	Nov. and Dec.	Jan. and Feb.	Mar. and Apr.	May and Jun.	July and Aug.	Sep. and Oct.
29	1/7 [b]	4/7	0/7	1/7	0/5	0/5	0/5	3/6	0/3	0/2	1/2	0/4	0/4	0/9	1/2	0/3
42	0/6	0/7	0/7	0/7	0/5	0/5	0/5	1/6	0/3	0/2	1/2	3/4	0/4	0/9	0/2	0/3
63	0/6	2/7	0/7	0/7	0/5	0/5	0/5	0/6	0/3	0/3	0/2	1/4	0/4	1/9	0/2	0/3
68	0/6	5/7	0/7	0/7	0/5	0/5	0/5	3/6	0/3	0/1	0/2	0/4	0/4	4/9	0/2	0/3
69	0/6	0/7	0/7	0/7	0/5	0/5	0/5	0/6	0/3	0/1	0/2	0/4	0/4	0/9	0/2	0/3
73	0/6	3/7	0/7	0/7	0/5	0/5	0/5	1/6	1/3 [c]	0/2	0/2	0/4	1/4 [f]	2/9	0/2	0/3
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	1/2	2/4	0/4	0/9	0/2	0/3
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	3/7	3/7	1/7	3/7	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.

[f] Riparian habitat observation on 20 April.

any one time or during any one year. For instance, data from radio-collared moose indicated that in February 1983, for every 22 moose, 19 females and 3 males, observed in floodplain areas, there were probably another 9 moose, 6 females and 3 males, that also use those habitats. Similarly, moose censuses in riparian habitats at that time may have to be expanded by a factor of 41% (9/22) to approximate the actual numbers of moose which use those habitats.

Most moose apparently utilize the Susitna River floodplain south of Talkeetna only as a winter range, but in all years some individuals remained in riparian areas and apparently utilized those habitats throughout the entire year. This behavior was most typical of individuals which were found to range in and near the large islanded areas of the Susitna River (i.e., the Delta Islands and the Big/Bell Island complexes). Available data indicated that roughly 18% (4 of 22, 4 of 27, and 5 of 23 radio-collared moose relocated in 1981, 1982 and 1983, respectively, Table 17) of the moose subpopulation which utilized floodplain habitats as winter range were found to be "resident" to those areas throughout the year. During more severe winter conditions, one would probably expect that the floodplain habitats are shared amongst a higher proportion of "nonresident" moose.

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

Additional data exhibiting variation in affinities for riparian habitats and in behavioral patterns for both individuals and subpopulations of moose are presented in Table 16. This summary of data for over 3 years of study demonstrate considerable differences in movement patterns between upstream and downstream moose subpopulations. Those moose subpopulations downstream from Talkeetna spent a considerable amount of time at distances greater than 3 miles from the Susitna River floodplain, whereas their counterparts north of Talkeetna were seldom relocated farther than 3 miles from the floodplain. Males in both subpopulations, usually ranged relatively farther than females from the riparian habitats, and males in downstream areas exhibited less affinity for floodplain habitats than those in upstream areas. These data also indicate notable differences in behavioral patterns between individual moose within a subpopulation (i.e., comparing minimum and maximum values for affinities).

In summary, 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 occur in moose subpopulations south of Talkeetna and in male moose of both subpopulations.

MOOSE WINTER USE OF SPECIFIC SUSITNA RIVER FLOODPLAIN AND ISLANDED AREAS

Alterations in Susitna River flow hydraulics will affect different habitat types differently, and those effects will secondarily vary depending on the location of that habitat on the river's overall floodplain. Changes in flow hydraulics may also have positive effects with respect to moose by duplicating specific desirable hydraulics at other locations on the floodplain and thereby creating preferred habitats. However, it must be remembered, that factors other than vegetative associations, as mentioned above, also interact to influence the precise quality of habitats for moose. Moose use of the Susitna River floodplain is not random. Moose most likely prefer, select and utilize specific habitat types and the quality of those habitat types may secondarily be influenced by factors such as location on the floodplain, local snow conditions, occurrence of predators and suitability of adjacent, nonfloodplain habitats during other seasonal periods.

One hypothetical method of assessing impacts of Susitna River hydroelectric development on moose, is to delineate and characterize which habitats are most heavily used (important) by moose, and to secondarily determine if those habitat characterics will be altered by proposed changes in river flow hydraulics. To examine this particular method of assessing moose-habitat relationships, age composition and densities of moose were determined for 6 specific sites delineated on the Susitna River floodplain (Table 18).

Data presented in Table 18 exhibit variation in densities and age composition of moose observed at different areas of the floodplain. In all years, greatest moose densities were observed on Bell Island. Moose densities on Alexander Island were also considerably greater than those in the other 4 areas, but were still less than those on Bell Island. In all 3 years, lowest densities of moose were observed on the Delta Islands. Moose densities observed on Bell Island ranged from 4 to 7 times higher than densities observed on the Delta Islands.

Differences in observed densities or apparent attractiveness of these areas to moose may, in part, be attributed to both habitat type and location on the floodplain. Vegetation on the Delta Islands appears largely to be the typical "climax" type riparian habitat mature forest characteristic of the Susitna River floodplain. Aside from occasional deep water sloughs, habitat on the Delta Islands is monotonous. Bell and Alexander Island contain similar climax riparian habitat but, in contrast, those islands

Table 18. Number, percent calves and densities for moose observed in floodplain and islanded areas along the Susitna River between Montana and Cook Inlet, Alaska, 1981-83.

Location	Sample area[1] Size (km²)		Moose observed[2] No.			Percent calves			Calculated density[3]		
	Surface	Terrestrial	1981-82	1982-83	1983-84	1981-82	1982-83	1983-84	1981-82	1982-83	1983-84
Kashwitna floodplain	14.5	5.5	27	39	12	23	27	25	1.9	2.7	0.8
Beaver Island	9.0	9.0	22	27	32	19	20	20	2.4	3.0	3.6
Alexander Island	10.5	10.5	29	80	54	27	24	18	2.8	7.6	5.1
Bell Island	13.0	13.0	41	120	101	18	18	24	3.2	9.2	6.6
Caswell floodplain	15.5	10.5	42	60	34	31	31	19	2.7	3.9	2.2
Delta Islands	21.0	18.0	16	27	21	18	21	18	0.8	1.3	1.0

1 Locations of sample areas are illustrated in Fig. . Total surface area and size of its terrestrial component area estimated from 1/63360 scale USGS topographic maps.

2 Data for moose observations are derived from 6 and 11 independent censuses conducted in the winters of 1981-82 and 1982-83, respectively. Numbers of moose represent the greatest number observed on a single census of each area. Calf percentages were calculated after accumulating totals for calves and individuals observed on all censuses within each entire winter.

3 Densities were calculated by dividing maximum number of moose observed at each location by its surface area size (km²).

are profusely interspersed with other plant communities (i.e., short and tall shrub, sedge meadow and immature mixed forests). Along with more subtle differences in vegetative composition, interspersion of habitat types appears to be slightly greater on Bell than on Alexander Island and may in part explain observed differences in moose densities between those two areas.

Moose densities observed on Beaver Island were intermediate between those observed on the Delta Islands and those observed on Bell and Alexander Islands. Habitat types on Beaver Island did not appear grossly different from those on the latter islands but proportional relationships and interspersion between those habitat types may have differed (i.e forests on Beaver Island were more extensive and infrequently interspersed with more seral habitat types). Moose densities on Beaver Island may have been lower because most transient moose originate mainly from the west and they encounter satisfactory winter range on other islands first, and do not proceed farther east; so immigrating moose merely fail to "reach" Beaver Island and its winter range remains "undiscovered" by those moose subpopulations.

The Caswell and Kashwitna floodplain areas are composed of numerous small islands of low relief which are dissected by a network of rivulets and shallow sloughs. Habitats in these areas are primarily short and tall shrub communities along with occasional stands of immature deciduous forest.

Though it was not known why these earlier successional plant communities appeared to attract fewer moose than some of the large islanded areas to the south, several potential reasons contributing to this discrepancy may be differences in: vegetative associations, density of forest cover, amount of snow cover, availability of alternate adjacent winter ranges and/or less dense moose subpopulations in adjacent areas.

Proulx (1983) found that forest cover was an important component of moose winter habitats in southern Quebec. Perhaps moose preferred areas which contained forest cover.

Though the Caswell and Kashwitna floodplain areas contained relatively low moose densities, both areas appeared to be used by a higher percentage of calf moose than other areas studied. In 2 of the 3 years studied, nearly twice the percentage of calves were observed on the Caswell floodplain area (31%) as on Bell Island (18%). Potential explanations for this occurrence are the following: cows with calves select low relief, open "floodplain" types of habitat, moose subpopulations which winter in this are more productive, more male moose occurred in the other areas and "diluted" the calf ratio or mortality factors (predation, nutrition and etc.) on calves are not similar between those moose subpopulations or within those habitats. Thompson and Vukelich (1981) found that cows with calves avoided areas where large concentrations of moose occurred but they also found that their use of cutover areas (relatively open, early successional habitats, similar to floodplain areas) was restricted.

These data suggest that age composition and density of moose on winter range were closely related to the occurrence and interspersion of a variety of habitat types.

In winter, gusty north winds commonly occur on the Susitna River floodplain south of the Yentna River. These winds blow fallen snow off the floodplain and frequently leave large portions of the area snowfree. Strong, gusty winds seldom occur near the Delta Islands and their effects on snowcover are greatly reduced because of the dense, extensive mature forests. Lack of persistent, deep snowcover, which may hinder moose movements and blanket ground forage vegetation, may contribute to Bell and Alexander Islands being more attractive to moose than the Delta Islands. Alternate winter range may be more readily available in areas adjacent to the Delta Islands than in areas adjacent to Bell and Alexander Islands and may enable greater proportions of local moose subpopulation to remain off the floodplain in winter or similar proportions of moose from both subpopulations may seek floodplain areas, but there may be a larger overall transient component with the moose subpopulation in areas adjacent to Bell and Alexander Islands than there is near the Delta Islands.

These baseline data provide some information and pose many questions regarding habitat use by moose. Perhaps future studies may be designed to critically evaluate specific differences between those habitat types and areas and to determine what affected their attractiveness to moose. These data also indicate that female moose with calves may select different types of habitats for winter range than single female moose.

By determining more specifically what vegetative types occurred in those areas and by assessing the role of flow hydraulics in creation and maintenance of those habitat types, one could perhaps predict the effects of hypothetical flow regimes on floodplain habitat types that appear most important for moose winter range.

SIZE, SHAPE AND SPATIAL ARRANGEMENT OF ANNUAL RANGES FOR RADIO-COLLARED MOOSE

Information on size, shape and spatial arrangement of ranges for male and female moose is useful in assessing how individuals and subpopulations utilize resources and habitats available on and off the Susitna River floodplain, in considering and selecting areas for habitat enhancement and in anticipating how moose might respond to enhanced habitats. 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 will 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 moose ranges, the areal 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 or other environmental factors. It is commonly thought that the value of the Susitna River floodplain to moose increases with severity of winter conditions, and it is apparent, that these sorts of data must be collected during a relatively "severe" winter, to fully appreciate the importance of the Susitna River floodplain to moose and to learn how moose use the floodplain under those conditions.

Data presented in Figs. 17, 18 and 19 illustrate relative size, shape and spatial relationships for annual range areas utilized by a subsample of radio-collared moose monitored from 1.5 to 3.5 years. These data exhibit a wide spectrum in types of patterns of moose use of the Susitna River floodplain: from individuals with annual ranges which center on floodplain habitats (No. 37, 90 and 95); to individuals with annual ranges that "traverse" floodplain habitats (No. 23, 87 and 100); and to individuals with annual ranges which merely abut floodplain habitats (No. 27, 40 and 99). Apparently, the Susitna River floodplain provides winter range for several subpopulations of moose which utilize spatially distinct ranges in different areas during other seasonal periods. The fact that moose from many different geographical areas (different subpopulations) utilize a common winter range indicates that winter range areas are limited and

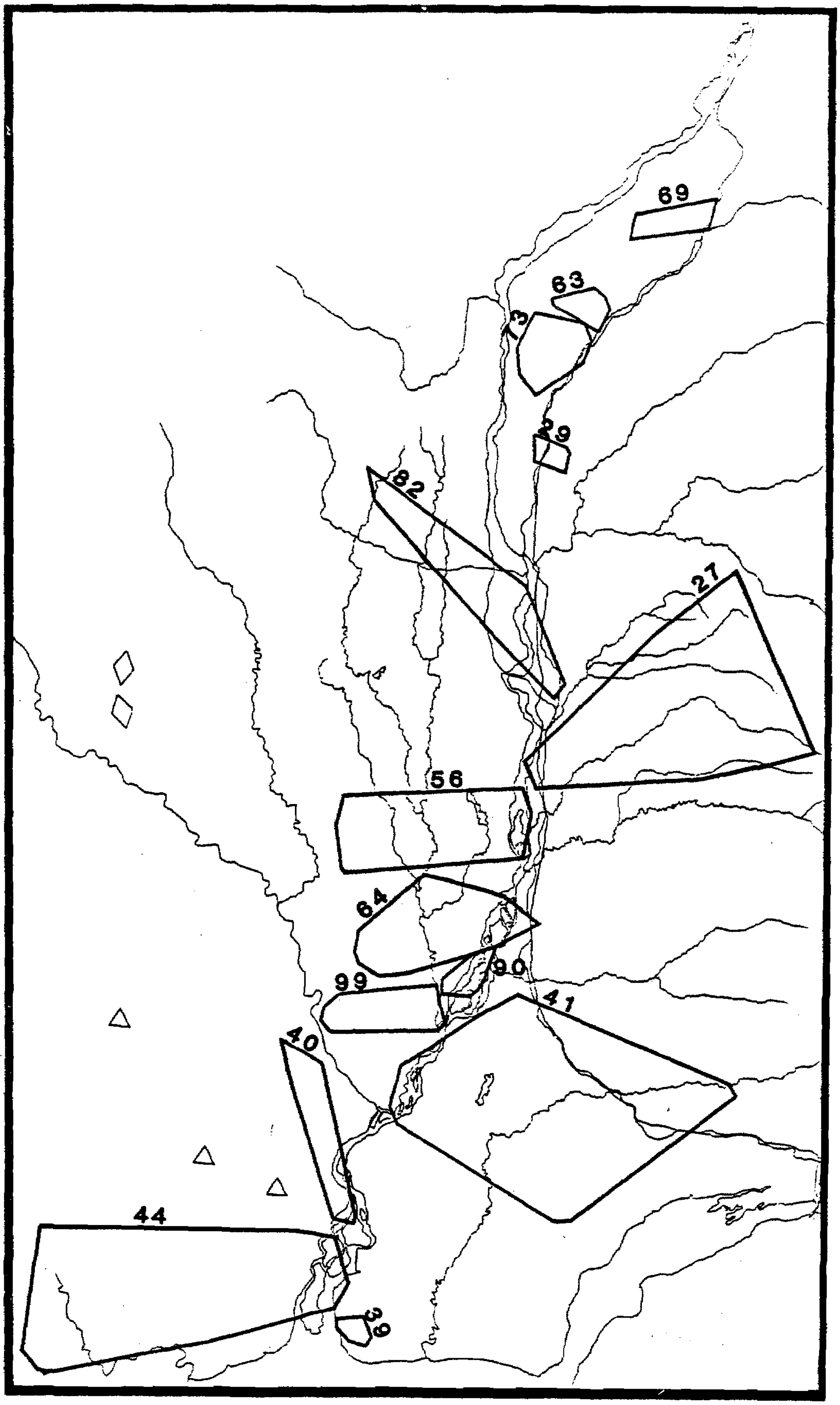

Figure 17. Shape (convex polygons) and spatial relationships for ranges of 11 female and 3 male (#27, 44 and 99) moose captured and radio-collared along the Susitna River, Alaska and relocated during 1980-83.

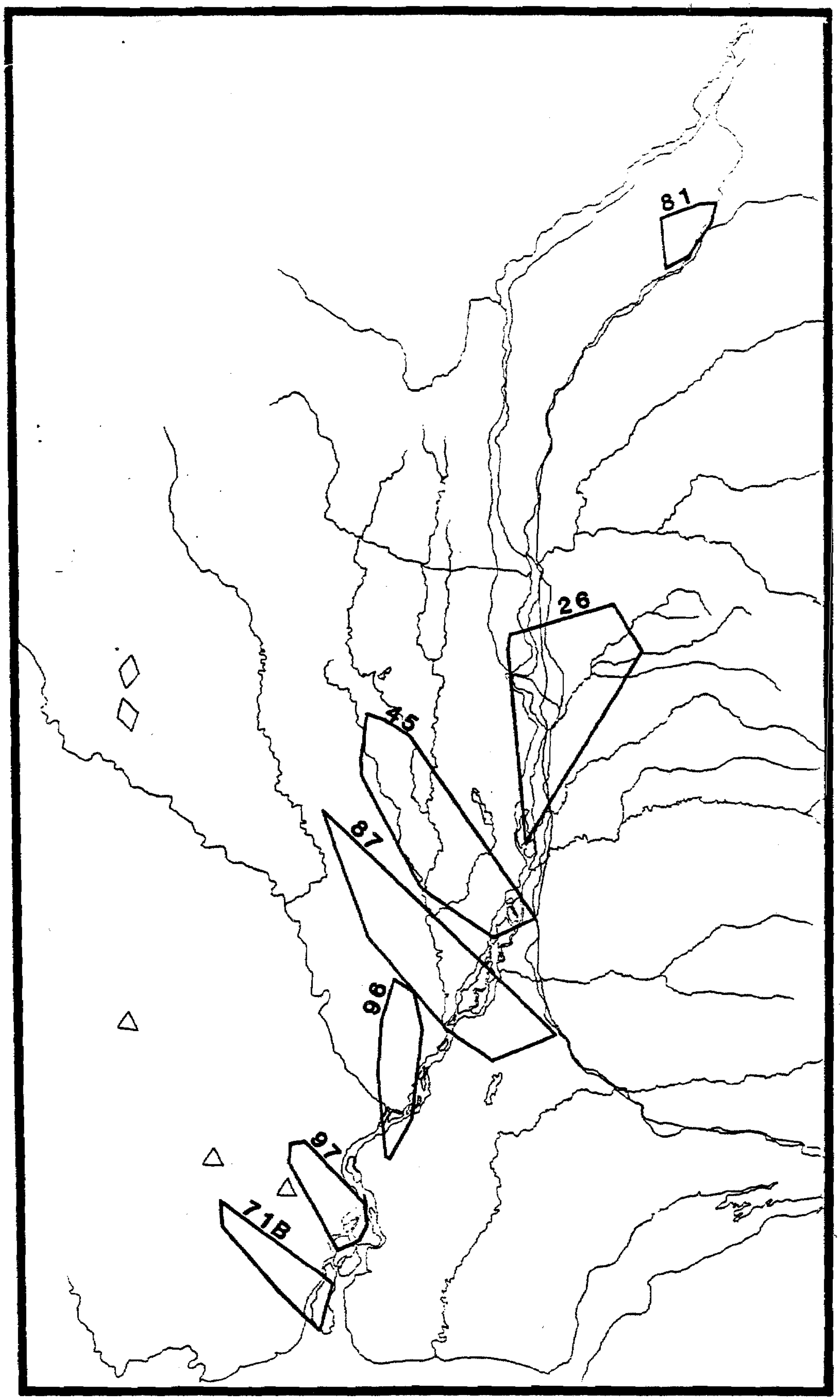

Figure 18. Shape (convex polygons) and spatial relationships for ranges of 7 female moose captured and radio-collared along the Susitna River, Alaska and relocated during 1980-83.

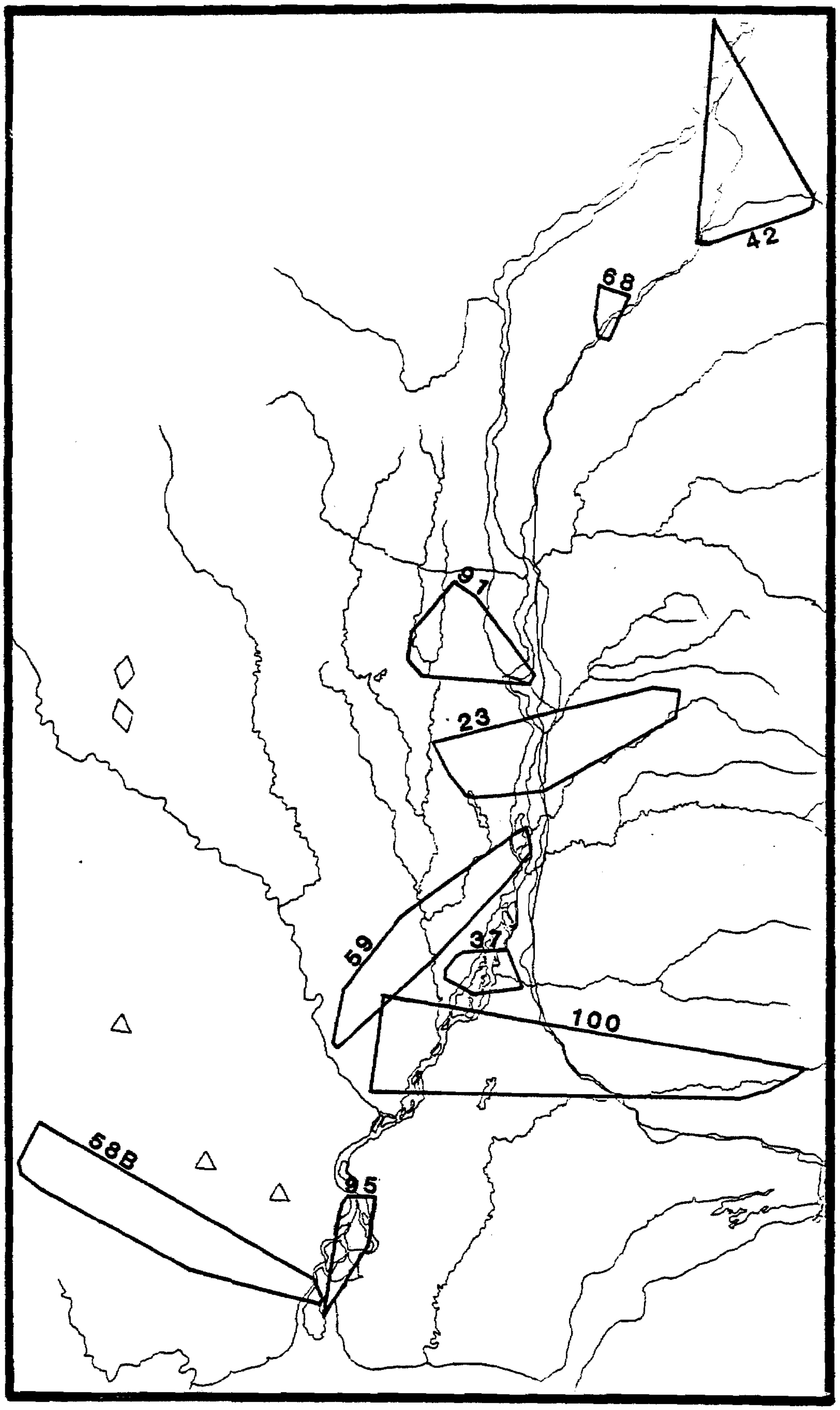

Figure 19. Shape (convex polygons) and spatial relationships for ranges of 7 female and 2 male (#91 and 95) moose captured and radio-collared along the Susitna River, Alaska and relocated during 1980-83.

do not commonly occur throughout the Susitna River Valley and suggests that the Susitna River floodplain functions as an important winter range for moose from this large area.

These data also show that except for large islanded areas south of Talkeetna, the Susitna River floodplain fails to provide a complete, annual range for moose (i.e,, most moose seek calving, summer and rutting ranges in other areas).

These data, along with those presented in Fig. 6, illustrate that very few radio-collared moose ranged east of the Susitna River and none ranged between the Kashwitna River and Willow Creek. Hypothetical reasons for the apparent failure of radio-collared moose to use these areas, are the following: 1) moose from those areas utilize winter range within that respective area; 2) moose from those areas move toward the Susitna River floodplain in winter, but find suitable range in "disturbed" sites along the Parks Highway, east of the floodplain; and 3) moose from those areas failed to be sampled because they move to the Susitna River floodplain only during "severe" winters or only very late in the winter period. In either case, for those reasons, individuals from subpopulations with the third types of behavioral pattern were not captured in the radio-collared samples.

Though females generally had smaller ranges than males, some (No. 41) utilized areas as large as males (No. 27). Some males (No. 95) were even known to range over areas smaller than those utilized by most females (No. 90).

Directional patterns for orientation of ranges appeared inconsistent, though the basic direction was east-west (No. 56, 99 and 100). North and south "slants" were also apparent (No. 40, 59, 47 and 95).

These data, along with those previously collected (Modafferi 1982), illustrate that moose north of Talkeetna generally ranged over smaller areas than moose south of Talkeetna. I doubt if overall range conditions are significantly "better" in the northern area to permit smaller ranges, but I suspect greater snow depths in the latter areas, have discouraged (through evolutionary processes) moose from traveling far to winter range and moose subpopulations have accommodated the lower quality range by existing at lower area wide densities.

ANNUAL VARIATION IN SIZE AND SHAPE OF RANGES FOR RADIO-COLLARED MOOSE

Annual variation in behavior and movement patterns for individual moose affects the size and shape of their annual range. In part, annual variation may be attributed to the effects of local weather and reproductive status of individual moose. Other factors, yet to be identified, surely also influence the configuration of moose annual ranges.

Since it is known that moose use of Susitna River floodplain habitats is greatly influenced by winter weather conditions, it is imperative that annual variations in moose behavior and movement patterns be delineated, to accurately assess and place "bounds" on moose use of those habitats. Data presented in Figs. 20 and 21, illustrate the extremes in variation that individual radio-collared moose exhibited in annual range use patterns.

Some individual moose exhibited relatively consistent annual (between year) patterns of range use (Fig. 20). Range use patterns exemplified by each these individual moose, probably represent general patterns of range use common to large numbers of moose within 4 behaviorally different subpopulations. Though these individuals utilized a similar and common winter range on

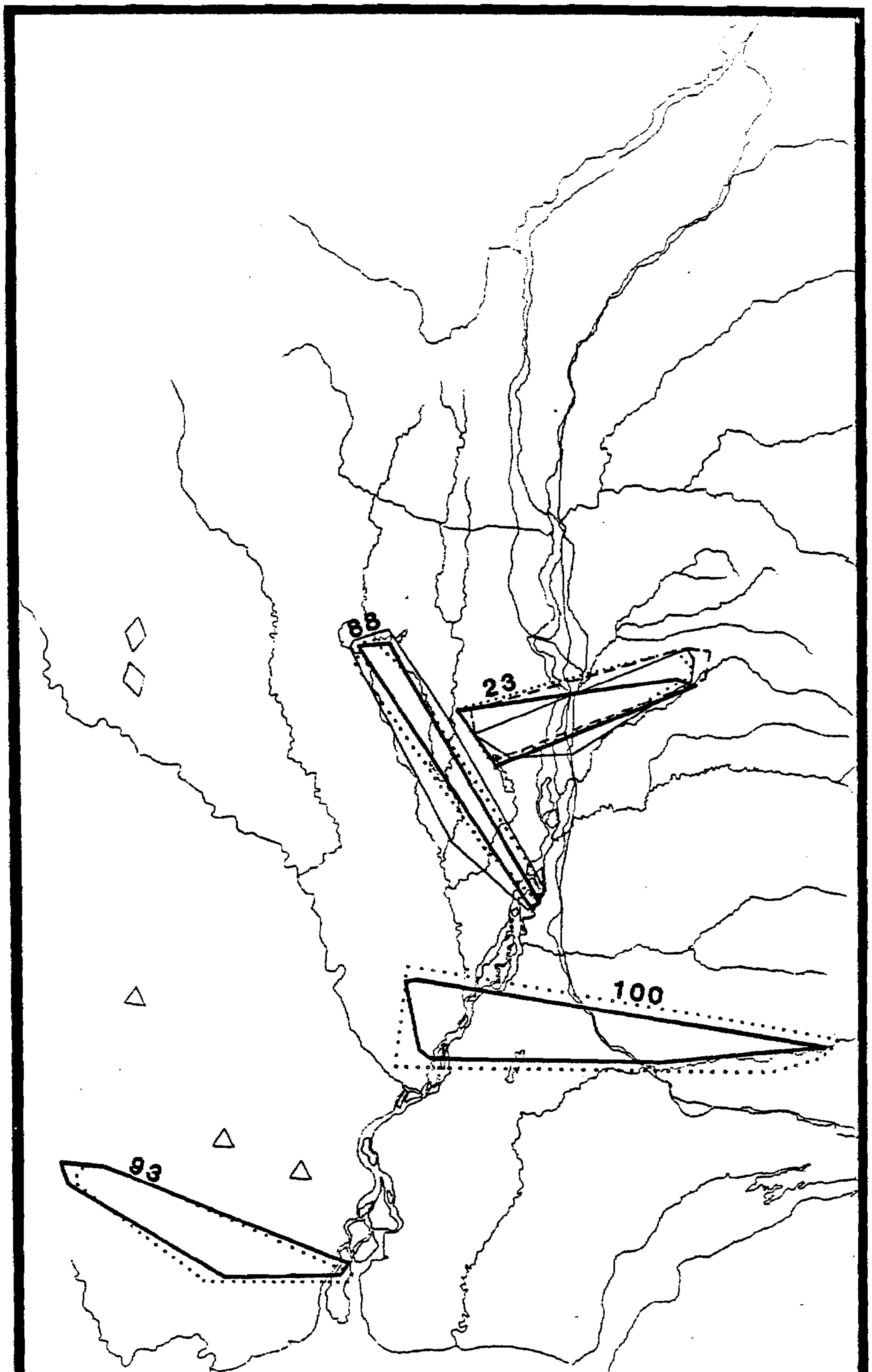

Figure 20. Annual ranges (convex polygons) for 4 female moose, captured and radio-collared along the Susitna River, Alaska, which exhibited relatively little "between year" variation in their movement patterns. Polygons encompass radio-relocation points for consecutive annual periods commencing from date of capture to the 1980-81 (------), 1981-82 (———), 1982-83 (·········) and 1983-84 (———) annual periods.

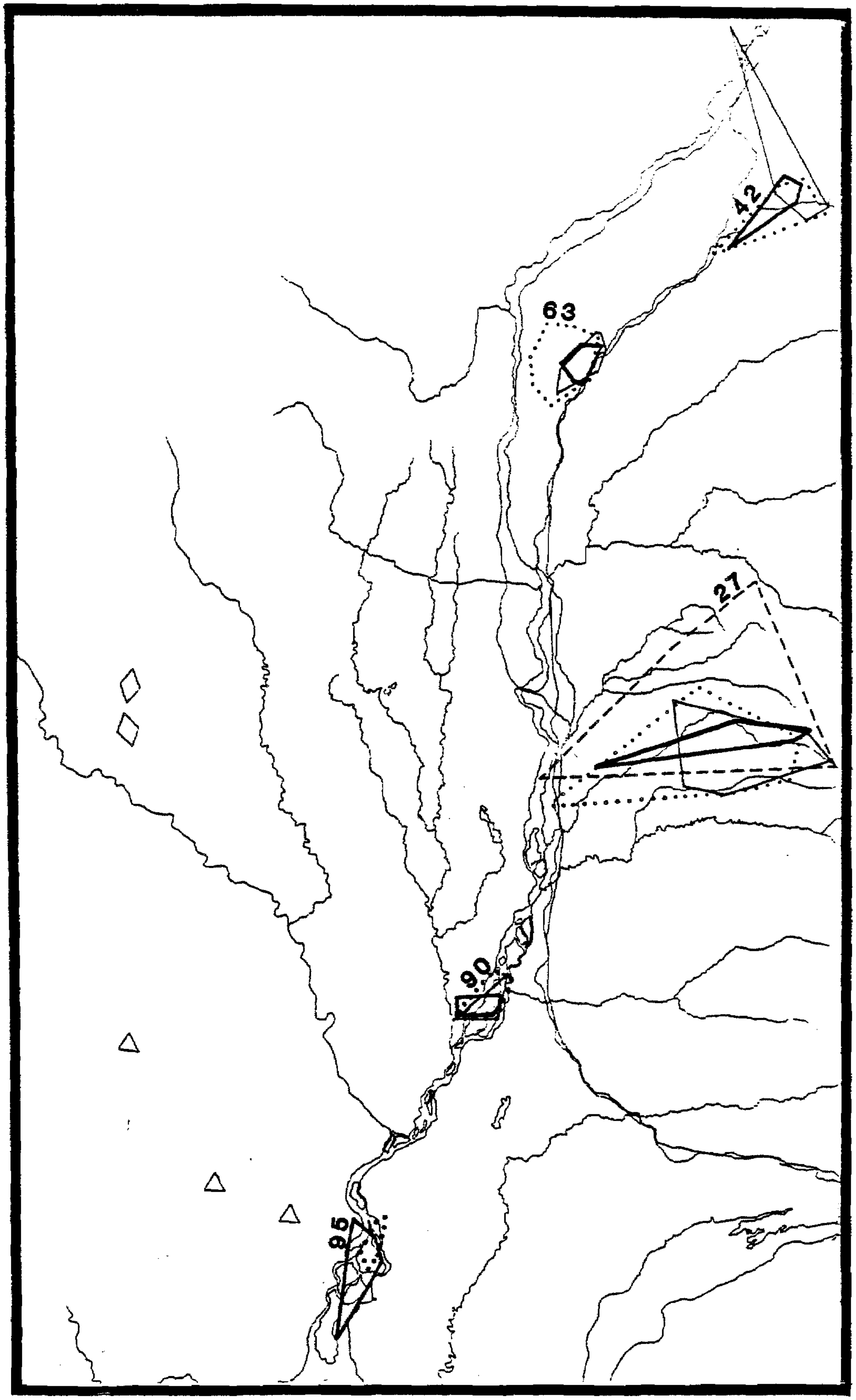

Figure 21. Annual ranges (convex polygons) for 3 female and 2 male (#27 and 95) moose, captured and radio-collared along the Susitna River, Alaska, which exhibited noteworthy "between year" variation in their movement patterns. Polygons encompass radio-relocation points for consecutive annual periods commencing from date of capture to the 1980-81 (------), 1981-82 (———), 1982-83 (·········) and 1983-84 (———) annual periods.

the Susitna River floodplain, and selected and utilized habitats in very different nonfloodplain areas during other seasonal periods, each utilized very similar annual ranges over 2, 3 or 4 consecutive years. Annual environmental variations may have affected the timing of movements of these individuals but those factors had little effect on the extent and direction of these movements. It might be said that a single year of study would have provided adequate information on annual range configuration for these individuals.

To the contrary, Fig. 21, depicts annual ranges for individual radio-collared moose which exhibited substantial annual (between year) variation in range use patterns. Behavioral patterns between these individuals also differed substantially, and suggest that these patterns may represent general behavioral patterns characteristic of different subpopulations of moose. In spite of these variations, these moose utilized a common type winter range on the Susitna River floodplain. Since these individuals exhibited significantly different annual patterns in range use during the 2, 3 or 4 years studied, it may be said that one year of study of these behavioral types of moose would have provided inadequate information on movements of patterns of range use. To adequately assess extent and locations of potential impacts of Susitna River hydroelectric development on moose with the latter type behavioral patterns, no less than 4 years of study would be required.

These data indicate that individual moose (No. 27, 42 and 63) which make exceptional and extraordinary movements may actually interact with several different moose subpopulations, and these apparently inconsistent behavioral patterns in annual range use may expose them to more different habitats, areas and subpopulations in a lifetime. Such behavioral patterns would enable this type of individual moose to locate other (or alternate) desirable habitats in new areas or "discover" recently available habitats, created naturally by wildfires or by human activities. This behavioral type of moose could potentially learn about enhanced habitats, created as a result of mitigation actions, that were apparently not formerly within their "apparent" or "usual" range.

DISTRIBUTION OF MOOSE IN NON-FLOODPLAIN HABITATS

Before one can knowledgeably predict ultimate impacts of Susitna River hydroelectric development on moose, one must understand how moose utilize the potential impact area (i.e. the ecological value of the area to moose must be determined). Because greatest moose use of the Susitna River floodplain occurs during the winter, initial downstream moose studies were primarily directed at assessing the ecological value of the floodplain as winter range for moose. These downstream moose studies indicated that several behaviorally distinct subgroups of moose form the population of moose which utilizes the Susitna River floodplain as winter range. These studies have provided information on how those moose populations utilize the Susitna River floodplain and have indicated the existence of other moose subpopulations in the Susitna River valley, which do not necessarily winter on the floodplain but may calve or summer in Susitna River riparian habitats. Though hydroelectric development may proximately affect specific portions of particular moose subpopulations, ultimate ecological consequences of those impacts can only be assessed after interrelationships between all moose populations in the Susitna River valley are understood.

Mitigation actions associated with hydroelectric development may be directed at providing winter habitats for moose. Such procedures may not always require alteration of existing habitats. Many contemporary habitats on and adjacent to the Susitna River appear to be preferred moose winter range and are presently heavily utilized by large numbers of moose. Presently, alteration of these habitats is not necessary, they need only be protected and maintained.

The greatest return from enhancement procedures may be possible in areas which presently receive minimal use by moose but have the potential to provide desirable winter range. Since many areas on the Susitna River floodplain presently provide adequate winter range for moose, nonfloodplain areas should receive consideration for enhancement. However, even amongst nonfloodplain areas, it is necessary to understand how moose are distributed in those areas during other seasonal periods, as well as during the winter. It would be unwise management to transform a subpopulations preferred calving or rutting habitats into winter range. Since it is not known how moose subpopulations which do not winter on the Susitna River floodplain (not sampled in this study) utilize nonfloodplain habitats as winter range, care must be taken not to unknowingly transform habitats utilized by one moose subpopulation to winter range habitats for another subpopulation.

Mitigation actions designed to benefit moose populations may occur through regulation of flow regimes. Since various instream flow regimes can have different effects on different habitats, quantity and timing of water discharge may be regulated at the damsite to alter or maintain particular floodplain habitats. However, since different habitat types will be affected differently and those effects will vary with respect to specific location along the river or on the floodplain, different flow regimes may ultimately affect different moose subpopulations differently . Since benefits of particular flow regimes may be mutually exclusive between moose subpopulations, it is desirable to understand the interrelationships between all moose subpopulations before recommending any particular flow regime.

Preliminary investigat.ons in downstream areas were directed at assessing winter distribution of moose in nonfloodplain areas and data were derived from a variety of sources and methods. These data which were gathered from early winter moose sex and age composition surveys (Table 19, Fig. 5), a late winter stratified random moose census (Table 20, Fig. 22), and late winter moose surveys in nonfloodplain areas (Table 21, Fig. 4), provide baseline information on fall to winter distribution of moose in areas removed from the Susitna River floodplain.

Data presented in Table 19 are derived from standard sex and age composition surveys conducted periodically by the Alaska Department of Fish and Game. Though these surveys are not specifically designed to determine moose distribution and abundance, they do still roughly reflect those values. Results of these surveys, as evidenced in previous winter moose river censuses, are probably subject to significant variation due to seasonal and annual weather patterns and should be treated cautiously. In view of potential shortcomings, these data suggest that more southerly areas adjacent to the Susitna River (Areas J, F, G and H; Fig. 5), support higher densities of moose than the more northern areas (A, B, C, D and E; Fig. 5). Since little movement out of Areas A, B and C was detected in the sample of moose radio collared in that area, it seems reasonable to believe that, excluding observer sightability corrections, these values may approximate year-round moose densities for those respective areas. Values from all these areas indicate that moose densities are well below 1 per sq mi. Though similar supporting data from radio-collared moose are lacking for Area D, I suspect that characteristics of its moose subpopulations resemble those of the former areas and that observed densities are near to actual moose densities. Although relatively low moose densities were also detected in Area E, I suspect moose populations in that area are more subject to large seasonal movements (winter emigration) and more moose may actually inhabit the area during other seasonal periods.

Table 19. Data from recent and past moose composition surveys conducted in areas adjacent to the Susitna River downstream from Devil Canyon, Alaska.

Area[1]		Most recent survey		Prior survey[3]	
Name	Size (mi^2)	No. moose[2]	Date	No. Moose	Date
A	90	73	Nov 1983	NA	
B	80	61	Nov 1983	NA	
C	90	56	Nov 1983	NA	
D	350	182	Nov 1983	NA	
E	430	202	Dec 1983	NA	
F	215	335	Dec 1983	471	Jan 1984
G	250	397	Dec 1983	780	Nov 1968
H	320	894	Dec 1983	1,017	Nov 1970
I	550	160	Nov 1982	573	Nov 1981
J	990	2,128[4]	Feb 1984	NA	

1 Location of survey area illustrated in Fig. 5. Size represents a rough approximation visually calculated from 1:250,000 scale USGS topographic maps.

2 Data obtained from Alaska Department of Fish and Game files. These surveys are primarily conducted to assess sex and age composition of moose populations; they are not conducted as strict population censuses and winter weather conditions can affect numbers of moose observed in all areas.

3 Historical high count where data were available. NA = no other data available.

4 Estimate obtained from a stratified random moose census; ± 12.7% at a 90% confidence interval.

Table 20. Data on strata classification, sample unit size, densities of moose and population estimates from a stratified random census conducted along the Susitna River, Alaska 24-29 February 1984.

Density strata classification[1]	No. units sampled (Total size 8.6 to 19.6 sq. mi)	Density observed within and between units sampled (moose per sq. mi)			Strata total (percent)	
		Low	High	Mean	Area(mi²)	No. Moose[1]
Low	9 (40)	0.0	0.7	0.3	615 (62)	203 (15)
Medium	6 (6)	0.5	1.2	0.8	79 (8)	64 (5)
High	14 (14)	1.6	4.3	2.8	198 (20)	550 (39)
Superhigh	7 (7)	3.5	14.2	6.1	98 (10)	580 (42)
Combined: unadjusted estimate	36 (67)				990	1,397[3]
adjusted estimate						2,218

1 Location of study area distribution of moose density as estimated from stratification survey are illustrated in Fig. 22.

2 No. moose estimated for all sample units within strata.

3 Total moose estimated. Adjustments to this estimate for two types of observer sightability correction factors (Gasaway et al. 1980) inflates estimates to 2,218 moose, between 1,858 and 2,399 moose estimated at a 90% confidence interval (±12.7% of estimate).

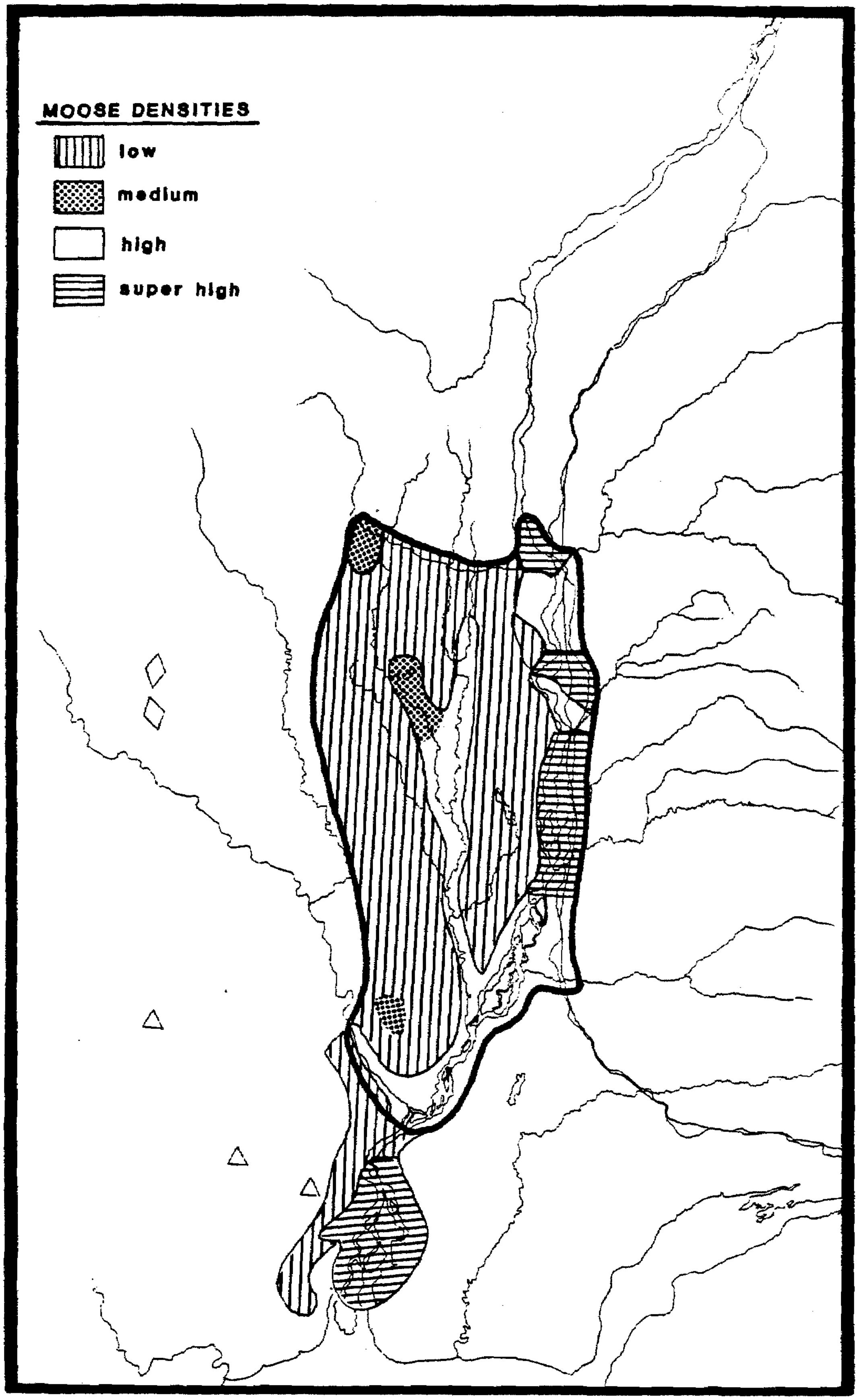

Figure 22. Locations of areas where moose population size (▬▬) was estimated and densities of moose were determined from the stratification flight of a random stratified census conducted along the Susitna River, Alaska, 26-29 February, 1984.

Table 21. Composition, numbers, and density for moose observed at various locations removed from the Susitna River floodplain, Alaska, 1984.

Location [1]	Size [2] (sq mi)	Date	No. observed Moose	Calves	Carcasses	Flight time [3] (min)	Density (moose/ sq mi)
Deshka River	60	5 March	37	3	13	NA	0.6
Moose Creek	30	5 March	58	9	0	NA	1.9
Trapper Creek	12	5 March	1	0	0	NA	0.1
Whitsol Lake	5	15 March	12	0	42	NA	2.4
Swede	4	8 March	7	0	0	28	3.1
Lockwood Lake	3	8 March	7	1	0	28	2.3
Kahiltna/ Moose Creek	3.5	8 March	11	0	0	28	3.1
Neil Lake	5.5	8 March	4	0	0	33	0.7
Kashwitna Knobs	3	8 March	5	0	0	11	1.7
Trapper Lake	2.5	8 March	0	0	0	15	0
Parker Lake	8	8 March	5 [4]	0	1	56	0.6

1 Refer to Fig. 4 for geographical location of survey areas.

2 Size for areas estimated from 1:63,360 scale USGS topographic maps. For river and creek areas sizes represent rough approximations of stream course distances. Surveys were confined to floodplain habitat paralleling water courses. Densities represent moose per mile of stream.

3 NA = flight time for stream surveys not applicable, since flight paths varied greatly.

4 All moose in Parker Lake survey area were observed along eastern boundary near riparian habitat.

In contrast, in the western foothills of the Talkeetna Mountains (Areas F and G and particularly H; Fig. 5), observed moose densities ranged from 1.5 to over 2.75 per sq mi. Though few moose from these subpopulations were represented in the radio-collared samples, it is believed that in "severe" winters a higher percentage of moose from these subpopulations move to the Susitna River riparian habitats.

Reasons for observed differences in moose densities between areas north and south of Talkeetna may be related to winter weather conditions, habitat attributes and level of predation. Areas north of Talkeetna along the Susitna River generally have greater amounts of snowfall than more southern areas. Heavy snowfall and extreme snow depths probably inhibit moose movements to, from and within this area in winter and decrease its desirability to moose. The Susitna River valley north of Talkeetna is narrow, steep sided and dominated by extensive stands of alder, the river banks are abrupt, the floodplain is brief and low relief islands of early successional vegetation are relatively scarce. These features are considerably less attractive to moose than the flat, wide braided river, extensive low relief floodplain, heavily islanded habitats characteristic of the Susitna River south of Talkeetna. In contrast to riparian areas south of Talkeetna, where coyotes and black bears are probably the most common potential predators, areas north of Talkeetna contain substantial populations of brown and black bears (Miller and McAllister 1982) and occasionally wolves (Ballard et al. 1982a) which probably act to suppress moose population levels. Extensive predation by wolves on adult moose and by bears on moose calves which has been documented for a nearby area (Ballard et al. 1982b) and data collected by Modafferi (1982) suggesting that during parturition female moose move to islands in the Susitna River to avoid harassment by predators, lend support to the contention that predation may affect population level.

If this were the case, and if this moose subpopulation was under a different wildlife management scheme (i.e., one that may decrease numbers of wolves and bears in the area), one would expect a corresponding increase in numbers of moose in that subpopulation. Perhaps, then, calculations of mitigation compensation for potential loss of moose to this subpopulation should consider the numbers of moose the area would support if it were intensively managed for them (i.e., if predator populations were maintained at lower levels).

Reasons for the relatively low counts of moose in Area I (extreme southeastern foothills of the Talkeetna Mountains, Fig. 5), are presently little understood. Some moose radio-collared on the Susitna River floodplain moved into this area for a short period during mid-winter and perhaps composition counts slightly later in the winter would have revealed densities similar to the more northern areas in the Talkeetna Mountains (F, G, and H). Relatively easy access to Area I may lead to more intense hunting pressure and a higher hunter kill and result in lower moose population levels. Additionally, a high annual "accidental" kill of moose in the winter (sometimes over 200) on the Parks Highway between Willow Creek and the Talkeetna River (Game Management Subunit 14B) by vehicles and on the Alaska Railroad right-of-way by trains may also contribute to depressing this moose subpopulation.

Other data included in Table 19, are results from previous moose composition surveys which illustrate variance that may be expected in these survey data. However, the higher counts may also indicate that these areas are capable of supporting significantly more moose under different conditions or at other times. If similar data were available for Areas A, B, C and D, we may see that historically these areas supported significantly more moose then were counted in 1983 and that, likewise, under some circumstances many more moose may be dependent on the Susitna River floodplain winter range than were observed in winters of 1981-84.

This rational must be considered when planning mitigation actions to compensate for possible loss of moose or their habitat, to fully appreciate the potential numbers of moose which may be involved.

Data in Table 20, exhibit the extreme importance of the Susitna River floodplain to moose subpopulations in Area J. Though Area J as a whole contained an estimated average of over 2 moose per sq mi in late winter, a high proportion of those moose occurred in riparian areas (Deshka River, Moose Creek, Yentna River, etc.) during the survey and probably more than half of the latter moose occurred and wintered on the Susitna River floodplain (Fig. 22).

Data in Fig. 22, indicate that large portions of Area J contain relatively low densities of wintering moose. Data from radio-collared moose (this report and Modafferi 1982 and 1983) indicate that many of the moose that inhabit the interior of this area during other seasonal periods move to the Susitna River flood-plain for winter range. Together, these data indicate that the interior of Area J would be a logical location to enhance available winter range for local moose subpopulations which usually winter on the Susitna River floodplain.

Data provided in Table 21 appear to contradict some data presented in Table 20. These apparent inconsistencies may in part be explained by the fact that survey data in the former table were obtained in March, during which time some moose had already proceeded to depart from riparian wintering areas to early spring non-riparian ranges. It may also be that amongst the expansive interior of Area J, small areas contain suitable winter range for moose (Whitsol Lake, Swede, Lockwood Lake and the Kahiltna/Moose Creek areas; Table 21), and support locally high moose densities. These data also suggest that because very low winter densities were observed at the Neil Lake, Trapper Lake and Parker Lake areas, they may be potential candidate areas for habitat enhancement; providing these areas do not provide a preferred range during another seasonal period. Parts of the Parker Lake area were consistently used by a radio-collared female moose (No. 45) during all other seasonal periods, but it is not known if many other moose, similarly, used this same habitat during those seasonal periods.

MOOSE USE OF DISTURBED SITES

Surveys conducted on disturbed sites will provide: 1) information on moose use of these apparently important areas which supplement the Susitna River floodplain moose winter range and; 2) information which will be useful in assessing, proposing and implementing mitigation actions for moose habitat enhancement programs. Knowledge of moose use of disturbed sites is particularly important since 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.

Human activities have altered natural habitats at numerous sites near the Susitna River floodplain and have resulted in the reestablishment of seral type vegetative communities. Vegetative associations which occur at these sites during a time period after the initial disturbance are composed of desirable moose browse plant species and attract large numbers of moose in winter.

Since these sites provide a substantial alternate, but temporary, food source for moose which normally winter on the Susitna River floodplain, one must determine how moose utilize them and how they interact with the floodplain sites, to adequately assess their role in winter ecology of dependent moose subpopulations.

Early successional vegetative stages in floodplain habitats are temporarily and spatially maintained over the long term by natural phenomena (floodplain subclimax), but disturbed sites are temporary occurrences and may only be maintained by the whims or positive actions of man.

Therefore, it is probable that at some time in the future, moose subpopulations along the Susitna River will most likely have to rely solely on the Susitna River floodplain for winter range.

To assess moose use of these areas, periodic censuses, paralleling the timing of river censuses, were conducted on 6 disturbed sites in the winters of 1981-82 and 1982-83 on and 13 disturbed sites in winter 1983-84.

Most sites surveyed were immediately adjacent to the Susitna River floodplain, but some sites were located up to 5 km east of the Susitna River. Because of the relative proximity of these sites to floodplain habitats, they may possibly compete with or compliment the latter winter range presently available to, and used, by moose subpopulations which usually winter on the Susitna River floodplain.

Though these sites were near to floodplain habitats, numbers of moose counted on them, were not included in talleys for river censuses. However, it seems likely that moose using many of these sites are <u>not</u> subgroups, discrete from those which use adjacent floodplain habitats. In reality, there is probably a flux of individual moose between both habitat types.

Data presented in Table 22 (and Fig. 3) demonstrate intensive use of some disturbed sites and variability in intensity and in seasonal and annual timing of use between different sites.

Table 22. Numbers of moose observed on sites adjacent to the Susitna River, Alaska, where climax vegetation has been altered by activities of man, 1981-84.

Winter	Date	Location[1] MW	MN	MM	TW	KL	MS	ME	GC	WC	KB	CW	CE	KE
1981-82	2 Dec	41	-	-	-	-	-							
	10 Dec	8	0	23	4	-	17							
	14 Dec	23	-	-	-	-	-							
	28 Dec	25	-	11	7	-	-							
	6 Feb	-	-	9	4	4	-							
	1 Mar	24	1	2	1	1	6							
	24 Mar	6	0	4	1	6	0							
	12 Apr	4	0	0	0	1	1							
1982-83	29 Oct	13	0	0	-	-	-							
	6 Nov	22	0	2	4	3	-							
	10 Nov	-	-	-	-	14	-							
	18 Nov	68	0	12	8	3	-							
	2 Dec	68	1	43	16	23	-							
	6 Dec	56	3	47	-	21	-							
	20 Dec	-	8	-	-	21	-							
	21 Dec	36	-	40	25	19	-							
	22 Dec	41	-	41	-	10	-							
	5 Jan	28	6	41	9	22	-							
	20 Jan	21	0	59	-	36	5							
	24 Jan	48	0	63	14	29	13							
	7 Feb	-	-	-	-	14	11							
	9 Feb	57	0	7	27	-	-							
	22 Feb	-	-	-	-	8	2							
	23 Feb	30	2	16	6	-	-							
	7 Mar	-	-	-	-	7	-							
	8 Mar	43	3	22	8	-	2							
	20 Mar	-	7	-	-	-	-							
	22 Mar	17	-	43	-	17	-							
	23 Mar	21	-	45	10	16	-							
	30 Mar	-	-	-	8	1	-							
	8 Apr	2	-	6	1	1	-							
1983-84	17 Nov	6	0	4	4	11	0	-	-	1	0	0	-	3
	18 Nov	-	-	-	-	-	-	0	0	-	-	0	-	-
	25 Nov	22	-	-	-	-	-	-	-	-	-	-	-	-
	29 Nov	45	0	5		3	0	3	0	3	2	0	0	-
	9 Dec	32	0	5	9	14	2	10	0	7	2	0	3	5
	16 Dec	47	0	7	11	7	2	6	0	5	0	0	3	-
	24 Dec	72	0	5	18	3	0	7	0	2	2	2	0	1
	30 Dec	49	0	0	1	0	0	-	-	-	-	-	-	-
	3 Jan	23	-	5	11	-	-	-	-	-	-	-	-	-
	5 Jan	73	0	12	14	8	0	12	6	1	2	4	3	2
	13 Jan	29	1	18	14	4	5	0	2	2	4	2	2	0
	17 Jan	-	4	21	13	3	4	4	6	1	6	6	5	1
	19 Jan	31	2	31	10	2	2	4	8	4	6	6	2	1
	27 Jan	49	4	25	5	16	6	7	22	8	15	7	4	2
	8 Feb	48	5	38	8	6	12	3	12	1	40	23	6	2
	20 Feb	49	6	26	21	8	25	3	21	1	27	22	9	1
	28 Feb	42	7	59	26	14	12	6	4	0	31	18	0	2
	5 Mar	19	0	43	10	16	5	0	4	2	33	34	2	0
	8 Mar	17	1	37	3	9	6	1	4	2	28	34	2	0
	15 Mar	3	0	38	3	8	6	0	1	5	16	16	0	0
	29 Mar	4	0	27	1	21	3	0	0	5	6	3	0	0

1 MW = Montana west, Mn = Montana north, Mm = Montana middle
TW = Talkeetna west, Kl = Kashwitna Lake, Ms = Montana south,
ME = Montana east, Gc = Goose Creek, Wc = Willow Creek,
KB = Kashwitna bluff, Cw = Chandalar west, Ce = Chandalar east and
KE = Kashwitna east. Locations Me, Gc, Wc, Kb, Cw, Ce and Ke were only surveyed during 1983-84.

In part, apparent variation between intensity of use between sites may be attributable to differences in size of individual sites, but it is probably also related to factors as plant species composition, age of plants, proximity to other similar sites, and location of site with respect to floodplain habitats and to general movement patterns of moose subpopulations.

The Montana west site was the most heavily used site; it is also the largest site and apparently is located in the pathway of a major moose subpopulation movement from west, to east of the Susitna River. A west to east movement of moose was documented for most radio-collared moose and also appears to be evidenced by the fact that moose numbers always increased at the Montana west site before at other sites east of the Susitna River. Decreases in moose numbers at Montana west, in mid- to late January, also appeared to correspond with increases in moose numbers at the Montana middle site located on the adjacent east bank of the Susitna River.

Low moose use of disturbed sites in winter 1981-82 may be attributed to the relatively mild weather conditions in that winter, compared to weather conditions in winters of 1982-83 and 1983-84. Differences in timing of use between the 1982-83 and 1983-84 winters may be attributed to differences in timing of seasonal snowfall; large quantities of snowfall occurred early in 1982-83, but in 1983-84 significant quantities of snowfall did not accumulate until much later in winter. Heavy moose use of Montana west occurred during late December in winter 1983-84, compared to late November-early December in the 1981-82 and 1982-83 winters and moose appeared to remain "staged" longer at that site as they did not "flow over" to the Montana middle site in significant numbers until late January or even late February 1984, several months later than in previous winters.

The apparent large buildup of moose at the Kashwitna bluff, Chandalar west, Montana south and Goose Creek sites late in winter 1983-84 may have been in response to the gradual, but significant overall, late winter accumulations of snowcover, or were the result of typical moose migratory movements.

The Montana north site was probably very recently disturbed as grasses and forbs appear to dominate the ground cover and shrub type vegetation was relatively scarce. This site also lacked tall shrub or tree cover which moose may prefer to bed in when not feeding. These factors, along with small size, may account for low use of this site by moose.

Moose were seldom observed evenly distributed throughout a particular site. They appeared to prefer to be in close associations with other moose. It was not uncommon to observe most individuals browsing in one portion of a site on one survey and on a subsequent survey see most individuals still concentrated but in different portion of the site. It is possible that the behavior to congregate is a defense mechanism to combat secretive approaches and attacks by wolves or simply exhibits a seasonal social tendency in moose. This intraspecific tolerance behavior also enables moose to occur and browse in very dense aggregations during the winter period.

It was not uncommon to observe many moose bedded down in the relatively open portions of a site. It may be that moose prefer to bed down in tall vegetative cover, but it was not uncommon to observe many moose bedded down in relatively open portions of a site. I suspect that, energetically, there is a positive heat gain for moose which bed in areas exposed to the sun over those moose which bed in forested surroundings, protected from wind and concealed from predators, but without any direct exposure to the sun. Though open habitats leave moose visually exposed to wolves, the lack of dense vegetative cover may also preclude secretive approaches by wolves.

It is not known why moose use of the Kashwitna Lake site was relatively low in 1983-84 compared to use in the previous winters. Perhaps vegetation at the site is overbrowsed and moose are no longer attracted there or activity of hunters during the late winter (January-February) open moose season caused moose to leave the site.

The Talkeetna west site appeared to be used less relative to other sites surveyed. This may be attributable to vegetative species composition, but this site also contained more "slash" and downed trees than any of the other sites. Moose may prefer to utilize sites that are not cluttered with downed trees and other debris which may hinder their movements or those of their calves.

The Willow Creek site was used by relatively few moose, but this is probably attributable to the substantial amount of coniferous regrowth it contained amongst potential decidous browse species. Whether the coniferous regrowth was attributable to site characteristics or techniques used to clear the site is presently unknown.

To adequately assess the long term importance of the Susitna River floodplain in winter ecology of moose downstream from Devil Canyon, the interaction between floodplain habitats and disturbed sites must be understood. Presently, disturbed sites probably provide winter range for as many moose as floodplain areas. If disturbed sites are not maintained in the early successional vegetative stages which provide preferred moose browse, then more moose will be forced to seek winter range in the "floodplain subclimax," riparian habitats along the Susitna River and the relative value of the latter habitats will be greatly increased. Additionally, knowledge obtained from the study of disturbed sites, may be utilized to assess, propose or implement mitigation actions involving enhancement of moose winter habitat.

PRODUCTIVITY AND CALF SURVIVAL FOR RADIO-COLLARED MOOSE

Moose subpopulations are limited by factors which affect production and survival of potential recruits to the population. To assess and understand ultimate impacts of hydroelectric development on moose subpopulations and to prepare appropriate mitigation plans, it is necessary to know which factors limit growth of those subpopulations prior to hydroelectric development and if the hierachy of those factors will be altered following that development.

Observed or hypothetical positive or negative impacts on production or survival of potential recruits are only academic, unless they are realized at the subpopulation level. An increase in calf production in an area where calves will likely die or be killed by predators should not be considered as a replacement or enhancement measure to that respective moose subpopulation. Implementing a predator management scheme to benefit moose subpopulations in an area where moose are limited by food resources, likewise should not be considered as a positive management measure for that moose subpopulation. Conversely, if moose subpopulations are limited by predators, loss of moose winter range to hydroelectric development may have no net <u>contemporary</u> effects on that moose subpopulation but it will ultimately affect future moose management options should predators be managed in a different manner.

If mitigation actions are to enhance particular moose subpopulations, then it is necessary to know which factor(s) may be limiting moose subpopulation growth before an appropriate mitigation plan can be selected. It may be futile to employ a winter range enhancement program, which primarily affects moose nutritive condition, to increase the size of a moose subpopulation that in reality is limited by predation. Conversely, in the former situation, it would be nonsense to implement a predator management scheme to benefit a moose subpopulation that is limited by availability of high quality winter range. Obviously, impacts of hydroelectric development on moose subpopulations and meaningful mitigation enhancement programs can only be assessed and designed, respectively, after factors which limit moose subpopulations are understood.

Studies designed to assess production and fate of moose calves and mortality of adult moose provide information on subpopulation status and factor(s) which may be limiting subpopulation growth. Data from these studies, can be used to assess impacts of hydroelectric development and to formulate meaningful mitigation programs.

Data provided in Table 23 indicate that between 88 (1983) and 98 (1982) percent of the radio-collared female moose produced calves annually. These data further indicated that 17, 61 and 72 percent of the productive females in 1981-83, respectively, produced twins. Forage conditions for downstream Susitna River moose subpopulations must be rated above average, since twinning rates of 70 percent were also found for productive female moose on "prime" Kenai Peninsula moose range (Franzmann and Schwartz 1984, in prep.). Actual and relative twinning rates for the radio-collared sample were probably higher, since they were determined with fixed-winged aircraft and searches were less intense in nature than the helicopter survey procedures conducted on the Kenai Peninsula.

Search efforts for calf moose in 1981 were not as intense as in subsequent years and may in part, account for the relatively low twinning rate observed for that year.

The relatively high rate of productivity for radio-collared females in 1982, may in part, be associated with the winter of 1981-82. Theoretically, mild winter weather conditions would

Table 23. Calf production for female moose radio-collared along the Susitna River between Devil Canyon and Cook Inlet and relocated during 1981-83.

Year[1]	No. females			No. calves per 100		Percent of females with			Percent productive
	N	with twins	with singles	females	productive females	no calves	singles	twins	females with twins
1981	27	4	20	104	117	11	74	15	17
1982	34	20	13	156	161	3	38	59	61
1983	32	18	7	134	172	22	22	56	72

[1] Data obtained primarily from observations at 7, 6 and 9 relocations of radio-collared moose during May and June in 1981, 1982 and 1983, respectively.

promote good foraging conditions and enable pregnant females to approach parturition in good nutritive condition and produce large numbers of high quality calves. Similarly, the inclement weather conditions in winter of 1982-83, may have affected nutritive condition of pregnant females and resulted in the relatively high number of nonproductive females observed during calving in 1983.

Data in Table 24 partition calf mortality into various seasonal periods. These data exhibit annual, as well as seasonal, differences in the patterns of calf mortality. Comparatively good calf survival occurred up to and through the mild winter of 1981-82 when less than 25 percent mortality occurred before early December and less than 30 percent of those calves subsequently disappeared by early April. Calf losses prior to December may actually have been higher, since as previously mentioned, search efforts were less intense that spring. These data suggest that over 50 percent of initial productivity was subsequently incorporated into the moose population.

Similar data for subsequent years of study (1982-84, Table 24) indicate that a higher percentage of calf mortality occurred before the early winter period. This higher rate of early winter mortality most probably was related to the heavy, late October and early November snowfalls which occurred in those winters, respectively.

Calf mortality between early and mid-winter was similar in 1981-82 and 1983-84. However, during the winter of 1982-83, when the greatest numbers of moose were counted in floodplain areas, calf mortality was more than twice that which occurred in the former two winters. Though snow conditions did not worsen nor ameliorate, these relatively high rates of calf mortality were apparently carried over into the early spring in 1982-83. The parallel and similarly high calf mortality rates exhibited during

Table 24. Calf survival and calf:cow ratios for female moose radio-collared along the Susitna River between Cook Inlet and Devil Canyon, Alaska, and relocated from 1981-84.

Year		1981-82		1982-83		1983-84
No. females		24		34		31
No. females with calves		22		33		25
No. calves produced		25		53		43
No. (percent) calves surviving to:						
Early winter	2 Dec.	19 (76)	13 Dec.	33 (62)	25 Nov.	21 (49)
Mid-winter	29 Jan.	14 (56)	4 Feb.	18 (34)	2 Feb.	17 (40)
Early spring	5 Apr.	13 (52)	1 Apr.	12 (23)	14 Mar.	11 (26)
No. calves per 100 females:						
at birth		104		156		139
by early spring		54		35		35

this period in 1983-84 were associated with continued snowfall, an increasing snowpack and the persistence of winter conditions into early spring. Since the latter data were only accumulated through 14 March (compared to 5 and 1 April in prior years), I suspect that mortality rates calculated for a more comparable time period would actually have been much higher, in spite of the fact that winter conditions drastically ameliorated in early March. During the mild winter of 1981-82, very low mortality rates were detected for this same late winter period.

Together, data collected during these three winter periods indicate the profound influence that winter weather conditions can have on productivity and calf survival in moose subpopulations that seek winter range on the Susitna River floodplain. Though summer range quality may influence the early winter nutritive condition of moose and affect their ability to cope with subsequent inclement winter weather, the following discussion will only consider the ecological relationship of Susitna River floodplain winter range to productivity and survival of moose. Winter range quality, winter weather conditions and perhaps moose population levels interact annually, and, in part, result in the "winter conditions," which affect nutritive condition of moose. Latent effects from previous winter conditions may affect condition and calf production of pregnant females. Inclement winter conditions may affect nutritive condition of pregnant females and result in lower quality (smaller physical size, lower nutritive condition, etc.), of in utero calves. The neonates, produced by dams exposed to inclement winter conditions, may experience higher rates of mortality, shortly after parturition, or much later, during the subsequent winter, than neonates produced from dams which were exposed to less severe winter conditions. Relatively early inclement winter conditions (perhaps as in 1982-83) may affect calf survival in several manners: 1) calves may be forced to travel great distances to the Susitna River floodplain winter range before they are physically or nutritionally ready; 2) an early influx of moose to the winter range dictates that the range must support a given number of moose over a relatively longer period of time; 3) an early influx of moose also implies the winter range must support a greater number of moose over a given period of time; 4) relatively large concentrations of moose on winter range for longer periods of time may increase rates of predation on them; 5) large moose concentrations may affect ability of the range to rejuvenate for subsequent years; 6) increased mortality from drowning or exposure may result if moose move to floodplain winter range early before river ice becomes sufficiently hard, and 7) increased mortality will result from collisions with trains and vehicles if moose move early to a winter range near railroad and highway rights-of-way. Effects of the aforementioned mortality factors will be reduced if occurrence of inclement winter conditions is delayed.

Winter conditions need not be "severe" (e.g. 1982-83) to cause significant calf mortality. If relatively mild winter conditions persist on into early spring (e.g. 1983-84), total calf mortality may approach that of an early winter.

Calf mortality which occurred before the early winter period, may be attributed to predation (1981-82) or a latent effect from winter conditions the previous year. Predation in areas south of Talkeetna is most likely from black bears, but brown bears and coyotes, and less likely wolves occur there and are also potential predators. In areas north of Talkeetna, brown bears and wolves are more common, black bears are similarly abundant and coyotes less common than in areas south of Talkeetna and the relative rates of their respective contribution to predation probably vary accordingly.

Since adult productivity and survival of calf moose ultimately affect subpopulation status, proximate factors which affect those variables must be identified and studied before impacts of hydroelectric development can be assessed. Furthermore, it should be known whether those affects are ultimately additive or compensatory to other sources of mortality sustained by those moose subpopulations.

ALPINE WINTER RANGE AND FORAGE

Since mitigation actions to benefit moose need not be limited to areas or subpopulations which may be directly impacted by Susitna River hydroelectric development, knowledge about moose winter ranges in areas remote from the floodplain and about moose subpopulations which utilize them will increase the land base from which mitigation lands may be knowledgeably selected.

In contrast to moose subpopulations which winter at low elevations (sea level, Bell Island to 250m, Devil Canyon) in floodplain habitats along the Susitna River, some moose subpopulations winter at higher elevations (up to 750m) near timberline along the western slopes of the Talkeetna Mountains. Though moose are commonly observed in these alpine areas from Devil Canyon south to the southwestern corner of the Talkeetna Mountains, particularly high concentrations have been reported in the area above timberline between the Peters Creek fork of Willow Creek and Little Willow Creek, "Willow Mountain" (see Fig. 1 and 5, Area H and Table 25).

Infrequent observations and meager data suggest that moose appear to gather in these areas above timberline during October, perhaps for the rut, and remain densely concentrated in some areas until late January (the aforementioned area), in other areas until late February (north Fork of the Kashwitna River) and in other areas until late April (Sheep Creek and South Fork of Montana Creek) before moving to lower elevations in late winter or early spring.

Table 25. Chemical components for samples of fern (Dryopteris dilatata) and willow (Salix sp.) moose browse collected at 700 - 800m elevation in the southwestern foothills of the Talkeetna Mountains, Alaska, 3 January 1983.

		Chemical components[1]															
Item Part	Sub-sample	Crude fat	NDF	ADF	Lignin	Cellulose	Residual Ash	N	P	K	Ca	Mg	Na	Cu*	Zn*	Mn*	Fe*
Fern:																	
Rhizome	1	4.5	23	19	10	8	0	1.3	0.12	0.7	0.0	0.3	0.1	0.1	44	173	129
	2	5.9	27	22	9	13	0.1	1.2	0.14	0.7	0.2	0.3	0.1	3.0	73	745	62
	3	5.9	33	29	15	14	0.3	1.2	0.13	0.6	0.2	0.3	0.1	5.0	77	570	133
	Mean	5.4	28	23	11	12	0.1	1.2	0.13	0.7	0.1	0.3	0.1	2.7	65	496	108
Rhizome and fiddleheads	1	5.1	26	19	9	10	0	1.6	0.25	1.3	0.2	0.3	0.1	4.0	61	183	98
Willow:																	
Apical shoots	1	4.1	45	39	14	25	0.2	1.2	0.18	0.4	0.6	0.1	0.1	7.0	92	137	91
	2	3.6	51	40	14	26	0.1	1.2	0.21	0.3	0.6	0.1	0.1	8.0	88	110	48
	Mean	3.9	48	40	14	26	0.2	1.2	0.20	0.4	0.6	0.1	0.1	7.5	90	124	70

1 NDF = neutral detergent fiber, ADF = acid detergent fiber.

Values expressed in percent of dry matter at 105°C; values with asterisk (*) expressed in ppm.

Data collected from a radio-collared female relocated periodically for 4 years (No. 22 in Modafferi, 1983) suggest that this individual ranges above timberline in the Sheep Creek/South Fork Montana Creek area until early spring (late April), then moves about 30 miles southeast to calve near Lockwood Lake, by mid-June she moves about 15 miles north to near Trapper Lake where she remains until the end of July when she again returns to the Lockwood Lake area, where she remains until the last week of September when she departs for the Sheep Creek area. By 1 October she is back on the alpine winter range near Sheep Creek. The evidence for this individual appears quite conclusive, and contrary to most all other radio-collared moose, that she appears to move into the Talkeetna Mountains for winter range (and perhaps the rut). Numbers of moose or subpopulations which share this or similar behavioral patterns are not presently known.

Moose which winter in these alpine areas have commonly been observed pawing away snow ("cratering") to obtain nonbrowse foods. At the Sheep Creek site, where moose No. 22 was captured and collared with a new transmitter, a sample of vegetation extracted, from a recent crater revealed fern rhizomes with young fronds (fiddleheads) and a grass (probably *Calamgrostis* sp.). At that time, it was not known which, if either, the moose were seeking.

A 3 January 1984 excursion to Willow Mountain revealed that fern rhizomes commonly occurred at the bottom of the craters. Most rhizomes were scraped into a concave form shaped like the incisors from a moose lower jaw. Some of the less disturbed rhizomes contained young fronds (fiddleheads). The moose were apparently feeding on fern rhizomes and may have primarily been seeking the fiddlehead portion.

Samples of fern (*Dryopteris dilatata*) rhizomes, immature fronds (fiddleheads) and apical shoots from nearby willows (*Salix* sp.) which had been browsed by moose were collected for chemical analyses. Data on composition of these food sources indicated that several major, desirable chemical components, crude fat, N (N x 6.25 = crude protein), P and K, occurred in higher concentrations in the fern items than in the willow apical shoot samples (fat 38% higher, N 33% higher in fiddleheads, P 25% higher in fiddleheads and K 225% higher in fiddleheads). The chemical analyses also revealed that several less desirable, fibrous components, lignin and plant cell wall constituents (NDF), were less concentrated in the fern items, than in the willow shoot samples (29% less lignin, 56% less NDF). Together, these data imply that diets composed of fern items would be of higher quality due to higher concentrations of essential nutrients and lower concentrations of the fibrous relatively undigestible components.

Whether moose subpopulations move to these alpine areas primarily to rut and subsequently and secondarily, linger near timberline to feed on nonbrowse food sources, which probably remain available through the winter because wind action prevents large accumulations of snow, or whether the reverse is true and moose primarily move to these areas for the latter reasons, is presently unknown. Moose on the Kenai Peninsula, Alaska, where annual snowfall is light, feed on other nonbrowse foods and associated high moose densities in that area were, in part, attributed to that activity (LeResche and Davis, 1973).

It would seem that if movements of a moose subpopulation from alpine areas to the Susitna River floodplain were precluded, because of the availability of nonbrowse foods, moose from that subpopulation would be in better nutritive condition and produce more higher quality calves than moose from subpopulations which had to make that journey. If this reasoning is correct, such moose subpopulations would potentially be much more productive than those which had to travel great distances to winter on the Susitna River floodplain. If circumstances on Willow Mountain are unique in the Susitna River Valley, perhaps protection of these fern rich habitats should be considered along with other mitigation plans.

PRELIMINARY CONSIDERATIONS FOR REVIEWING, SELECTING, CREATING AND MAINTAINING LAND AREAS FOR THE BENEFIT OF MOOSE POPULATIONS.

Some lands are already highly productive or desirable for moose and may only need to be protected from alterations and/or developments in the future to benefit moose subpopulations. Alteration or rehabilitation of these lands is presently not necessary. However, in order to sustain high levels of productivity on these lands, moose populations must be managed and maintained at levels commensurate with carrying capacity of the range. These lands need not be winter range habitats but may be calving or rutting areas or simply travel corridors between summer and winter ranges. These areas may be natural and undisturbed or they may be altered habitats that in the past were cleared and now are at the seral vegetative stages desired by moose. Presently, several of the latter type areas have been located and data documenting moose use (timing and numbers) of them are available (see MOOSE USE OF DISTURBED SITES pg. 86). It is possible that areas, which already support substantial wintering populations of moose, may be procured from their present landholder and maintained (maybe further improved) in that enhanced condition indefinitely.

Other lands along the Susitna River may presently be unproductive for moose or be declining in productivity but have the potential to be rehabilitated, manipulated and/or enhanced to increase their productivity for moose. However, under these circumstances it should be reemphasized that if mitigation actions are to enhance particular moose subpopulations, then it is necessary to know which factor(s) may be limiting moose subpopulation growth before an appropriate mitigation plan be selected. It may be futile to employ a winter range enhancement program, which primarily affects moose nutritive condition, to increase the size of a moose subpopulation that in reality is limited by predation. Conversely, in the former situation, it would be nonsense to implement a predator management scheme to benefit a moose subpopulation that is limited by availability of high quality winter range. Obviously, impacts of hydroelectric development on moose subpopulations and meaningful mitigation enhancement programs can only be assessed and designed, respectively, after factors which limit moose subpopulations are understood.

Rehabilitation of lands for moose typically involves removing climax type vegetation to encourage growth of higher quality early successional vegetative types than were previously available on that given area or range.

It is critical that age and species composition of succeeding vegetative types be those which are preferred by moose. I have observed sites where it appears climax vegetation had been altered by human activities, but the resulting regrowth was predominantly spruce; a highly undesirable winter browse species for moose. One of these sites immediately abutted another where regrowth was composed of preferred browse species. Apparently, subtle environmental factors may be present and result in contrasting regrowth patterns. Obviously, selection of sites to be enhanced must be conducted in a knowledgeable manner.

Rehabilitated lands may be of little value to moose until preferred successional vegetative types dominate the site. The time lag between alteration and appearance of preferred browse may be 3 or 5 years (Spencer and Chatelain 1953 and Preston 1983, respectively) but can vary with habitat type, site characteristics and techniques employed.

Interspersion of habitat types may be important to a successful rehabilitation program. Extensive cleared areas, lacking adjacent cover (spruce forests or densely vegetated berms) may be less than ideal for moose winter range. Ideal winter range probably is composed of a mix of cover types and browse species.

Moose may be slow to utilize a newly rehabilitated habitat that is spatially removed from their more usual patterns of movement or winter ranges. Newly rehabilitated areas may have to be colonized by a "new generation" of moose. However, colonization and plant succession may proceed at the same rate so that the area may be at its peak carrying capacity of moose when preferred browse is also at its peak of development and availability. It may be undesirable or difficult to develop a newly enhanced winter range if substantial numbers of moose immediately start to use the area before preferred vegetative types are firmly established.

Enhanced habitats that are in close proximity to a usual and heavily used winter range or are located between usual summer and winter ranges may receive more immediate use by moose than enhanced habitats which are more removed from existing moose subpopulations. Enhanced areas located between existing seasonal moose ranges, may temporarily hold moose as they pass through the area in route to their usual wintering area, and in effect receive immediate use and decrease use of their usual winter range.

Since enhanced habitats are designed to attract and hold large numbers of moose, consideration must be given to location of these rehabilitated areas with respect to highway vehicle and railroad rights-of-way. If enhanced habitats are located near such rights-of-way or moose must move across them when traveling from one range to another, many moose will be killed annually and tremendous public safety problems will result. Similarly, location of enhanced areas near present or potential residential housing subdivisions or field agricultural businesses may cause large concentrations of moose which may impact residential landscape plants, cultured agricultural shrubs and endanger residential occupants.

If carrying capacity of winter range is increased, the resulting increase in moose subpopulations may have detrimental impacts on other potential limiting components in their ecosystem; i.e., spring, summer and fall foraging areas.

Each winter range type rehabilitated area should be managed on a rotational basis, so that a given proportion of the area contains the composition and age class of plants preferred by moose. Perhaps each area could be divided into four parts, one of which is rehabilitated every other summer. This method of land management will foster a rather stable carrying capacity and prevent boom/bust forage conditions.

When selecting areas for enhancement, maximum annual snow depths which occur every 10-20 years should be considered. Snow depths less than 40 cm did not hinder moose movements on the Kenai Peninsula (Franzmann et al. 1984).

Plans for long term maintenance of enhanced areas must accompany proposals for creation of them. If areas are not maintained, elevated moose populations would be forced to utilize other remaining winter range and would lead to overutilization of forage available on those ranges.

If areas are to be enhanced and maintained in that state, access to them must be reasonally convenient, particularly if heavy equipment will be required for rehabilitation.

Enhanced areas need not be large. Data presently available indicate that 40 to 70 moose may browse in about 2 km^2 of early successional habitat from November through March (Table 22).

Location of enhanced sites should not be limited to areas immediately adjacent to Susitna River. Lands near alpine areas along Montana, Sheep, Kashwitna and Willow Creek as well as areas 5 to 15 miles west of the Susitna River should also be considered for enhancement.

Preliminary data from moose censuses along the Susitna River floodplain indicate that cow moose with calves may not be evenly distributed throughout that winter range. Possibly, location of enhancement sites may benefit particular sex and age classes of moose.

Numbers of moose using enhanced areas must be managed and regulated to prevent overutilization of food resources. Regular open hunting season (1-30 September) may not be an adequate management measure and seasonally later, additional open hunting periods when moose are on the winter range (enhanced areas) may be necessary to control population growth. The latter technique would appear to be the most direct, specific and precise method of controlling moose population size and preventing overbrowsing and starvation on the winter range and would also provide the maximum sustainable yield of browse and moose. If open hunting seasons were the primary population controlling measure, it would be necessary that enhanced areas were readily accessible to hunters.

Since enhanced areas must be maintained over a long term period (indefinitely?), careful consideration should be given to potential and planned future land uses on adjacent land and the more distant lands upon which the respective moose subpopulations subsist during other seasonal periods. It would be shortsighted to enhance winter habitat in an area, if it were known that a major highway was to be constructed between the enhanced winter range and summer range of that particular moose subpopulation.

Perhaps, most of all we must be knowledgeable about moose, enhanced habitats, and how moose use them before going out and altering climax vegetation. Baseline, general studies could be conducted where happenstance, "enhanced" areas presently exist, to assess characteristics of the areas, how moose use them and to predict how new ones may be created to best serve local moose populations. Additionally, before altering habitats for the benefit of moose, we must assess the ultimate impacts of those changes on its prior wildlife inhabitants.

Lastly, follow-up studies should be conducted on several select areas after enhancement takes place, to determine how moose are utilizing the areas and if their use is different than was anticipated.

POTENTIAL 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, fertilizing effects of inorganic and/or organic nutrient loads, water for ice surface area, 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 (may result in physical, physiological, visual, isolation and insulation problems for moose), 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: development associated with pre and post project*influx of humans, transmission corridors, railway and vehicle rights-of-way, project facilities, attracts predators and conspecific competitors.

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

Human Encroachment: construction and maintenance employees, hunters, visitors, recreationists.

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

Impoundment: inundation displaces predators and conspecific competitors which move to downstream areas.

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 moose subpopulations which are ecologically affiliated with the Susitna River floodplain. Before such data are available, I recommend continuation of a general, broad based research study of the ecology of moose subpopulations 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 continually provide an updated data base useful for knowledgeably assessing impacts or predicting responses of moose to any type of hydroelectric development on the Susitna River. These studies will also provide the data base necessary to plan and make recommendations for various mitigation actions designed to benefit moose subpopulations.

As limits of expected changes and variation in flow hydraulics and in plant communities are further refined, research on downstream moose may likewise be re-directed to investigate particular impacts in finer detail. At the present time, it seems inappropriate to become too specific in addressing particular potential impacts on moose while disregarding other more general baseline studies.

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 these potential changes are more clearly outlined, general information on behavior of these moose subpopulations 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, the data collected on behavior of these more southern moose subpopulations may, at worse, form a basis for assessing and recommending various mitigation actions in this area. For these reasons, relocation of radio-collared moose, downstream from Talkeetna, should continue through the winter of 1984-85.

Periodic winter censuses for moose in floodplain habitats along the Susitna River should be continued through the winter of 1984-85. These censuses document variation within and between winters in the distribution and intensity of moose use for all stretches and floodplain habitat types along the Susitna River downstream from Devil Canyon. This information also provides the basis for classifying winter severity. Perhaps, in the future, only key portions (high use areas) of the floodplain need be surveyed to document annual variation and identify winter severity and surveys of the entire floodplain need be conducted only if winter conditions are gauged as severe. Information on annual variation in size and shape of moose ranges should continue to be collected.

Data obtained from relocation of radio-collared moose and winter moose censuses over a number of years provide information to assess within and between variations in movements and moose use of Susitna River floodplain habitats. Ideally, this type of data should also be collected in a relatively severe winter.

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 in which about 1300+ moose are observed in floodplain habitats along the Susitna River.

Since protection and enhancement of plant communities to favor moose may be a prime mitigation option for project related loss of moose or their habitat, surveys to assess moose use of sites where vegetative communities have already been altered by man, should be continued. To more fully learn about ecology of those sites and their interface with moose ecology, I strongly recommend that the sample of moose radio-collared at the Talkeetna

West site continue to be relocated and perhaps an additional sample of moose be radio-collared at a site on the east side of the Susitna River (at either the Montana middle, Kashwitna Lake or Kashwitna bluffs disturbed site).

Because large alterations in flow regimes and floodplain habitats are expected between Talkeetna and Devil Canyon and information presently available for this stretch of the Susitna River floodplain is limited and heavily skewed toward females, an additional sample of moose should be radio-collared in that area to increase our general knowledge about those particular moose subpopulations. Island habitats in this reach of the floodplain appear important to female moose during calving and decreased post project spring river flows may alter many of these habitats. Since behavior patterns for male moose differ greatly from those of females and presently little information is available on males in that area, efforts should be made to radio-collar additional males in that subpopulation.

REFERENCES

Arneson, P. 1981. Moose-downstream. AK. Dept. Fish and Game. Susitna Hydroelectric Proj. Ann. Prog. Rept. Big Game Studies. Part II. 64 pp.

Ballard, W. B., C. L. Gardner and S. D. Miller. 1982a. Nelchina yearling moose mortality study. AK. Dept. Fish and Game. Fed. Aid Wild. Rest. Proj. Final Rept., W-21-1 and W-21-2, Job 1.27R. Juneau. 37pp.

__________, J. H. Westlund and J. R. Dau. 1982b. Moose-Upstream. AK. Dept. Fish and Game. Susitna Hydroelectric Proj. Phase I Final Rept. Big Game Studies. Vol. III. 119pp.

Bishop, R. H., and R. A. Rausch. 1974. Moose population fluctuations in Alaska, 1950-1972. Naturaliste can. 101:559-593.

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

Collins, W. B. 1983. Increased or decreased energy for moose? The Susitna hydroelectric project. Agroborealis 15:42-45.

Edwards, J. 1983. Diet shifts in moose due to predator avoidance. Oecologia 60:185-189.

Franzmann, A. W., C. C. Schwartz and D. C. Johnson. 1984. Moose Research Report. AK. Dept. Fish and Game. Fed. Aid Wildl. Rest. Prog. Rept., W-22-1, Job 1.27R and 1.31R. Juneau. 65pp.

__________ and C. C. Schwartz. 1984. Condition assessment of moose populations via productivity expressed as twinning rates. In Prep.

Gasaway, W. C., S. D. DuBois and S. J. Harbo. 1981. Moose survey procedures development. AK. Dept. Fish and Game. Fed. Aid Wild. Rest. Proj. Final Rept. W-17-9 through W-17-11, W-21-1 and W-21-2. Juneau. 66pp.

LeResche, R. E. 1974. Moose migrations in North America. Naturaliste can. 101:393-415.

__________, and J. L. Davis. 1973. Importance of nonbrowse foods to moose on the Kenai Peninsula, Alaska. J. Wildl. Manage. 37(3):279-287.

__________, and R. A. Rausch. 1974. Accuracy and precision of aerial moose censusing. J. Wildl. Manage. 38:175-182.

Miller, S. and D. Anctil. 1981. Biometrics and data processing. AK. Dept. of Fish and Game. Susitna Hydroelectric Proj. Ann. Prog. Rept. Big Game Studies. Part I. 16pp.

Miller, S. D. and D. C. McAllister. 1982. Black Bear and Brown Bear. AK. Dept. Fish and Game. Susitna Hydroelectric Proj. Phase I Final Rept. Big Game Studies. Vol. VI. 233 pp.

Modafferi, R. D. 1982. Moose-Downstream. AK. Dept. Fish and Game. Susitna Hydroelectric Proj. Phase I Final Rept. Big Game Studies. Vol. II. 114pp.

__________. 1983. Moose-Downstream. AK. Dept. Fish and Game. Susitna Hydroelectric Proj. Phase II Ann. Prog. Rept. Big Game Studies. Vol. II. 114pp.

Preston, D. J. 1983. Moose habitat in areas of ongoing and proposed agricultural developments and moose populations in areas of ongoing and proposed agricultural developments. AK. Dept. Fish and Game. Fed. Aid Wildl. Rest. Proj. Final Rept. W-21-2 and W-22-1, Job 1.34R and 1.35R. Juneau. 17pp.

Proulx, G. 1983. Characteristics of moose (*Alces alces*) winter yards on different exposures and slopes in southern Quebec. Can. J. Zool. 61:112-118.

Rausch, R. A. 1958. The problem of railroad-moose conflicts in the Susitna Valley. AK. Dept. Fish and Game. Fed. Aid Wildl. Rest. Proj. Final Rept. Juneau. 12(1):1-116.

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

Spencer, D. L. and E. F. Chatelain. 1953. Progress in the management of the moose of southcentral Alaska. Trans. N. Am. Wildl. Conf. 8:539-552.

Stringham, S. F. 1974. Mother-infant relations in moose. Naturaliste can. 101:559-593.

Thompson, I. D. and M. F. Vukelich. 1981. Use of logged habitats in winter by moose cows with calves in northeastern Ontario. Can. J. Zool. 59:2103-2114.

Van Ballenberghe, V. 1977. Migratory behavior of moose in southcentral Alaska. Proc. Inter. Congr. Game Biol. 13:103-109.

PERSONAL COMMUNICATION

Collins, William. Agric. Exper. State., Univ. of AK, Biologist, April 1984.

Miller, Sterling, AK Dept. Fish and Game, Game Biologist, May 1984.