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SUSITNA HYDROELECTRIC PROJECT

PHASE I FINAL REPORT

BIG GAME STUDIES

Volume II MOOSE - DOWNSTREAM

Ronald D. Modafferi

ALASKA DEPARTMENT OF FISH AND GAME
Submitted to the Alaska Power Authority
March 1982

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PREFACE

In early 1980, the Alaska Department of Fish and Game contracted with the Alaska Power Authority to collect information useful in assessing the impacts of the proposed Susitna Hydroelectric Project on moose, caribou, wolf, wolverine, black bear, brown bear and Dall sheep. This information, along with information on furbearers, small mammals, birds, and plant ecology collected by the University of Alaska, is to be used by Terrestrial Environmental Specialists, Inc. of Phoenix, New York, in preparation of exhibits for the Alaska Power Authority's application for a Federal Energy Regulatory Commission license to construct the project.

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. If the decision is made to submit the application, studies will continue into Phase II to provide additional information during the anticipated 2 to 3 year period between application and final FERC approval of the license.

Wildlife studies did not fit well into this schedule. Data collection could not start until early spring 1980, and had to be terminated during fall 1981 to allow for analysis and report writing. (Data continued to be collected during winter 1981-82, but could not be included in the Phase I report.) The design of the hydroelectric project had not been determined. Little data was available on wildlife use of the immediate project area, although some species had been intensively studied nearby. Consequently, it was necessary to start with fairly general studies of wildlife populations to determine how each species used the area and identify potential impact mechanisms. This was the thrust of the Phase I Big Game Studies. During Phase II, we expect to narrow the focus of our studies to evaluate specific impact mechanisms, quantify impacts and evaluate mitigation measures.

Therefore, the Final Phase I Report is not intended as a complete assessment of the impacts of the Susitna Hydroelectric Project on big game.

The reports are organized into the following eight 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

SUMMARY

The recent demand for nonfossil 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 primary involve immediate loss of habitats through inundation. Post-impoundment impacts will probably involve gradual and less dramatic changes in environments through altered and controlled hydraulic flow regimes. Such environmental effects may affect wildlife directly through hydrologic conditions and/or be mediated indirectly through several intermediate environmental components. Irrespective of the nature of the cause, the ultimate impacts of indirect effects or direct effects on migratory species of wildlife may be realized at distances quite removed from their proximate cause.

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

Objectives of this study were to determine the probable nature

and approximate magnitude of impacts of the proposed Susitna River hydroelectric project on moose (*Alces alces gigas* Miller) in areas along the Susitna River downstream from the prospective Devil Canyon dam site.

To ascertain productivity, habitat use, patterns of movement and to identify populations of moose that are ecologically affiliated with riparian habitats along the Susitna River, 2 samples of moose, 4 males and 6 females and 5 males and 24 females, respectively, were captured and radio collared in riparian habitats along the Susitna River between Devil Canyon and the Delta Islands on 17 April 1980 and 10-12 March 1981, respectively and were radio-relocated through 15 October 1981.

Information on productivity and condition was obtained from most individual moose captured. The bulk of data on habitat use, patterns of movement and identity of populations was synthesized from information collected at sites of relocation for three males and three females and four males and 23 females radio-collared in the 1980 and 1981 samples, respectively.

These data were complimented with information collected on three aerial censuses for moose, conducted during the early parts of December, January and February 1981-82, in riparian habitats along the Susitna River between Devil Canyon and Cook Inlet, to assess the relative magnitude and regional use of riparian habitats. These census data also provided additional information on productivity/survival of moose which winter in riparian habitats.

To relocate radio-collared moose, surveys were conducted at about biweekly intervals through 16 March 1981 and at about weekly intervals from that time through 15 October 1981. This schedule provided two, five, seven and five relocation sites for most individual moose during the winter (1 January thru 28 February), calving (14 May thru 17 June), summer (1 July thru 31 August) and breeding (14 September thru 15 October) periods, respectively.

Relocations with dates not included within those periods were categorized into spring, summer, autumn and post-breeding transitory interval periods.

Types of vegetation observed within a 2-4 ha area surrounding each relocation site were recorded and a rating for percent canopy dominance was given to each type which covered 10 percent or more of the field area. Vegetation types included spruce, birch, alder, cottonwood, willow, aspen, sedge, grass, sedge x grass, muskeg, devilsclub, fern and horsetail.

Preliminary findings exhibited grossly different patterns of behavior and geographically discrete breeding areas for three groups of moose within the radio-collared samples and resulted in a subpopulation classification for individuals with breeding ranges centered in 3 areas: 1) to the north of Talkeetna (northern), 2) to the south of Talkeetna and on the eastside of the Susitna River (eastside) and 3) to the south of Talkeetna and not in eastside areas (westside).

In most interpretive analyses, sex, seasonal period and subpopulation categories were considered.

Since magnitude of use of winter ranges by moose is partly related to severity of climatic conditions, information contained in this report must be interpreted tentatively because of the relatively mild winters of 1979-80 and 1980-81.

All moose radio-collared south of Talkeetna were captured within the outmost banks of the Susitna River. Because of the relative scarcity of moose available in riparian habitats to the north of Talkeetna, some individuals were captured up to 400 m from the river.

None of the 5 moose captured in riparian habitats in April of

1980 were relocated in those habitats in the winter of 1980-81, though numerous other moose were present.

Most moose radio-collared south of Talkeetna in 1981 had departed from Susitna River riparian habitats by mid-April; males appeared to precede females. Directions of departure were not random; most moose retreated to the west and several remained in or near an extensive large island complex throughout the study period.

Differences in general patterns of movements observed between the 1980 and 1981 samples of moose captured south of Talkeetna were in part attributed to differences in the response of local populations to snow cover and plant phenology.

Moose radio-collared to the north of Talkeetna were mostly relocated on south-southeast-facing slopes on the north-northwest side of the Susitna River basin. This behavior was attributed to local population phenomena and/or habitat selection.

Most females radio-collared north of Talkeetna were commonly relocated in riparian habitats during the calving period, apparently in response to the availability of highly nutritious and easily digestible forage plants. After the calving period these females returned to the south southeast facing slopes above the river basin where they remained throughout the period of study.

Females radio-collared south of Talkeetna, which departed Susitna River riparian habitat by mid-April, did not return to those riparian areas during the calving period, as did radio-collared females in areas to the north. Instead they were commonly relocated in relatively open, medium-height spruce/ muskeg habitats to the west of the Susitna River. A noteworthy concentration of radio-collared females occurred near Trapper Lake during the calving season. As for females in more northern areas, use of these moist habitats during the calving period was attributed to the availability of high quality herbaceous forage.

Moose radio-collared north of Talkeetna were seldom relocated more than 3 mi from the Susitna River. Moose in westside areas were nearly as frequently relocated at distances greater than 3 mi from the Susitna River as they were at distances nearer to the River. One eastside male was seldom relocated nearer than 10 mi from the Susitna River; females in that area were more commonly relocated farther than 5 mi from the Susitna River than at closer distances.

In comparison to females in other areas, each of the three seasonal ranges for those radio-collared north of Talkeetna averaged smallest in size and were located nearest to the Susitna River.

Data indicated that the average moose radio-collared in areas north of Talkeetna did not have to travel as far from its winter range to locate habitats required during other seasonal periods. Though this appears to imply that areas north of Talkeetna are a more heterogeneous and complete assemblage of habitats, it may also be interpreted to indicate that adjacent habitats are of such poor quality that moose cannot physiologically afford to venture far from nor to travel far to winter on the Susitna River, or that in this area the Susitna River is not very attractive as winter range for moose.

Alder was the dominant vegetative type observed at relocation sites for females north of Talkeetna. Spruce, a species valuable to moose for cover, occurred at most sites but was not very dense. Relocation sites south of Talkeetna were dominated by birch and spruce in occurrence and density; although spruce occurred more commonly than birch and rated higher in canopy coverage than at relocation sites to the north, it still ranked considerably lower than birch in canopy coverage.

Perhaps it was the prevalence of alder and the relatively poor representation of birch and spruce that may make areas north of Talkeetna less desirable for female moose than those areas south of Talkeetna.

Three aerial censuses conducted between early December and early February revealed 322, 324 and 239 moose, respectively in riparian habitats along the Susitna River from Devil Canyon to Cook Inlet in the relatively mild winter of 1981-82. These data indicated the number of moose that may occur in these areas on a given day, but they did not give any indication of whether the same individuals were observed on each day.

Moose observed on each census were not evenly distributed between Devil Canyon and Cook Inlet. On each census about 90 percent of the moose were observed between Montana Creek and Cook Inlet. Even within the latter area some locales exhibited extremely dense concentrations of moose.

About 50 percent of the moose observed in riparian habitats were calves and their dams. Twenty nine, 26 and 22 percent of the moose observed on the three respective censuses were calves. If moose seek Susitna River riparian habitats to avoid deep and persistent snow cover in non-riparian habitats, it would seem that this behavior would be particularly important for calves whose legs are considerably shorter than those of adults and would have more difficulty negotiating deep snow.

Profiles of condition related blood parameters from the samples of moose captured and radio-collared were rated in below average condition and resembled those from a low productivity population. However, this implication is questionable because of the relatively high rate of productivity observed for radio-collared individuals and moose observed on aerial censuses. Eighty-one percent of the 26 females for which data were available in 1981 were observed with young. Considering the occurrence of twins at least 93 calves may have been produced by every one hundred of the cow moose that wintered on the Susitna River.

Although predators occurred in the study area, and no instances of predation were observed. Circumstantial evidence indicated that most predation which does occur is probably attributable to black (*Ursus americanus*) and brown bears (*Ursus arctos*). Brown and black bears occur throughout the Susitna River Valley. Brown bears are probably most dense in mountainous areas with black bears found more commonly in lowland and riparian habitats. The apparent similarity in habitat requirements between moose and black bears may place them both in like habitats during the calving and summer periods.

Wolves are rare in the study area and have never been observed.

Data indicated that radio-collared moose captured between Devil Canyon and the Delta Islands, a linear river distance of about 155 km, ultimately ranged over an area encompassing about 5000 km^2.

Based on general patterns of movement documented for radio-collared moose, large geographical units where radio-collared moose were never relocated and areas along the Susitna River where data have yet to be collected, nine hypothetical local populations of moose are delineated.

Potential impacts of the proposed Susitna River hydroelectric project on populations of moose downstream from the impoundments can be grouped under two general headings: 1) those impacts associated with construction and maintenance of the facilities and 2) those impacts associated with characteristics of the water and regulation of its flow. Impacts may directly affect moose or operate indirectly through the influence of other intermediary environmental components as, vegetation, other wildlife, man and etc. Due to the wide ranging behavior of moose effects of impacts incurred by individuals in close proximity to the Susitna River may be ultimately realized in populations more than 35 km away.

Predications of impacts on moose are in part dependent on predications of affects of water levels on vegetative communities, which in part are dependant on regulation of flow regimes and depths and contours of the river bed. Though a precise assessment of particular impacts is not possible at this time, general areas for special concern are noteworthy.

The value of the Susitna River to moose is keyed to the instability it imposes on adjacent riparian habitats which in turn results in continuous creation and maintenance of seral type vegetative communities. Regulation and/or control of flow regimes at the impoundments would tend to stabilize the downstream river system, promote a more classical process of plant succession and probably will result in loss of some of the habitats required by moose.

Decreased variability in water levels will cause some communities to become more xeric and less desirable for moose, and other more hydric communities to become mesic and more desirable for moose. Though some habitats desirable to moose may be created, their location and spatial distribution must be considered in assessing their value to moose. Moose are very traditional in their use of particular habitats and may be slow to locate and utilize those newly created at other locations.

If one assumes habitats are presently being fully utilized by moose, any loss in moose habitat might create over utilization in areas where displaced individuals attempt to subsist.

It seems probable that controlled and reduced flow regimes will result in a net loss in a portion of those habitats desired by moose, that a definite centralization, channelization or confinement of riparian habitats more to the center of the river will occur and that ultimately riparian habitats will be distributed over less surface area.

Altered flow regimes will affect considerably more land surface area in the broad, flat extensively braided portions of the Susitna River to the south of Talkeetna than in the narrower deep channeled portion of the Susitna River to the north of Talkeetna.

Impacts north of Talkeetna will include some related to the projected lack of ice during the winter and warm water temperatures in early spring.

During cold parts of the winter the relatively warm open water may lead to extensive frosting of vegetation in the river basin. Consumption of highly iced or frosted browse may create metabolic imbalances in moose. Open water may be energetically inhospitable for moose and may preclude their crossing the river, access to island habitats and use of the frozen river as a travel route; all would tend to restrict movements of moose during cold parts of the winter.

If timing of use of riparian habitats by moose north of Talkeetna during the calving period is based on availability of high quality food plants, female moose may have to alter their behavior if the occurrence of relatively warmer water in late winter-early spring accelerates resurgence of growth in aquatic and riparian vegetation, as diet quality is very important to post-parturient, lactating females and newly born calves.

The lack of thin ice, ice flows and ice jams on the Susitna River north of Talkeetna would probably decrease mortality of female moose which frequent those habitats in early spring.

Though impacts occurring north of Talkeetna will generally affect considerably fewer moose, the relative survival value of riparian habitats to that population of moose is probably greater than for moose in areas south of Talkeetna, due to the severity of winter which can occur in the former area.

Alterations in flow regimes which affect populations of beavers along the riparian habitats will have secondary affects on moose, since several activities of beavers are of a positive benefit to moose. These effects may be very significant in riparian habitats along the Susitna River south of Talkeetna where substantial populations of beavers occur.

Activities associated with construction and maintenance of hydroelectric facilities and transmission lines will have significant impacts on local populations of moose. Probably the greatest impacts will result from the development and maintenance of access routes for construction and maintenance of the impoundments and transmission lines.

Construction activities will probably temporarily displace moose, but once construction is completed moose will return to use those unaltered habitats and may even show preference for disturbed sites. Past experiences in Southcentral Alaska indicate that disturbances associated with construction and maintenance vehicular and transmission line rights of way will favor the regrowth of browse preferred by moose. Since these areas will probably attract moose during the winter, they should not be located near highways or railroad systems or where they would cause moose to cross such areas. Numerous moose are killed by highway vehicles and trains during the winter because of the proximity of winter ranges to highways and railroad tracks. Though attractive to moose, the spatial distribution and location of these disturbed sites may detract from their utility in acting as a substitute for naturally occurring riparian habitats along the Susitna River.

The ultimate public status of access rights of way will affect their impacts on populations of moose. If rights of way are open to public use the resulting increase in access afforded to hunters will dictate more refined management regulations than presently exist, particularly in the more remote areas north of Talkeetna but also south of Talkeetna if transmission lines are removed from areas where substantial development already exists.

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INTRODUCTION

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

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

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

Though impoundments will be located in the upper reaches of the

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

The Susitna River flows about 215 km downstream from Devil Canyon before entering Cook Inlet. In a narrow sense, the surrounding Susitna River Valley watershed encompasses approximately 800,000 km^2 of extremely productive habitat for many species of wildlife. Perhaps, its innate value as wintering habitat for moose (*Alces alces gigas* Miller) is unsurpassed elsewhere in the State.

Prior to statehood, the Susitna Valley was ranked as the most productive moose habitat in the territory (Chatelain 1951). During this same time period, some wintering areas were said to sustain moose at concentrations greater than $22/km^2$ (Spencer and Chatelain 1953). More recent evidence indicates that concentrations and densities of moose in the Susitna Valley are greatest when deep snows in surrounding areas and at higher elevations persist into late winter and obscure browse species (Van Ballenberghe 1977). 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 (Rausch 1971), 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, abandonment of land cleared for homesteads, land cleared for highway and railroad construction and rights of way and mild winters.

By the 1970's, browse on previously cleared land had been lost through succession, strict fire suppression policies and 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 smaller and less dramatic scales and were primarily restricted to riparian habitats along the Susitna River; 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 of the Susitna River is altered to accommodate hydroelectric development. Though alterations in the flow regime of the Susitna River 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 availabile to various subpopulations of moose.

The present research study was designed to determine the probable nature and approximate magnitude of impacts of a hydroelectric project on subpopulations of moose which are ecologically affiliated with that portion of the Susitna River downstream from Devil Canyon. 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 of each subpopulation; and 3) to determine timing, location and relative magnitude of moose use of various riparian habitats along the lower Susitna River.

The following report contains a summary of findings through Phase I (October 15,1981), and includes some of the results previously presented in the March 1, 1981 annual progress report.

STUDY AREA

The Devil Canyon dam site lies about 215 km upstream from where the Susitna River empties into Cook Inlet. While traversing that distance the river descends from about 300 m in elevation to sea level. In its course to the sea, characteristics of the river and adjacent riparian habitats undergo a pattern of change. These changes can be roughly separated into the following four physiographic zones (see Fig. 1, and Table 1):

I) An 80 km section of river from Devil Canyon to Talkeetna. Through this stretch, the river changes elevation from 300 to 105 m and maintains a narrow (less then 150 m wide) character, interrupted by relatively few widely separated, seldom abreast, islands. Along the northern three-forths of this route, the river is flanked on each side by mountains commonly ranging over 700 m. To the south, as the river approaches Talkeetna, these mountains grade down into a plateau. Cottonwood and alder dominate the river margin. A spruce/birch complex occurs in the river basin and extensive stands of alder dominate the steep valley slopes which at higher elevations grade into a moist tundra of sedge, alder and dwarf birch and willow.

II) A 30 km section of river from Talkeetna to Montana Creek. At Talkeetna, the Susitna River broadens to about 2 km in width as a result of the increase in water volume contributed by its confluence with the Chulitna and Talkeetna Rivers, a decrease in grade and a general flattening in relief of adjacent terrain. It is here, that the Susitna becomes braided as many small islands break up the mainstem flow. Apparently, these islands form from combined silt loads of the 3 rivers and a reduced general flow rate; but seasonal purges of water keep the islands relatively small and temporary. The Susitna maintains this braided character as it drops only 30 m in elevation before its confluence

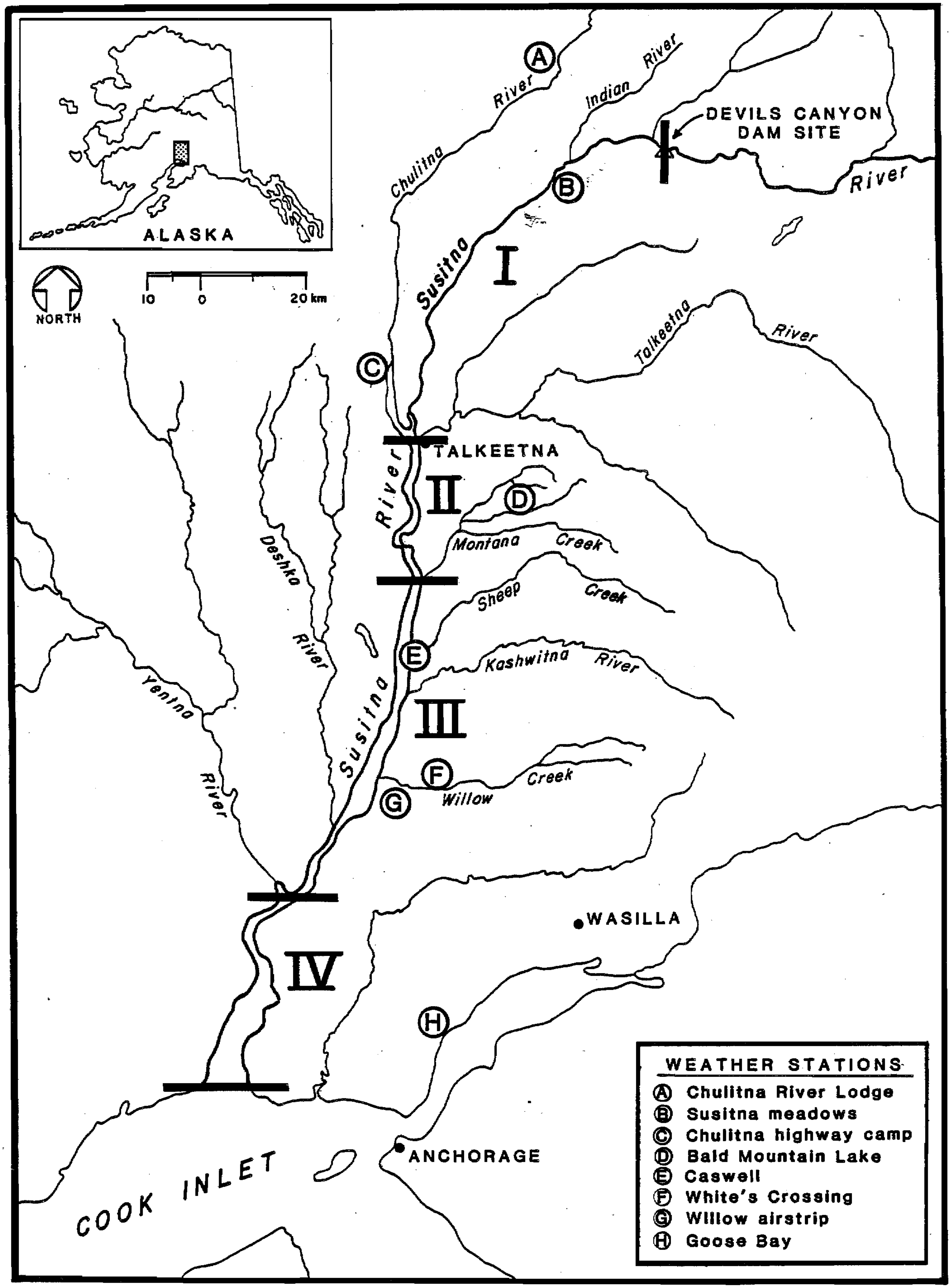

Figure 1. The study area in Southcentral Alaska showing locations of weather stations (circled letters), four physiographic zones of the Susitna River (Roman numerals) and prominent tributary streams between Devils Canyon and Cook Inlet, Alaska.

Table 1. Physical and geographical characteristics for selected zones along the Susitna River from Devil Canyon dam site to Cook Inlet, Alaska.

Zone	Geographical boundaries	Approximate distance (km)	Elevational change	Grade m/km	Prominent tributaries	Contribution to total flow (%)
I	Devil Canyon to Talkeetna	80	300 to 105	2.5	Susitna River Indian River	20[1]
II	Talkeetna to Montana Creek	30	105 to 76	1.0	Chulitna River Talkeetna River	20 10
III	Montana Creek to Yentna River	65	76 to 15	0.9	Montana Creek, Sheep Creek, Kashwitna River, Little Willow Creek, Willow Creek, Deshka River	10
IV	Yentna River to Cook Inlet	40	15 to sea level	0.4	Yentna River	40

[1] Data obtained from Alaska Power Authority Public Participation Office Newsletter. November, 1980. "The Susitna Hydro Studies", 8pp.

with Montana Creek. Wet treeless, sedge and grass bogs and open low growing black spruce/paper birch forests combine to dominate the vegetative complex on the flat plateau which extends 25 km to the west of the Susitna River. Beyond this distance slight increases in elevation are accompanied by a disappearance of open bogs and an increase in the density, expanse and tree size of the spruce/ birch forests. To the east of the river open bogs are less common and spruce/birch forests are more dense and size of individual trees appears to increase before giving way to the dwarf birch, willow and ericaceous shrub dominated alpine tundra about 25 km away in the foothills of the Talkeetna Mountains.

III) A 65 km section of river between Montana Creek and the Yentna River. Through this stretch of river, extensive tributary systems enter from the East and West. Several of the east side tributaries originate 40 or more km away at elevations near 1,000 m in the Talkeetna Mountains. Apparently, a decrease in gradient and flow rate and cumulative silting from upstream and local tributaries have acted in concert to form a very extensive island system in this zone; where islands greater than 2 km^2 are common, where the river may braid into 15 or more channels and where the river frequently exceeds 5 km in breadth. Vegetative types adjacent to the west side of the river in this zone are similar to those of Zone II but the extensive wet treeless bog areas become much less common and are replaced by spruce/birch forests in both the lower half and the more remote parts of the Zone. Wet treeless bogs are common along the east bank of this section of the river and in the north give way to spruce/birch forests as elevations increase about 10 km from the river. Superimposed on the former habitat, within a 5 km band along the east side of the river south to Willow Creek are an abundance of disturbed, second growth, subclimax vegetative communities created incidental to the

Alaska Railroad, the Parks Highway, farms, homesteads and other construction activities. Alpine tundra becomes a prominent vegetative type at 650 m elevation and 20 km to the east of the river in the Talkeetna Mountains. Tributary streams that reach into the Talkeetna Mountains are lined with a cottonwood, alder, willow, spruce, and birch vegetative complex.

Vegetation in the Southeastern part of this Zone is characterized by a combination of open treeless bogs, numerous small lakes and open low growing spruce/birch forests. Here, these habitats prevail up to 30 km from the river, as the latter tails off to the west at the southern extent of the Talkeetna Mountains; and

IV) A 40 km section of river ending at Cook Inlet. Island characteristics of the Susitna River are temporarily obliterated after its confluence with the Yentna River, and for about 15 km it becomes a single channeled river less than 1 km wide. However, in its last 20 km, the Susitna River reaches up to 18 km from bank to bank and again becomes braided with a series of very large islands whose surface areas exceed 65 km^2. Vegetation in the northeastern part of this Zone is a continuation of the open treeless bogs and open low growing spruce/birch forests from the north. The northwestern quarter of Zone IV is dominated by fairly dense mature spruce/birch forests interspersed with riparian wetlands. Alpine tundra is found within 8 km to the west of the river on Mount Susitna, which rises abruptly to over 1300 m. Habitats adjacent to the Susitna River, in the lower half of Zone IV, are characteristically wet grass/sedge tundra marshes associated with shallow bog lakes.

Fig. 2 schematically illustrates the occurrence of these habitats in the study area and a more complete characterization of vegetative types that occur in those habitats appears in Table 2. A

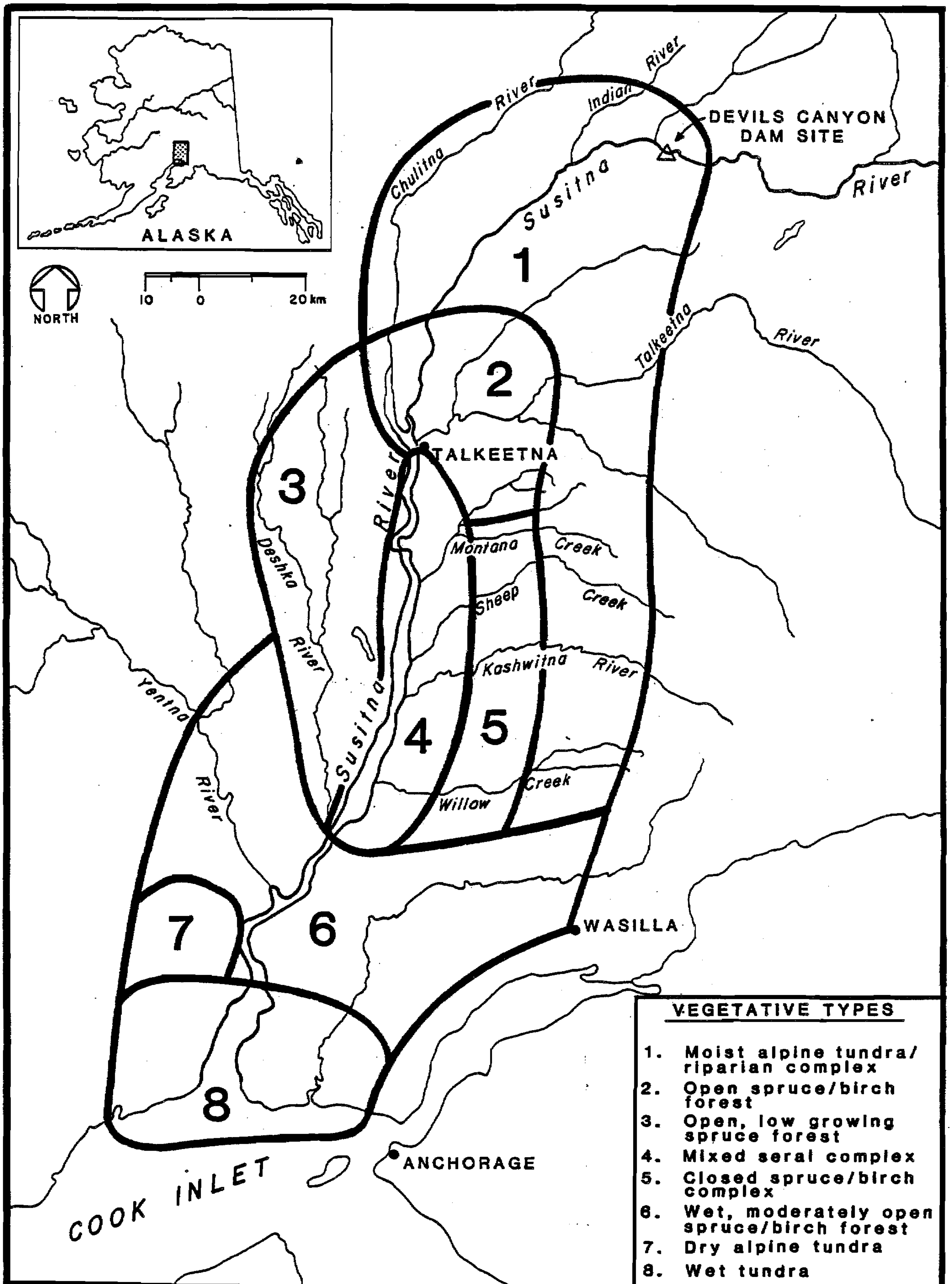

Figure 2. Idealized habitat map showing the distribution of vegetative types which occur in the Susitna River watershed between Devils Canyon and Cook Inlet, Alaska.

Table 2. Vegetative characteristics for general habitat types which occur in the Susitna River watershed from Devil Canyon to Cook Inlet, Alaska.

Map ID No.	Habitat type[1] (elevation, m)	Vegetative characteristics
1	Moist alpine tundra/riparian complex (600-1500)	- Low growing heath species, dwarf birches and willows on ridge tops; slopes densely covered with alder; spruce/birch forests at lower elevations, with cottonwood, alder and willow occurring along stream margins.
2	Open spruce/birch forest (150-600)	- Predominantly dense spruce/birch forests, occasional shallow bog pond, wet tundra vegetation occurring around pond margins and in openings.
3	Open, low growing spruce forest (30-300)	- Poorly drained wet sites, dominated by black spruce, heath shrubs, sedges, grasses and sphagnum mosses; numerous slightly higher, dry "islands" of spruce/birch forest distributed between wet sites.
4	Mixed seral complex (30-180)	- Mixture of variously disturbed sites with seral species; open low growing spruce forests; and open spruce/birch forests.
5	Closed spruce birch forest (180-600)	- Dense to moderately dense spruce/birch forests, intermixed with occasional open low growing spruce forests.
6	Wet, moderately open spruce/birch forest (6-300)	- Wet moderately open spruce/birch forests, interspersed with numerous shallow bog ponds and open low growing spruce forests.
7	Dry alpine tundra (60-130)	- Dense spruce/birch forests at elevations below 1000 m, low growing eracaceous shrubs, grasses, sedges, crowberry and mountain avens at higher elevations.
8	Wet tundra (0-130)	- Numerous shallow bog lakes, vegetation predominantly sedges, cottongrass, shrub willows and birches, cranberry, blueberry, sweetgale and Labrador tea.

[1] For more detailed descriptions see Viereck and Little (1972).

more specific characterization of the described habitats can be obtained in Viereck and Little (1972).

Historical climatic records for the Susitna River Valley vary from extensive and complete to spotty and scanty, depending on the specific locality. Records for Anchorage, which are probably representative of the lower Susitna River region, and Talkeetna are complete for more than 20 years; data from other locations are considerably less complete.

In general, climatic conditions throughout the study area grade from those strongly under oceanic influence, at Cook Inlet, to those in the Devil Canyon area where continental weather patterns become more dominant.

Summaries of precipitation and temperature records presented in Tables 3 and 4 respectively, document general characteristics and demonstrate the gradient from a moderated, maritime climate to a more harsh and extreme continentally influenced climate as one moves from Cook Inlet, inland, up the Susitna River toward Talkeetna where mean monthly temperatures are generally lower and more characteristically the daily and seasonal extremes are much cooler and warmer.

Likewise, variation in snowfall at locations along the Susitna River, is also attributable to broad climatic patterns. Generally, snowfall is greater and persists longer as one moves from Cook Inlet coastal areas up the Susitna River to the more interiorly located Devil Canyon area.

Climatic regimes are known to have direct and indirect affects on moose (Bishop and Rausch 1974); and, it can be expected that differences in climatic patterns for various geographical locations, as one moves up the Susitna River and farther from the influence of Cook Inlet, will have more profound effects on moose.

Table 3. Total precipitation and snowfall for various locations in geographic zones along the Susitna River downstream from the prospective Devil Canyon dam site.

Geographic Zone	Station location	Elevation (m)	Inclusive dates	Total precipitation Annual mean (cm, years)	Snowfall Annual mean (cm)	Snowfall Greatest depth on ground for any month (years)
I	Chulitna River Lodge	381	1971-78	81[2]	434	191
	Chulitna Highway Camp	152	1973-79	86	513	163
	Susitna Meadows	274	1970-75	109	NA	203[3]
II	Talkeetna Airport	105	1941-80	71	272	132 (1967-80)
	Bald Mountain Lake	654	NA[1]		NA	142[3]
III	Caswell	88	1949-57	64	351	183
	White's Crossing, Willow	82	---	61 (1963-75)	NA	155 (1970-76)
	Willow Airstrip	61	1964-81	NA	NA	130[3]
IV	Anchorage Airport	35	1943-81	38	178	79 (1963-81)
	Goose Bay	30	1969-76	36	NA	NA

[1] Data not available.

[2] Data obtained from U.S. weather service, meteorological summary reports.

[3] U.S. Department of Agriculture, Soil Conservation Service snow surveys.

Table 4. Mean daily maximum, monthly mean and mean daily minimum temperatures (°C) for Anchorage (1953-80) and Talkeetna (1940-80), Alaska.

Location / Value	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Anchorage												
Daily maximum	-7	-3	-1	7	13	17	19	18	13	6	-2	-6
Monthly mean	-11	-8	-4	2	8	13	14	13	9	2	-6	-11
Daily minimum	-16	-13	-9	-3	3	8	10	9	4	-2	-10	-15
Talkeetna												
Daily maximum	-7	-3	1	7	13	19	20	18	13	5	-3	-8
Monthly mean	-13	-9	-7	1	7	13	16	13	8	0	-8	-13
Daily minimum	-18	-15	-14	-6	1	7	9	7	3	-4	-13	-18

Due to variation in temperatures, one would expect that the more remote a moose is from Cook Inlet, the more severe are its thermoregulatory problems.

Similarly, due to the variation in amount and persistence of snowfall, one would hypothesize that its direct and indirect effects on moose would increase substantially as one moved away from Cook Inlet to regions of greater and more persistant snowfall.

METHODS

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

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

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

While immobilized moose were collared, measured, palpated for feti, tagged with monel metal ear tags, a sample of whole blood was taken, an incisor tooth was extracted, physical conformation was assessed and for females, association with calves was noted.

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

Relocation flights with Cessna 172 or 180 aircraft equipped with a yagi antenna on each wing were conducted at intervals of two weeks in 1980 and one week in 1981. Inclement weather occasionally altered this schedule. Dates for relocation flights on which this report is based appear in Appendix A.

Locations (audio-visual or audio) were noted on 1/63360 scale USGS topographic maps and later transferred to mylar overlays for computer digitization. For more complete details of data management, see Miller and Anctil (1981). Two subsamples of moose provided information on movements, population identity, habitat use, physical condition and productivity. One subsample of 10 moose was captured between Sheep Creek and Sherman on 17 April 1980 and another subsample of 29 moose was captured between the Delta Islands and Portage Creek on 10-12 March 1981. This report contains data on moose monitored through 15 October 1981, at which time up to 51 and 29 relocations were available for some individuals captured in 1980 and 1981, respectively.

In order to relate habitat type and use to requirements of moose and to establish a relationship between either and the Susitna River, a descriptive technique based on 4 ranges and respective life history phenomena that occurred on them, was employed. Size and centers of these ranges were determined and then related spatially to each other and to the Susitna River. A description of the 4 ranges, their life history base and inclusive calendar dates are presented in Table 5.

Calendar dates for the ranges did not encompass the entire year; between dates for ranges, intervals were delineated to accommodate movement or transition from one range to another. To prevent transitory movements from affecting calculation of location or size of ranges, a very narrow spread of inclusive dates was selected to describe each range. Perhaps determination of size of a range suffered at the expense of its 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.

To assess types of habitats used, characteristics of vegetation,

Table 5. 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.	14 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.	15 September thru 31 October
Post breeding transitory interval	------	---

topography, and ground cover within a 2 - 4 ha area surrounding each relocation site were noted on paper. This description of the site included information on snow cover and depth, slope, aspect of the slope, whether the site was within mean high water line of the Susitna River (or an adjacent and interconnected slough), and information on relative abundance of vegetative species represented in the area.

In 1980, vegetation observed at the relocation sites was categorized into the very broad and general classification scheme of Viereck and Dyrness (1980).

In 1981, vegetative characteristics of each relocation site were subjectively ranked into a quantitative system based on percent of ground/canopy coverage as viewed from aboard the circling aircraft. Species represented within the vicinity of the relocation site were ranked from trace to 100 percent coverage. Species occupying less than 10 percent of the field site were ranked as trace. Categories included in this classification were the following: willow, alder, spruce, aspen, birch, grass, sedge, grass/sedge complex, wet muskeg (sedge, grass, Labrador tea, blueberries, cranberry and etc.), devilsclub, fern, cottonwood, and water. Relocation sites characterized in this manner were secondarily classified to the Viereck and Dyrness (1980) scheme as used in 1980. Each relocation site was photographed. In total, these data were used to generally characterize habitat used by moose on each of the 4 ranges as well as to specifically describe typical habitat used by moose when within the confines of the Susitna River.

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

By the time I became familiar with this project in early 1981, radio collared moose had already begun to leave the Susitna River area; censuses would have been futile. No periodic river censuses were conducted in the winter of 1980-81. Thus far in the winter of 1981-82, 3 river censuses have been conducted, the first on 9 and 10 December 1981, the second on 28 December 1981 and 4 January 1982 and the third on 2 and 6 February 1982. Though the timing of these censuses did not overlap with this reporting period, I analyzed salient aspects of those results due to their relative importance in this study. A more detailed account of these and additional censuses will appear in a subsequent report.

Aerial river censuses are conducted with a PA-18 aircraft flown at low elevation in a parallel transect pattern. Though limitations of aerial surveys of moose were known (LeResche and Rausch 1974), the object of aerial river censuses was to count all moose within the confines of the Susitna River and any of its interconnecting sloughs. During aerial river censuses the following categories of moose were distinguished: Large antlered males, small antlered males, lone non-antlered animals, females with one calf, females with two calves, and lone calves. Location of each observation was noted on USGS 1/63360 scale topographic maps. Five or 6 aerial river censuses will be conducted between mid-December and mid-March of 1981-82. This time period should encompass the build up, peak and decline in use of Susitna river riparian habitats.

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

Information on productivity of moose that are affiliated with habitats along the Susitna River, was gathered from 3 sources: 1) Palpation for feti in captured moose; 2) Observation of radio-collared female moose during routine aerial relocation flights and 3) Aerial river censuses.

Condition of the population was assessed through standard physical measurement and blood chemistry indices obtained from individuals in the 2 samples of live captured animals. Physical measurements recorded were the following: total length, hind foot length, girth, neck circumference and head length. Some measurements were disregarded for incompletely immobilized individuals. Blood chemistry indices were provided by results of standard SMAC 24 and protein electrophoresis automated analyses conducted by a commercial medical laboratory. Hemotacrit and PVC valves were determined by standard procedures. Indices of condition were compared against those from other populations of Alaskan moose (Franzmann and LeResche 1978).

Age for individuals in the live captured sample of moose was determined by counting cemental annuli in ground sections from incisor teeth (Sergeant and Pimlott 1959).

Techniques for determination of browse availability and utilization were presented in a previous report (Arneson 1981) and will not be repeated here. In 1981, no further work was conducted on determination of browse availability and utilization. Similar work may be pursued in the future following critical review of data gathered on timing of habitat use and selection of habitats used.

RESULTS

LIMITATIONS OF SAMPLES AND SAMPLING EFFORT

In response to inadequate logistical continuity at the outset of this study in 1979, prescribed sampling procedures were modified (Arneson 1981). Due to the anticipated affect of a delay in seasonal timing on the representativeness of a sample; the sampling effort in 1980 was greatly reduced.

On 17 April 1980, a sample of only 4 male and 6 female moose was captured and radio-collared along the Susitna River between Sherman and Sheep Creek.

From 10-12 March 1981, a second sample of 5 male and 24 female moose was captured and radio-collared along the Susitna River between Portage Creek and the Delta Islands.

In obtaining the sample in 1981, an attempt was made to spatially distribute captures throughout the Susitna River study area between Devil Canyon and the Delta Islands. In achieving that goal, the general location of captures was probably distributed in relation to the density of moose encountered along the river route (Fig. 3).

Three of the 10 moose captured and radio-collared 17 April, No. 20, 24, and 28, shed their collars by 10, 6 and 27 June 1980 after yielding only 3, 1, and 4 aerial relocations, respectively. Another individual (male No. 93) was killed by a hunter on 25 September 1980 after providing 13 radio relocations. The remaining 3 males and 3 females furnished radio relocations throughout the study period.

Of the 29 moose captured and radio-collared 10-12 March 1981, 26 provided radio relocations during the entire study period. Radio relocations for one particular male (No. 58) failed to indicate

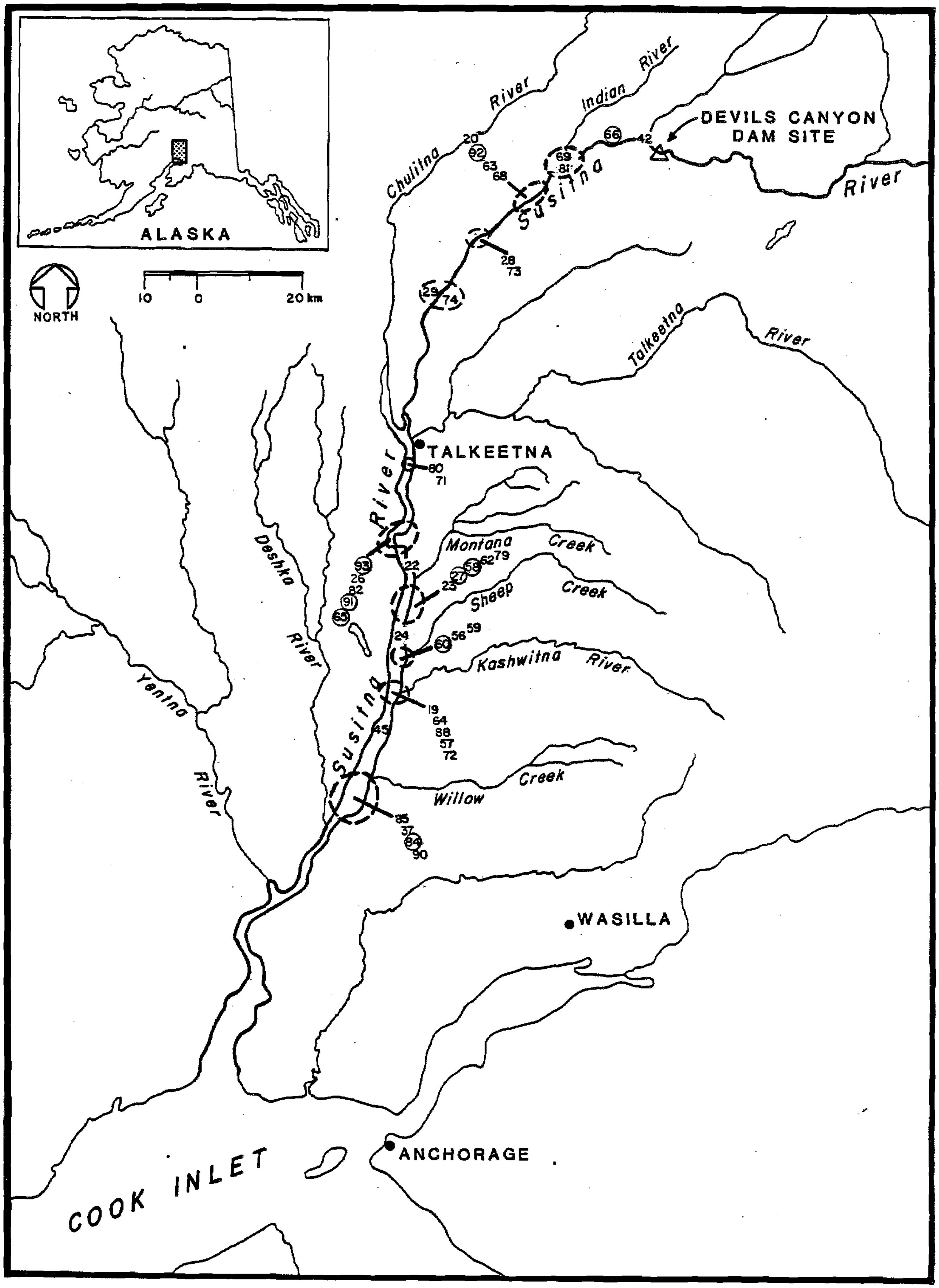

Figure 3. Locations of capture for 10 moose radio-collared 17 April, 1980 (#20, 22, 23, 24, 26, 27, 28, 91, 92, 93) and 29 moose radio-collared 10-12 March, 1981 (remaining numbers) on the Susitna River between Devils Canyon and Cook Inlet, Alaska. (circled numbers=males)

any change in location after the 16th observation. The transmitter has continued to emit signals but the site has not yet been visited to determine whether the collar was shed or the animal is still collared and dead.

Movements by another individual (female, No. 80) ceased in late May-early June after about 10 relocations. This animal was later found to be dead on a sandbar along the Susitna River near Chase. A superficial physical examination of the animal failed to reveal any sign of external injury. The timing of her death appeared to coincide with ice breakup on the upper Susitna River; a time when the river was cluttered with large pieces of drifting ice. It is possible that the animal fell through and/or got caught in an ice jam and died from hypothermia. Being around calving time, it is also possible that her death was the result of an abnormal pregnancy; the animal was not examined internally.

Individual No. 72 (a female with a calf) provided 23 radio relocations before being shot and killed 6 September 1980 by a hunter.

In summary, results presented in this report are based primarily on data gathered from the relatively infrequent observations of a sample of 3 male and 3 female radio-collared moose studied between mid-April 1980 and mid-March 1981 and from the relatively frequent observations of those same individuals and an additional sample of 4 male and 22 female moose studied from mid-March 1981 through October 1981. More specifically, a sample of 6 individual moose have each provided a maximum of 51 radio relations over the 18 month period of study from mid-March 1980 to mid-October 1981 and a sample of 26 individual moose have each provided a maximum of 29 radio relocations during the latter 7 months of that same study period.

Aspects of the winter ecology of moose treated in this report are supported by the small body of data gathered from the sample of 6 radio-collared moose studied during the winter of 1980-81. Due to the late seasonal time when this sample was obtained, its representativeness of the populations of moose that utilize the Susitna River in winter is questionable.

Since the magnitude of use of the Susitna River by moose for winter range is related to the amount of snowfall and its persistence as ground cover into early spring, the relatively mild winters of 1979-80 and 1980-81 and below average snowfall which occurred during these two winters of study must be weighed when considering results presented in this report.

Behavior recorded for the sample of moose captured 10-12 March 1981, lend support to the contention that the sample of moose captured 17 April 1980 may not be representative of all moose (or populations of moose) that winter on the Susitna River (Table 6). These data demonstrate that a major portion of the sample of female moose captured and radio-collared downstream from Talkeetna in 1981 had departed from Susitna riverine habitats sometime between 6 and 20 April. These data also suggest that most male moose leave the riverine winter range habitats sometime after mid-March, or 2 to 3 weeks prior to the exodus of females. Not only does it seem probable that when the 17 April 1980 sample was taken many moose had already departed from riverine habitats, but also that those which had departed had primarily done so to the west of the Susitna River where they appear to have ranged throughout this study.

Additionally, the pattern of relocations recorded for the sample of moose captured and radio-collared 17 April 1980 suggests that sexes behaved differently from those in the sample of moose captured and radio-collared 10-12 March 1981.

Data available for the small samples of males captured and radio-collared downstream from Talkeetna in 1980 and 1981 indicate that the activity patterns of those captured in 1981 were primarily

Table 6. Dates indicating chronology of departure from Susitna River wintering areas for male and female moose radio-collared on the Susitna River downstream from Talkeetna, 10-12 March 1981.

Date[1]	Females		Males	
	Riparian[2]	Non-riparian	Riparian	Non-riparian
10-12 March	16	0	4	0
16 March	9	7	4	0
23 March	8	8	1	3
3 April	7	5	0	2
6 April	7	9	0	4
14 April	3	7	0	1
20 April	6	11	1	3
22-23 April	4	13	0	4
28 April	3	14	0	4

1 All individuals not relocated on each date.

2 Riparian = individuals relocated within the outmost banks of the Susitna River; Non-riparian = individuals relocated outside of the outmost banks of the Susitna River.

centered in areas west of the Susitna River (Fig. 4). Whereas, one of the 3 males captured downstream from Talkeetna in 1980 has always been relocated on the eastside of the Susitna River (Fig. 5).

Similarly, differential patterns in behavior were also exhibited between the much larger 1980 and 1981 samples of female moose captured and radio-collared south of Talkeetna. Two of the female moose captured and radio-collared in 1980 and monitored through this study appeared to spend the calving and summer periods west of the Susitna River but all three occupied breeding and wintering ranges on the east side of the river (Fig. 6).

Radio relocations for the 24 females captured and radio-collared in 1981 demonstrated tremendous fidelity to the west side of the Susitna River (Fig. 7). Only 4 of the 24 females were radio-relocated on the east side of the Susitna River, 3 of them (No. 37, 85 and 79) occupied seasonal ranges on that side of the river but only 1 of those 3 (No. 79) spent the breeding season on that side of the river. One of the remaining 20 female moose (No. 90) and 2 of the previous 3 (No. 37 and 85) spent a considerable amount of time near the river or on islands in the river. The remaining 19 female moose captured and radio-collared south of Talkeetna in 1981 exclusively used areas to the west of the Susitna River.

Female No. 79, a subject of the 1981 sample, behaved similarly to female No. 23, a subject of the 1980 sample. During the seasonal periods (calving, summer and breeding) for which data are available, the patterns of movements and ranges used by these 2 individuals have been essentially the same.

All 8 of the females captured and radio-collared north of Talkeetna were usually located in habitats to the north-northwest of the Susitna River rather than in habitats to the south-southeast of the Susitna River (Fig. 7). However, this pattern of behavior

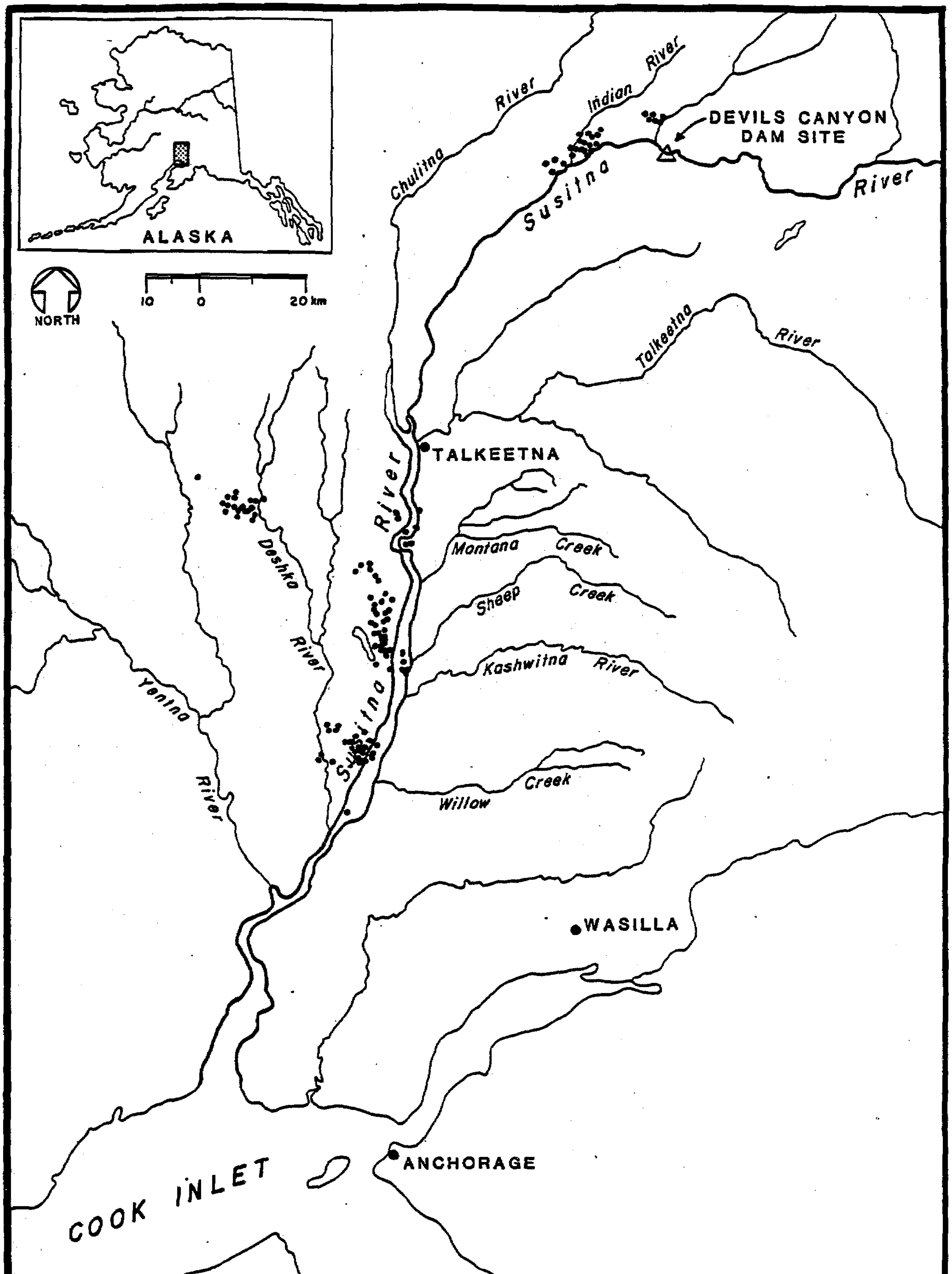

Figure 4. Spatial relationship of radio relocations for 5 male moose collared 10-12 March, 1981.

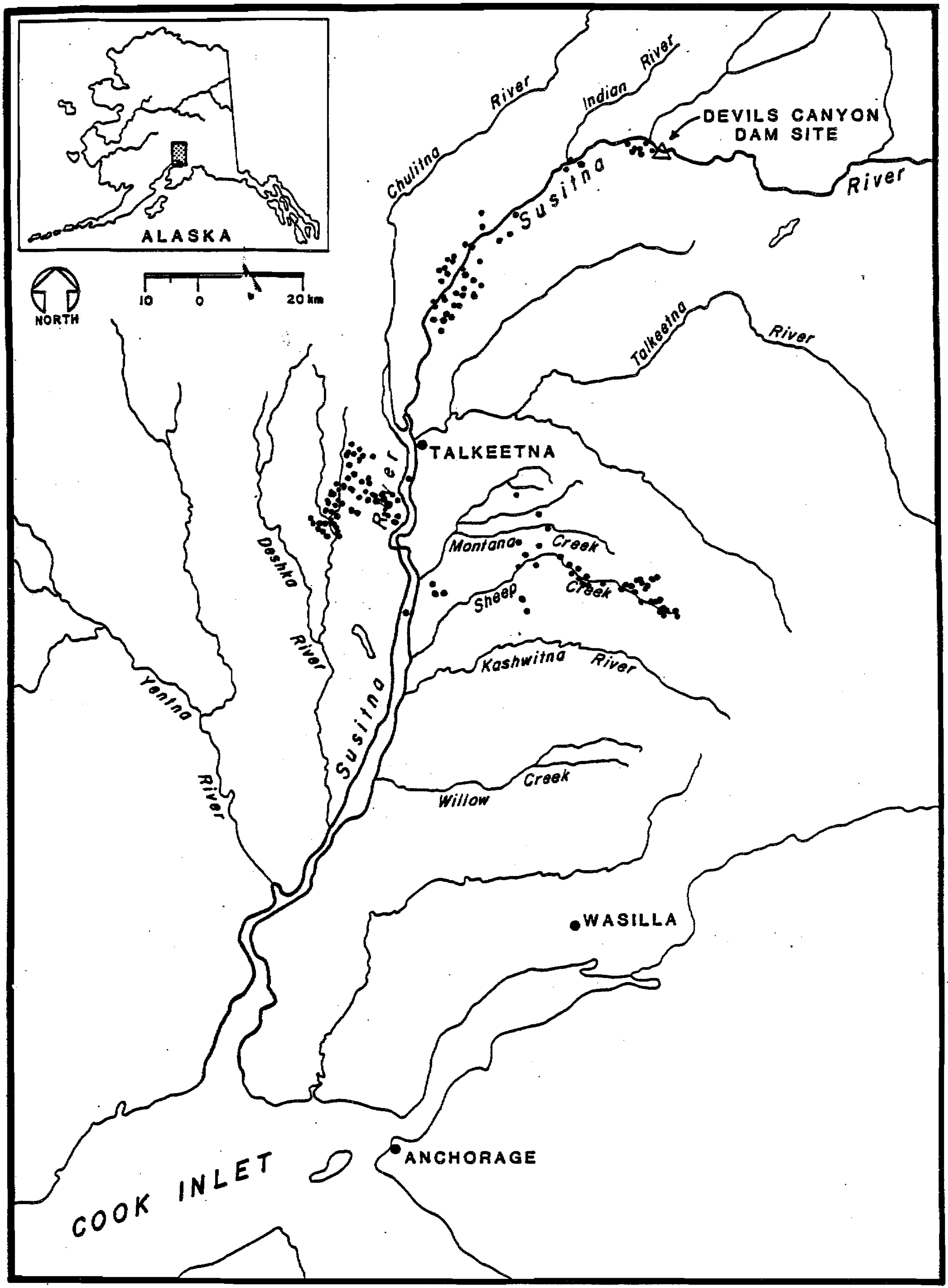

Figure 5. Spatial relationship of radio relocations for 4 male moose collared 17 April, 1980.

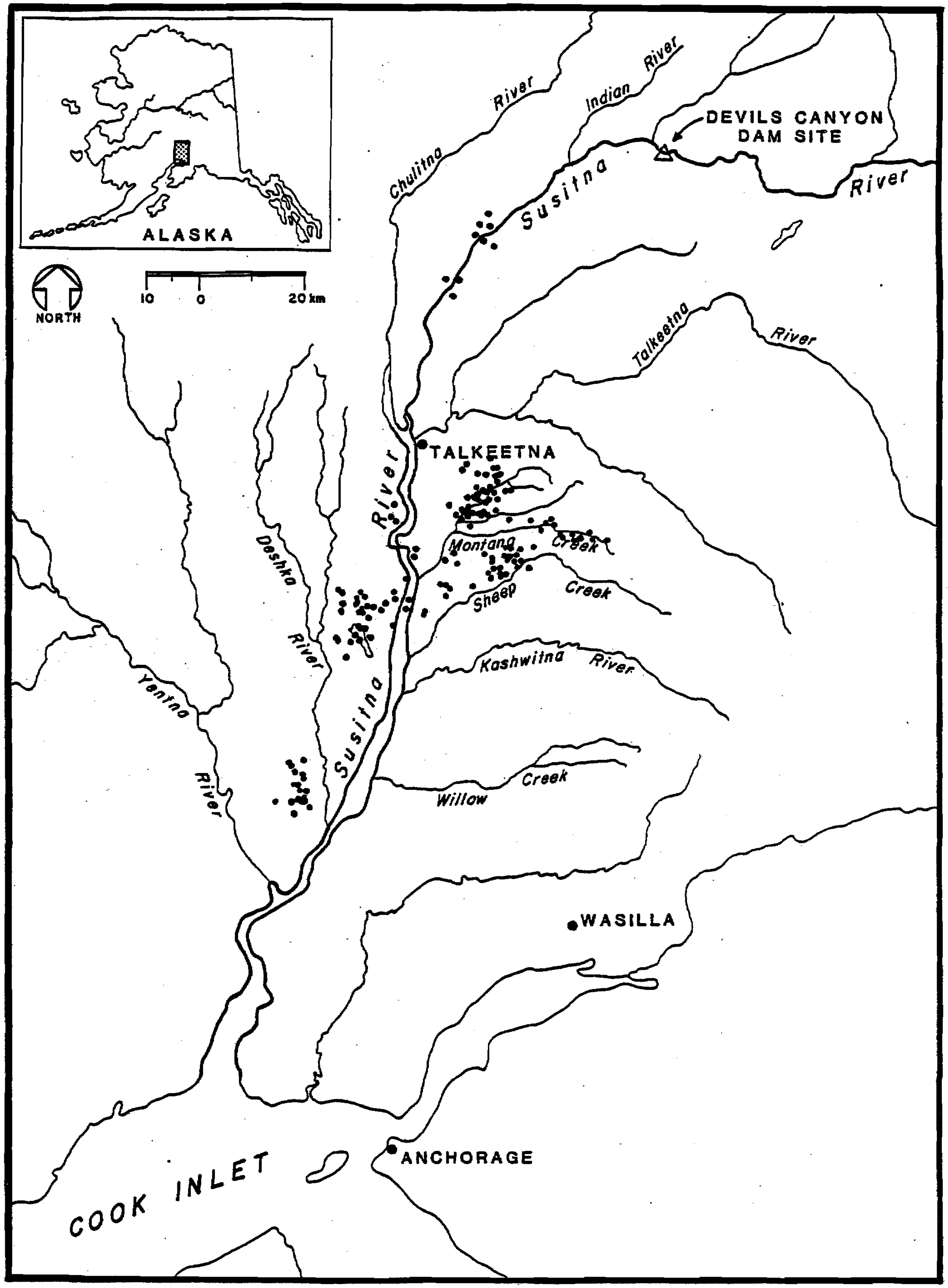

Figure 6. Spatial relationship of radio relocations for 6 female moose collared 17 April, 1980.

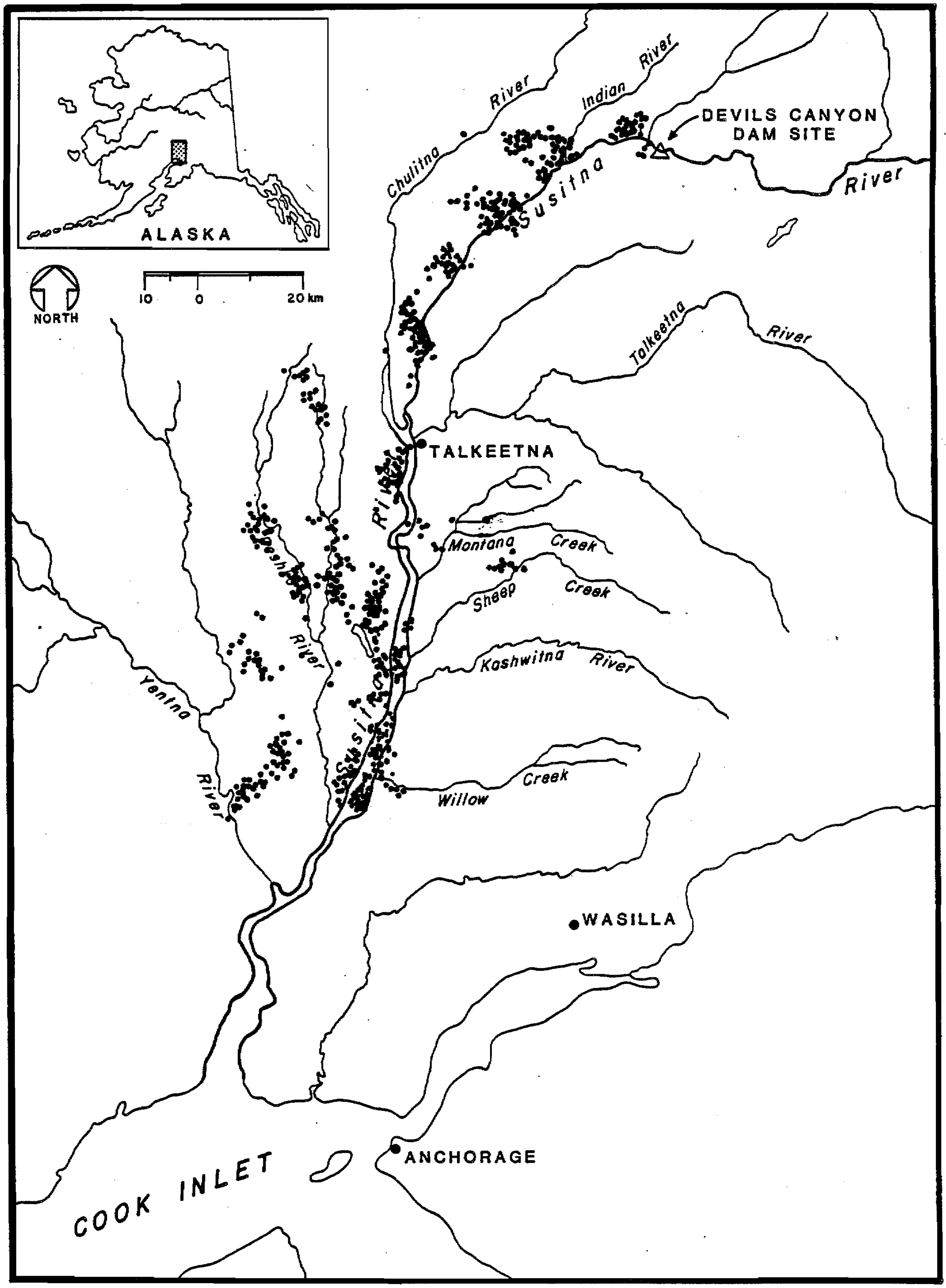

Figure 7. Spatial relationship of radio relocations for 24 female moose collared 10-12 March, 1981.

for female moose north of Talkeetna, most probably was not an artifact of sampling but was related to ecological differences between habitats on opposite sides of the river.

SEASONAL DISTRIBUTION AND MOVEMENT PATTERNS

General

Calculations of location, size or spatial distribution of particular ranges for each individual moose were determined from a number of radio relocation points within each respective seasonal date period. Generally, these data were the result of calculations performed on 2, 5, 7 and 5 radio locations for each individual moose during the winter (Fig. 8), calving (Fig. 9), summer (Fig. 10) and breeding (Fig. 11) range periods, respectively, from 17 April 1980 through 15 October 1981.

Winter Range Period

Results pertaining to the winter range period (1 January to 28 February) are derived primarily from the few observations furnished by 6 individuals captured and radio-collared 17 April 1980 and subsequently monitored through the winter of 1980-81. To augment this relative void of information during the winter period, I have assumed that the locations of capture for the 29 moose radio-collared 10-12 March 1981 were an approximate representation of the centers of their ranges for the winter of 1980-81.

Spatial relationships for winter ranges determined for the sample of 6 moose radio-collared in 1980 indicate the following: 1) none of the 6 radio-collared moose returned to the Susitna River during the winter of 1980-81 (Fig. 8); 2) all 3 of the females had winter ranges on the eastside of the Susitna River at distances of 7.3, 14.2 and 26.4 km from the river (Table 7); 3) winter ranges for the 3 males were in the upstream, downstream eastside, and downstream westside areas located 1.9, 24.3 and 10.6 km from the Susitna River, respectively.

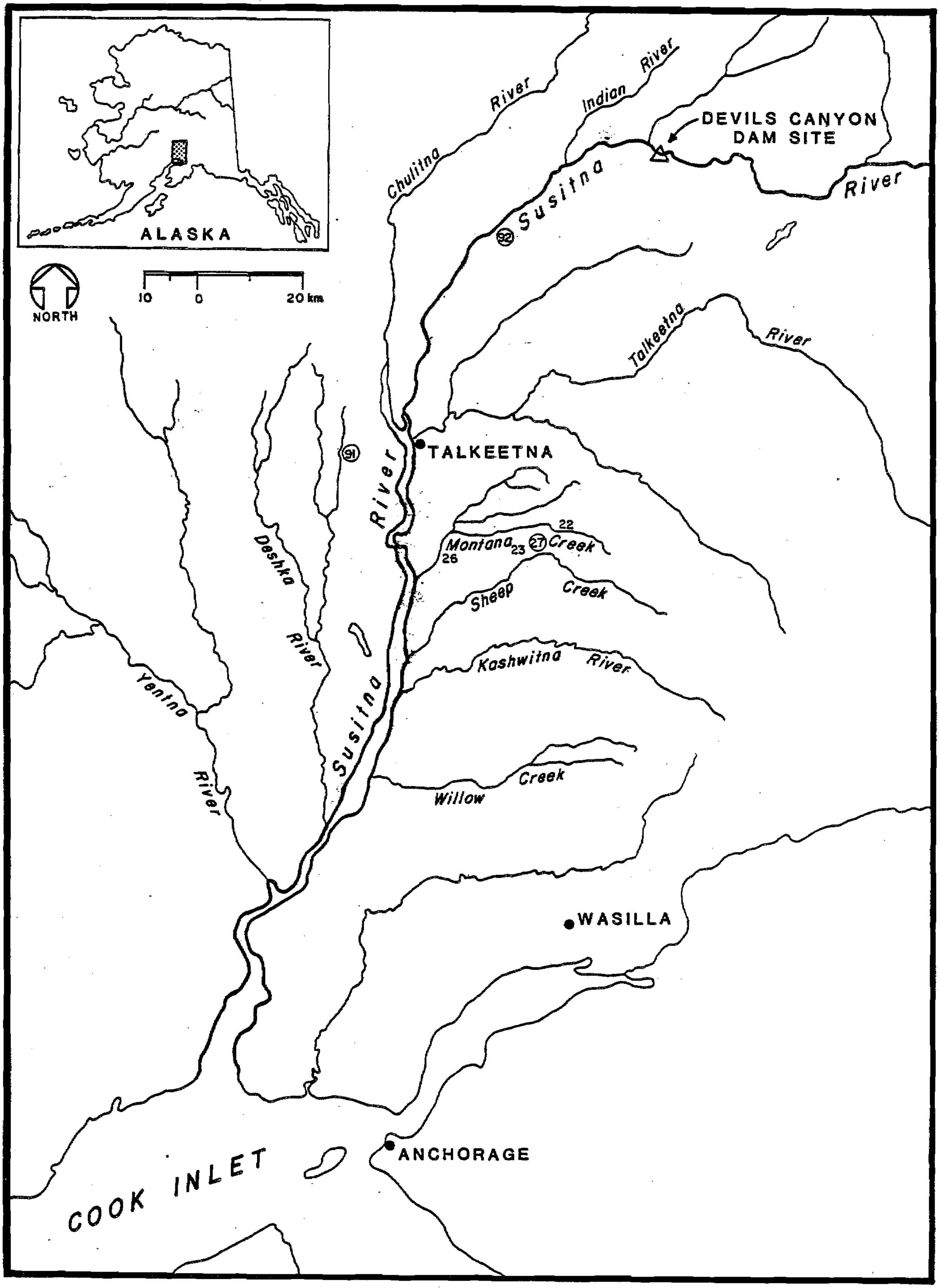

Figure 8. Spatial relationship of winter ranges (1 January–28 February) for 6 of the moose radio-collared on the Susitna River between Devils Canyon and the Delta Islands, Alaska, 1980. (circled numbers = males)

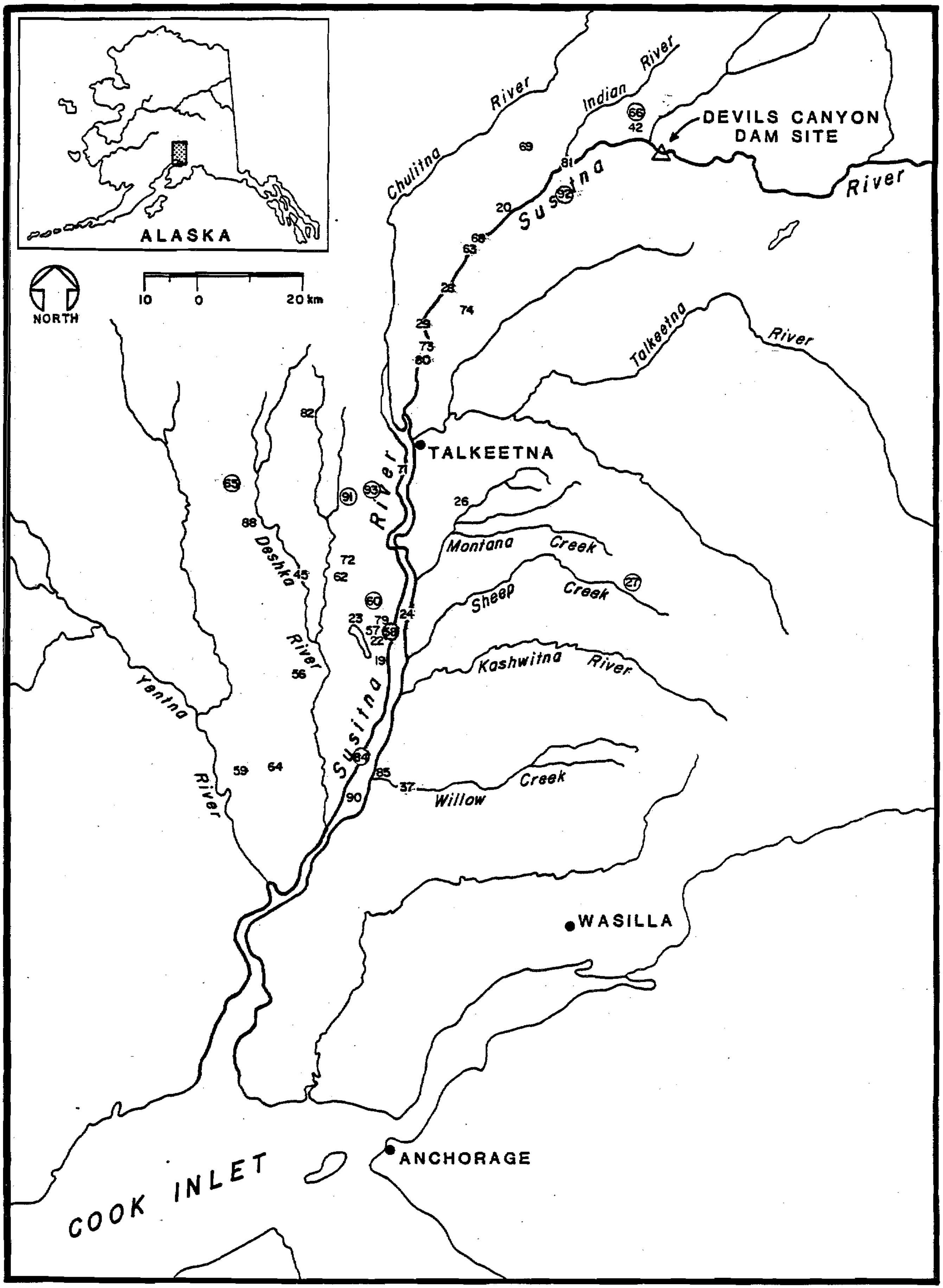

Figure 9. Spatial relationship of calving ranges (14 May–17 June) for 39 of the moose radio-collared on the Susitna River between Devils Canyon and the Delta Islands, Alaska, 1980–81. (circled numbers=males)

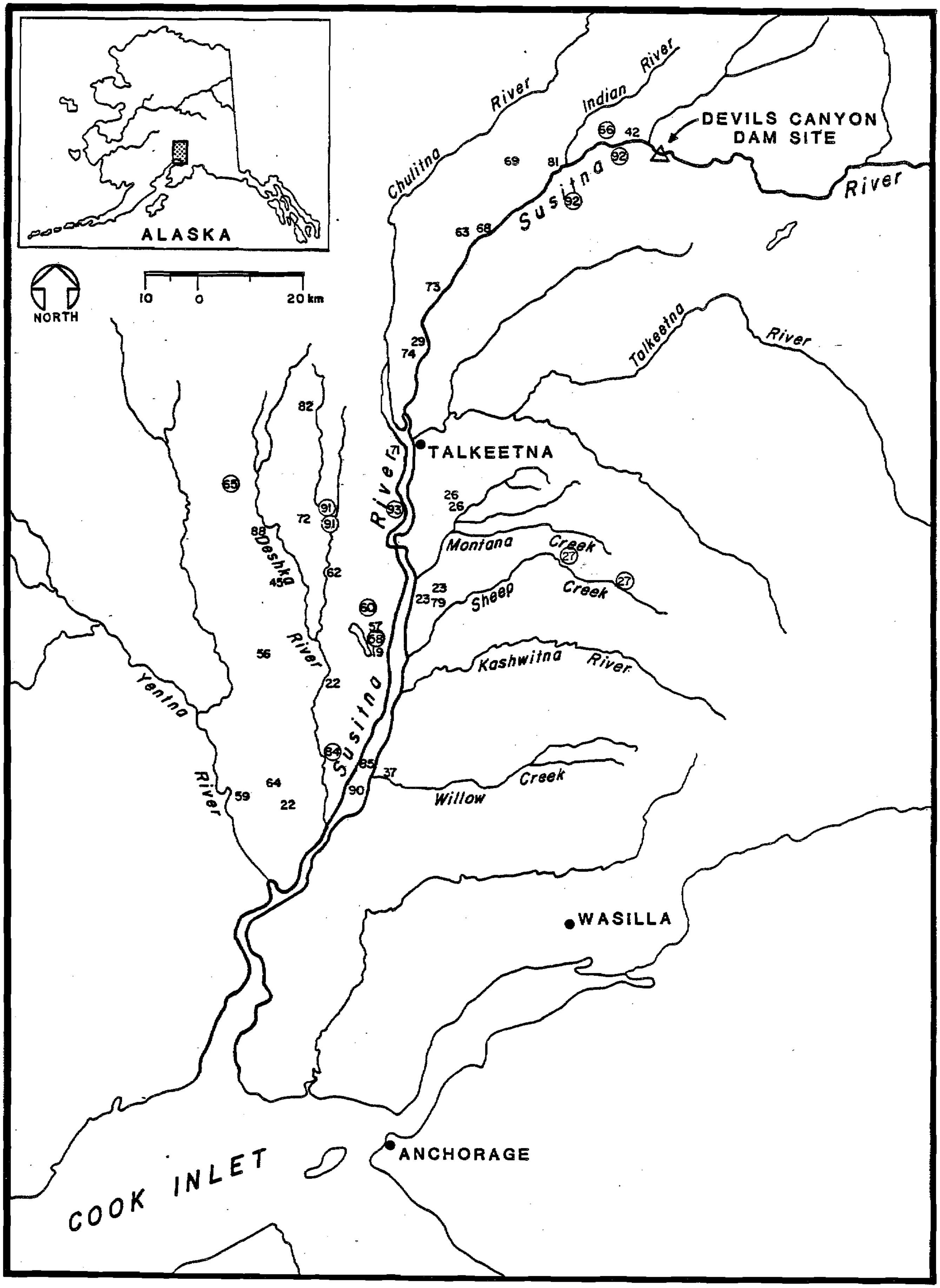

Figure 10. Spatial relationship of summer ranges (1 July–31 August) for 35 of the moose radio-collared on the Susitna River between Devils Canyon and the Delta Islands, Alaska, 1980–81. (circled numbers = males)

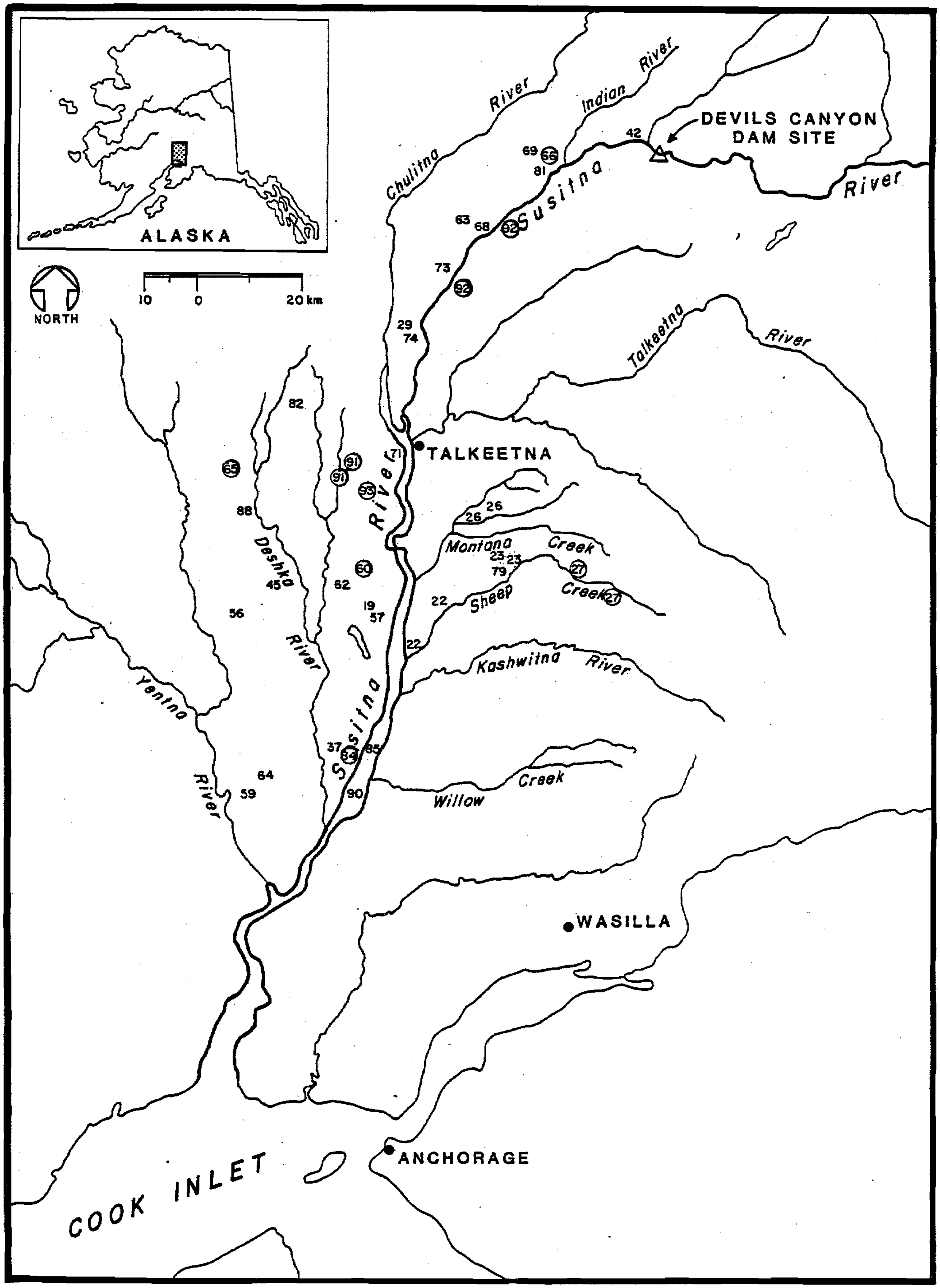

Figure 11. Spatial relationship of breeding ranges (14 September–31 October) for 34 of the moose radio-collared on the Susitna River between Devils Canyon and the Delta Islands, Alaska, 1980–81. (circled numbers=males)

Too few observations were recorded during the 1980-81 winter period to calculate sizes for individual winter ranges.

Calving Range Period

Results pertaining to the calving range period are derived primarily from observations of 36 radio-collared moose captured 17 April 1980 or 10-12 March 1981 and monitored from 14 May through 17 June 1981. Data collected for the 6 individuals followed through the calving period in 1980 was insufficient for analysis.

Spatial relationships of the calving ranges calculated for 36 of the moose captured and radio-collared along the Susitna River indicate the following: 1) 6 of the 10 females and neither of the 2 males north of Talkeetna were in riverine habitat along the Susitna River during the calving period (Fig. 9); 2) 4 of the moose captured south of Talkeetna were observed in or near Susitna riverine habitats, 21 were not; 3) of the 26 radio-collared moose downstream from Talkeetna and monitored during the calving period: 14 females and 4 males had ranges to the west of the Susitna River, 3 females and 1 male had ranges on or very near the River and 3 females and one male had ranges to the east of the River, 4) on the average both male (3.2 km) and female (2.3 km) moose upstream from Talkeetna had calving ranges nearer to the Susitna River than did their counterparts downstream from Talkeetna (Table 7), with maximum values of 30.6 km and 30.9 km for westside and eastside downstream males, respectively; and maxima of 19.9 and 4.6 km for westside and eastside downstream females, respectively; 5) though calving ranges for 9 female moose on the westside of the Susitna River were dispersed throughout an extensive area, ranges for 5 females were clustered in less than a 50 km^2 area to the east of Trapper Lake; 6) females used smaller ranges than males during the calving period and those ranges for 7 upstream females were of considerably smaller average size (1.61 km^2) than those for 14 downstream westside (11.83 km^2) or 4 eastside (11.83 km^2) females (Table 8); 7) distances between centers of winter ranges (as per qualified

Table 7. Minimum, maximum and mean distances (km) to the Susitna River from geometrical centers of the calving range, summer range, and breeding range for male and female moose radio-collared in several locations along the Susitna River between Devil Canyon and the Delta Islands, Alaska 1980-81.

Sex	Calving range 14 May to 17 June					Summer range 1 July to 31 August					Breeding range 14 September to 31 October				
Location[1]	N[2]	Min[3]	Max	Mean	SD	N	Min	Max	Mean	SD	N	Min	Max	Mean	SD
Females															
Upstream	8	0.0	5.0	2.25	2.55	8	0.7	4.3	2.60	2.24	8	1.2	4.9	3.09	1.42
Downstream															
Westside	14	0.0	19.9	9.22	7.86	14	0	24.0	10.37	8.68	13	0	25.0	10.74	9.56
Eastside	4	2.1	4.6	5.33	2.63	7	2.2	10.1	6.67	3.54	7	32.2	16.9	8.91	6.28
Males															
Upstream	2	3.0	3.4	3.2	0.28	3	1.7	3.0	2.37	0.65	3	1.6	2.0	1.8	0.2
Downstream															
Westside	1	30.6	30.6	--	--	2	26.7	36.2	31.5	--	2	26.4	35.3	30.9	--
Eastside	5	1.5	30.9	9.80	12.06	6	3.2	29.2	10.48	9.96	6	2.0	28.8	10.28	9.49

1 Upstream = moose radio-collared north of Talkeetna, downstream = moose radio-collared south of Talkeetna, westside = moose spending the breeding season on the west side of the Susitna River, and Westside = moose spending the breeding season on the westside of the Susitna River.

2 N = moose seasons of data: 2 moose each studied 1 season = 1 moose studied for 2 seasons and each equals N=2.

3 Min = minimum, Max = maximum and SD = standard deviation for distance values in each category.

Table 8. Minimum, maximum and mean values for sizes (km²) of areas (ranges) used during the calving, summering, and breeding seasons by male and female moose radio-collared in several locations along the Susitna River between Devil Canyon and the Delta Islands, Alaska 1980-81.

Sex Location[1]	Calving range 14 May to 17 June					Summer range 1 July to 31 August					Breeding range 14 September to 31 October				
	N[2]	Min[3]	Max	Mean	SD	N	Min	Max	Mean	SD	N	Min	Max	Mean	SD
Females															
Upstream	7[4]	0.6	3.7	1.61	1.11	8	1.0	11.3	5.51	3.61	8	1.0	9.4	3.83	2.99
Downstream Westside	14	2.2	19.4	6.03	5.48	14	1.0	11.4	6.84	5.46	13	0.7	10.6	4.37	3.29
Eastside	4	1.0	19.9	11.83	9.11	6	2.3	66.2	29.15	28.56	5	3.3	10.5	5.66	2.81
Males															
Upstream	2	5.9	116.8	61.35	--	3	24.3	125.0	63.17	54.14	3	12.0	18.9	15.27	3.46
Downstream Westside	4	10.4	25.1	15.98	9.34	6	0.4	23.6	7.42	8.35	5	3.9	14.2	8.28	4.60
Eastside	1	27.5	27.5	--	--	2	4.5	79.8	42.3	--	2	3.3	5.5	4.4	--

[1] Upstream = moose radio-collared north of Talkeetna, downstream = moose radio-collared south of Talkeetna, westside = moose spending the breeding season on the west side of the Susitna River, and Westside = moose spending the breeding season on the westside of the Susitna River.

[2] N = moose seasons of data: 2 moose each studied 1 season = 1 moose studied for 2 seasons and each equals N=2.

[3] Min = minimum, Max = maximum and SD = standard deviation for distance values in each category.

[4] One individual in this group had a spring range of 50.17 km² since it was so drastically different it was not included in that calculation.

calculation of centers for winter ranges) and centers of calving ranges averaged 3.5 and 11.5 km for upstream females and males, respectively, comparable values for all other sex x area categories averaged more than 13.5 km (Table 9).

Summer Range Period

Results pertaining to the summer range period are derived primarily from data obtained during radio relocations of 34 moose captured and collared on 17 April 1980 or 10-12 March 1981 and monitored from 1 July to 31 August. Spatial relationships of the summer ranges calculated for 34 of the moose captured and collared along the Susitna indicate the following: 1) only 2 of the 34 radio-collared moose for which data were available had summer ranges centering on the Susitna River, both individuals were females in an extensive island area of the River, the Delta Islands (Fig. 10); 2) 9 of the 10 radio-collared moose upstream from Talkeetna had summer ranges on the north-northwestern side of the Susitna River, the other individual, a male radio-collared in 1980, used the south-southeast side of the river for 2 consecutive summer periods; 3) 17 of the 24 radio-collared moose monitored downstream from Talkeetna during the summer period had ranges to the west of the Susitna River, 2 had ranges centering on the River and 5 had ranges to the east of the River; 4) All 6 of the moose radio-collared in 1980 had summer ranges in the same general areas for 2 consecutive years; 5) 3 of the 5 radio-collared moose with summer ranges to the east of the Susitna River were from the 1980 sample; 6) the apparent clustering of female moose to the east of Trapper Lake exhibited during the calving period was not apparent during the summer period; 7) considering average distances, both male and female moose upstream from Talkeetna had summer ranges nearer to the Susitna River than did their counterparts downstream from Talkeetna (Table 7); 8) average distances between centers of summer ranges and the Susitna River were less for downstream eastside females (6.67 km) than for westside females (10.37 km); 9) maximum distances from the Susitna River for summer ranges was 24.0 km and 36.2 km for

Table 9. Minimum, maximum and mean values for distances (km) between geometric centers of winter, calving, summer and breeding ranges for male and female moose radio-collared along the Susitna River between Devil Canyon and the Delta Islands, Alaska 1980-81.

Sex Location[1]	Winter range to calving range[4]					Calving range to summer range					Summer range to breeding range					Breeding range to winter range				
	N[2]	Min[3]	Max	Mean	SD	N	Min	Max	Mean	SD	N	Min	Max	Mean	SD	N	Min	Max	Mean	SD
Females																				
Upstream	8	0.5	10.0	3.45	3.96	8	0.4	12.0	3.09	3.86	8	0.3	3.1	1.9	1.16	8	1.9	5.5	2.95	1.18
Downstream Westside	14	0.5	36.2	17.16	13.38	14	0.4	8.3	3.26	2.47	13	1.2	6.4	3.01	1.96	13	0.5	43.5	18.14	14.30
Eastside	4	3.7	39.6	19.43	16.38	4	2.7	30.0	13.63	11.82	7	1.7	36.6	14.44	11.78	6	2.1	30.5	12.23	11.53
Males																				
Upstream	2	7.8	15.2	11.5	--	2	4.5	4.5	4.5	--	3	11.2	37.2	20.7	14.34	3	0.5	10.5	5.13	5.04
Downstream Westside	4	6.2	34.3	13.88	13.63	4	0.8	7.4	3.43	2.81	5	2.1	8.9	6.02	3.14	5	2.9	32.0	12.36	11.94
Eastside	1	9.7	9.9	--	--	1	5.9	5.9	--	--	2	5.7	10.4	8.05	--	2	10.2	15.5	12.85	--

[1] Upstream = moose radio-collared north of Talkeetna, downstream = moose radio-collared south of Talkeetna, westside = moose spending the breeding season on the west side of the Susitna River, and Westside = moose spending the breeding season on the westside of the Susitna River.

[2] N = moose seasons of data: 2 moose each studied 1 season = 1 moose studied for 2 seasons and each equals N=2.

[3] Min = minimum, max = maximum and SD = standard deviation for distance values in each category.

[4] Due to lack of data for calculating winter ranges for moose captured in 1981, site of capture (10 March) was used as an approximate substitute for that value.

females and males, respectively; and 10) average sizes of summer ranges were slightly less for upstream females (5.51 km^2) than for downstream westside females (6.84 km^2) and both values were slightly smaller than those for downstream westside males (7.42 km^2); 11) average sizes of summer ranges for upstream and downstream eastside males exceed 40 km^2, similar ranges for downstream eastside females averaged 29.15 km^2 (Table 8); 12) average distances between the centers of spring and summer ranges were not greatly different for most sex x area categories (3.09-5.9 km) excepting those for downstream eastside females (13.63 km) (Table 9); and 13) for each sex x area category, distances between centers of winter and spring ranges were greater than distances between centers of spring and summer ranges, maximum distances between the latter for each sex ranged from 4.5 km for an upstream male to 30.0 km for a downstream eastside female.

Breeding Range Period

Breeding ranges were derived from data obtained during relocations of 33 moose captured and collared on 17 April 1980 or 10-12 March 1981 and monitored from 14 September through 31 October.

Spatial relationships of the breeding ranges calculated for 33 of the moose captured and collared along the Susitna River indicate the following: 1) 2 of the 34 radio-collared moose for which data were available had breeding ranges that centered on the Susitna River in the Delta Island area, summer ranges of these same individuals (No. 85 and 90) were also centered on the river (Table 10); 2) 9 of the 10 moose radio-collared upstream from Talkeetna had breeding ranges on the north-northwestern side of the Susitna River, the individual on the southside is a male from the 1980 sample which has used that side of the river for 2 consecutive breeding seasons; 3) of the 33 radio-collared moose with breeding ranges located to the south of Talkeetna, 16 were centered to the west of the Susitna River, 2 were centered on the Susitna River and 5 (4 of which were captured in the 1980 sample)

Table 10. Date periods for use of riverine habitats by male and female moose radio-collared at several locations along the Susitna River between Devil Canyon and the Delta Islands, Alaska, 1980-81.

		FEMALES			MALES		
		Upstream[1] (10/10)[2]	Downstream[3]		Upstream (2/3)	Downstream	
Calander date	Transitory Interval(TI) or Range		Eastside (4/7)	Westside (15/15)		Eastside (1/2)	Westside (6/7)
1 November to 31 December	Winter TI	ND[4]	0:0/9	ND	1:1/3	0:0/2	0:0/3
1 January to 28 February	Winter Range	ND	0:0/6	ND	0:0/2	0:0/2	0:0/2
1 March to 13 May	Spring TI	2:3/57[5]	1:2/30	11:48/126	0:0/15	0:0/8	4:6/41
14 May to 17 June	Calving Range	6:16/42	1:1/23	4:14/73[6]	0:0/11	0:0/5	0:0/27
18 June to 30 June	Summer TI	0:0/11[7]	0:0/10	2:2/14	0:0/4	0:0/3	0:0/9
1 July to 31 August	Summer Range	0:0/56	2:2/43	4:14/98	1:2/19	0:0/12	1:3/43[8]
1 September to 13 September	Autumn TI	1:1/16	0:0/11	4:6/27[9]	0:0/4	0:0/3	0:0/10
14 September to 31 October	Breeding Range	1:1/40	0:0/34	4:17/65	0:0/15	0:0/10	1:4/27[10]

1 Upstream = moose radio-collared north of Talkeetna, Downstream = moose radio-collared south of Talkeetna, Westside = moose that spent the breeding season on the west side of the Susitna River and Eastside = moose that spent the breeding season on the east side of the river.

2 10/10 = 10 different moose yielded 10 moose years of data; 4/6 = 4 different moose yielded 6 moose years of data, ie. 2 of the moose studied each provided 2 moose years of data, each of the others provided 1 moose year of data.

3 Individual No. 24 shed radio-collar before first tracking flight and not included.

4 ND = No data available.

5 2:3/58 = 2 individual moose provided 3 relocations on riverine habitat out of 58 total relocations for that period and category of moose.

6-10 Monitoring of particular individuals discontinued: [6] = No. 80 died; [7] = No. 20 and 28 shed collars in 1980; [8] = No. 58 ceased moving; [9] = No. 72 killed by a hunter and [10] = No. 93 killed by a hunter.

were centered to the east of the river; 4) all 6 of the moose from the 1980 sample used the same general areas during both the 1980 and 1981 breeding periods, the greatest distance between ranges used in subsequent years was 15 km for an upstream male (No. 92); 5) females No. 22 and 23 had calving ranges on the west side of the Susitna River in each of the 2 years studied but each year returned to the east side of the river where they ranged during the breeding period, females No. 37 and 85 did the opposite, both moved from eastside calving ranges to breeding ranges on the westside of the river and on the river, respectively, and an upstream male (No. 66) moved about 10 km between summer and breeding ranges; 6) breeding ranges for females were on the average slightly farther from the Susitna River than were their summer ranges, for males breeding ranges were nearer to the Susitna River than were their summer ranges, and the most remote breeding ranges from the river were 25 and 35 km, respectively, for females and males, (Table 7); 7) breeding ranges for females appeared to be smaller than either calving or summer ranges (Table 8), a similar trend seemed prevalent for males as maximum sizes for their breeding ranges were smaller than maximum values for other ranges; 8) downstream eastside females appeared to move similar distances from calving to summer ranges as from summer ranges to breeding ranges, whereas downstream westside and upstream females traveled shorter average distances to their breeding ranges than to their summer ranges (Table 9); and 9) males traveled farther from summer ranges to breeding ranges than from calving ranges to summer ranges.

If it is assumed that individual moose radio-collared in March 1981 are destined in the winter of 1981-82 to return to the same ranges used in the winter of 1980-81 (as per qualified determination of winter range-capture site), the following interpretations of results would be appropriate: 1) average distances from breeding ranges to winter ranges would be considerably less than for males (5.13 km) and females (2.95 km) north of Talkeetna than for any sex x area category downstream from Talkeetna (minimum average value: 12.23 km) (Table 9); and 2) downstream westside females would have to travel the farthest average distance (18.14 km) of any sex x area category to return from their breeding ranges to ranges used the previous winter, and, particular downstream females could travel the shortest (0.5 km) as well as the longest (43.5 km) distance between these same two ranges, and 3) average distances between breeding ranges and winter ranges for downstream eastside females (12.23 km) and downstream westside (12.36 km) and eastside (12.85 km) males were similar.

AFFINITIES FOR HABITATS ALONG THE SUSITNA RIVER

Riparian habitat use along the Susitna River are from radio-locations of 10 and 29 moose captured and radio-collared 17 April 1980 and 10-12 March 1981, respectively, and monitored through 15 October 1981.

It should be reemphasized that the majority of these data are from moose that were monitored from mid-April to mid-October, and data for the time period when the magnitude of moose use of Susitna riverine areas is known to be greatest (the winter period, 1 January - 28 February) are solely derived from the sample of 10 moose captured and radio-collared 17 April 1980.

Data for moose radio-collared in areas upstream from Talkeetna and in eastside and westside areas downstream from Talkeetna demonstrate strikingly different affinities for riparian habitats along the Susitna River (Appendix B and Fig. 12).

Two male moose radio-collared in areas upstream from Talkeetna were commonly located in habitats near the Susitna River but in only 3 of 75 total relocations were they on the river-plain itself. Over 50 and 90 percent of their relocations were within 1 and 3 mi., respectively, of the Susitna River.

Similarly, data for 10 female moose radio-collared in the same general area, indicated that about 80 percent of their relocations were within 3 mi. of the Susitna River and as for males, females were as likely to be found within 1 mi. as within 3 mi. of the river. However, in contrast to the males, females were located more than twice as frequently in riparian habitats or on islands in the Susitna River (Fig. 12).

Data gathered from both sexes of moose radio-collared in the upstream areas indicate that they were seldom located in areas more than 5 mi. from the Susitna River.

In areas downstream from Talkeetna, data collected for radio-collared moose, not associated with habitats on the eastside of the Susitna River indicated that they spent considerably more time in riparian habitats of the Susitna River than did their counterparts to the north or east (Fig. 12).

Both sexes of radio-collared moose, in both areas downstream from Talkeetna, were also more frequently located in habitats more distant from the Susitna River than was the case for moose in areas to the north of Tâlkeetna.

At closer inspection, data gathered on the occurrence of relocation of moose in riparian habitats along the Susitna River reveal obvious differences in the seasonal timing and duration of use, between the different areas where moose were studied (Table 10).

Data for moose radio-collared north of Talkeetna indicate that 16 of 21 relocations in riparian habitats occurred during a one month period; a time when most other moose are bearing young. Data collected from the same moose over a five month period during other seasons indicate that only 5 of 180 relocations occurred in riparian habitats.

Data collected for radio-collared moose downstream and to the westside of the Susitna River indicate the following: 1) 9 of the 16 females and all 4 of the males remained on the Susitna

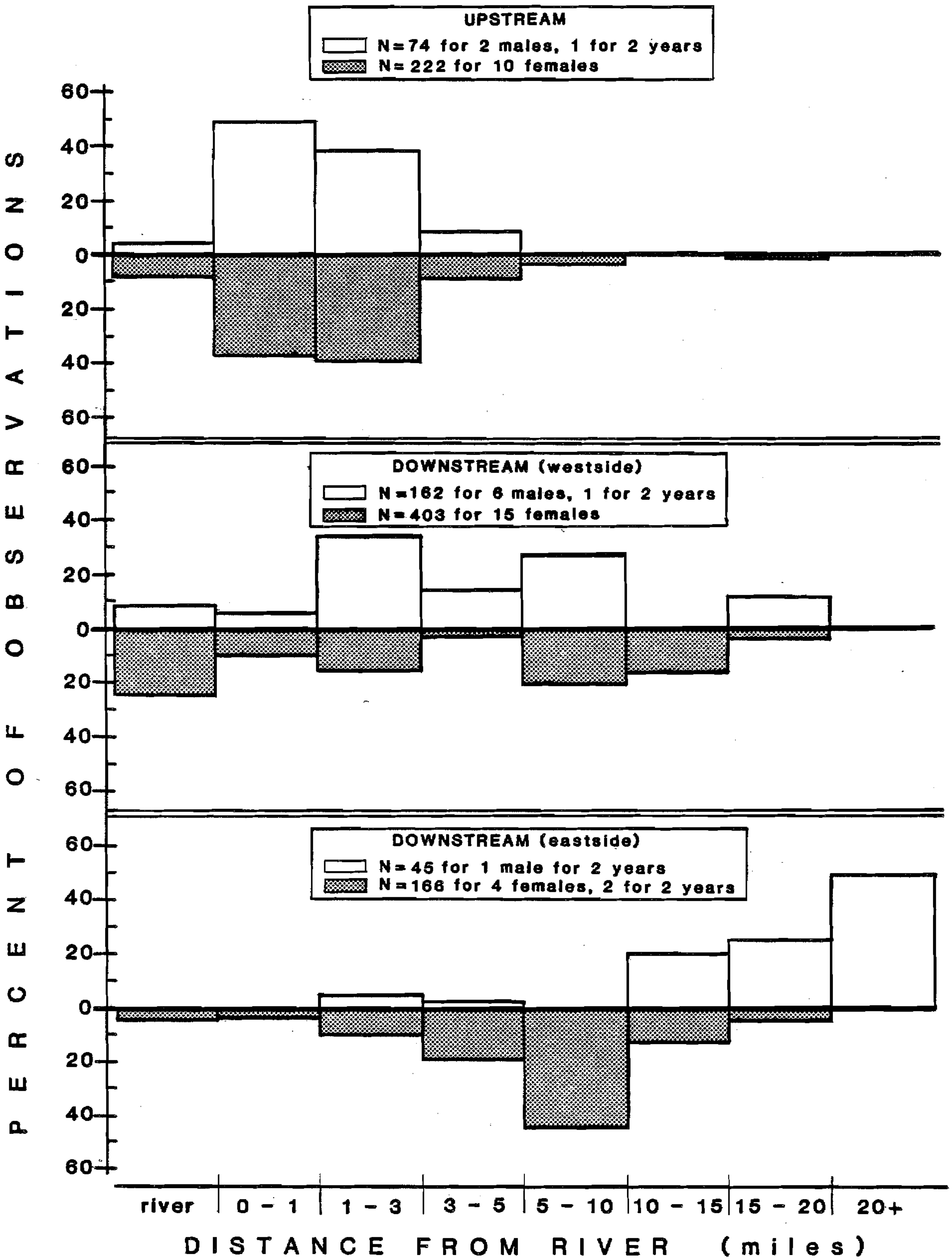

Figure 12. Relative proximity of relocations to the Susitna River for 9 male and 29 female moose radio-collared along the river between Devils Canyon and the Delta Islands, Alaska, 1980-81. Upstream=moose captured north of Talkeetna; Downstream=moose captured south of Talkeetna; Westside=captured moose that spent the breeding season to the west of the Susitna River; Eastside=captured moose that spent the breeding season to the east of the Susitna River.

River for a short period after capture (Table 6); 2) by mid-May all of the males had departed riparian habitats and only 4 females remained; 3) 2 to 4 of the westside females were located in riparian habitat during each of the seasonal periods; 4) the several observations of downstream eastside females made in riparian habitat appeared to occur while they were in transit to or from calving and/or summer ranges on opposite sides of the Susitna River; 5) 3 individual downstream westside females, No. 37, 85 and 90 accounted for 13, 25 and 27, respectively of the relocations in riparian habitats; 6) individual No. 80, radio-collared south of Talkeetna, traveled to a riparian area along the Susitna River to the north of Talkeetna during the calving period; 7) 1 downstream westside male (No. 84) was frequently located in riparian habitat, but none of the other 3 males from this area returned to the Susitna River after departing in early spring.

Data collected on the one radio-collared male that occupied habitats to the east of the Susitna River indicated the following: 1) over 90 percent of the relocations for this individual were at distances greater than 10 miles from the Susitna River; 2) aside from the time of initial capture, this male has never been relocated on the Susitna River after 45 observations (Table 10).

VEGETATIVE COMPONENTS OF RIPARIAN AND NON-RIPARIAN HABITATS USED BY MOOSE

Vegetative components of habitats used by moose were derived from observations during 4 seasonal periods at 409 non-riparian and 103 riparian sites of relocation for 6 and 29 moose radio-collared 17 April 1980 and 10-12 March 1981, respectively, along the Susitna River between Devil Canyon and the Delta Islands and subsequent radio relocations from 16 March 1981 through 15 October 1981.

Data presented document gross differences between habitats frequented by moose radio-collared in areas north of Talkeetna and those radio-collared in areas south of Talkeetna. These data indicate that selection and use of particular habitats were in part dependent on the sex of moose and seasonal period. They also furnish descriptive information on vegetative characteristics of riparian and non-riparian habitats selected and/or frequented by moose along the Susitna River.

Males Radio-collared North of Talkeetna

Outstanding vegetative characteristics noted at the 54 non-riparian relocation sites for 2 males radio-collared north of Talkeetna include the following: 1) alder, birch and spruce occurred at 83, 80 and 83 percent, respectively of the relocation sites and among seasonal averages had ratings averaging 46, 36 and 27 percent, respectively, for canopy coverage (Table 11); 2) sedge and/or grass occurred at 29 of the relocation sites and had average ratings of 32, 28, 34 and 24 percent for canopy coverage in calving, summer, breeding and transition periods, respectively; 3) willow was observed at 14 percent of the relocation sites and among seasonal averages, averaged a 14 percent rating in canopy coverage and 4) 3 of 4 observations of devilsclub occurred during the summer period.

Neither of the 2 male moose radio-collared north of Talkeetna were relocated in riparian habitats between mid-March and mid-October 1981.

Females Radio-collared North of Talkeetna

Vegetative characteristics observed at the 196 non-riparian relocation sites for 8 females radio-collared north of Talkeetna indicated the following: 1) alder, birch and spruce occurred at 90, 71 and 84 percent of the non-riparian relocation sites, respectively and had average canopy coverage ratings of 62, 35 and 19 percent, respectively for unweighed averages within

Table 11. Occurrence and mean percent of canopy coverage for types of vegetation and habitat types (riparian or non riparian) observed at sites of relocation for two male moose captured and radio-collared along the Susitna River north of Talkeetna, Alaska and monitored during calving, summer, breeding and transitional periods from 16 March to 15 October 1981.

Vegetative type[1]	Seasonal period[2]															
	Calving				Summer				Breeding				All transitions			
	NR (N=10)	%	R (N=0)	%	NR (N=14)	%	R (N=0)	%	NR (N=10)	%	R (N=0)	%	NR (N=20)	%	R (N=0)	%
Alder	6	30	0	-	14	34	0	-	10	38	0	-	15	37	0	-
Birch	8	32	0	-	11	27	0	-	7	14	0	-	17	35	0	-
Spruce	9	17	0	-	10	19	0	-	9	13	0	-	17	32	0	-
Cottonwood	2	38	0	-	3	11	0	-	0	-	0	-	3	10	0	-
Sedge	2	40	0	-	1	20	0	-	0	-	0	-	0	-	0	-
Grass	2	35	0	-	0	-	0	-	0	-	0	-	3	27	0	-
Sedge and/or grass	1	20	0	-	8	36	0	-	10	39	0	-	2	30	0	-
Willow	3	22	0	-	1	30	0	-	1	10	0	-	3	37	0	-
Fern	-	-	-	-	1	10	0	-	-	-	-	-	0	-	0	-
Devilsclub					3	17	0	-					1	20	0	-
Horsetail					-	-	-	-					-	-	-	-
Muskeg																
Aspen																
Water																

1 Terminology according to Viereck and Little (1972) and Anderson (1961).

2 Calving = 14 May-17 June; Summer = 1 July-31 August; Breeding = 14 September-31 October; All transitions = remainder of time from 16 April to 15 October, excluding calving, summer and breeding periods. NR = non riparian and R = riparian, within the outmost banks of the Susitna River; Percent = average for percents of canopy coverage at sites where present; and N = No. of sites.

seasonal periods (Table 12); 2) percent canopy coverages for spruce were rated lowest of the 3 dominant tree types in each of the 4 seasonal periods (14, 9, 10 and 24 percent, respectively for the calving, summer, breeding and transitional periods); 3) sedge and/or grass occurred in 73, 84, 97 and 27 percent of the relocation sites, respectively, for the same seasonal periods and rated between 23 and 60 percent for canopy coverage in vegetative type x seasonal period categories; 4) willow was observed at 13 percent of the relocation sites and averaged 25 percent among averages for seasonal periods and 5) fern and devilsclub were observed at 21 and 7 percent, respectively of the summer period relocation sites.

Twenty-one of the 217 relocation sites for females radio-collared north of Talkeetna were in Susitna River riparian habitats. Noteworthy features of these data were the following: 1) 76 percent of the observations in riparian habitat occurred during the calving period and 38 percent of the moose relocated during the calving period were in riparian habitats (Table 12); 2) cottonwood, alder and willow occurred at 94, 63 and 50 percent, respectively, of the riparian relocation sites and those vegetative types rated an average of 49, 25 and 16 percent, respectively, among seasonal period averages for canopy coverage; 3) birch occurred at 38 percent of the riparian relocation sites and had an average rating of 36 percent for seasonal period averages; 4) spruce occurred at 31 percent of the sites but averaged only 19 percent for canopy coverage among seasonal period averages; 5) sedge and/or grass occurred at less than 20 percent of the riparian relocation sites and 6) birch and spruce were observed at all transition period riparian relocation sites, alder and cottonwood were not.

<u>Males Radio-collared South of Talkeetna</u>

Notable features of the vegetative characteristics observed at 147 non-riparian relocation sites for five males radio-collared south of Talkeetna were the following; 1) alder, birch and

Table 12. Occurrence and mean percent of canopy coverage for types of vegetation and habitat types (riparian or non-riparian) observed at relocation sites for 8 female moose captured and radio-collared along the Susitna River north of Talkeetna, Alaska and monitored during calving, summer, breeding and transitional periods from 16 March to 15 October 1981.

Vegetative type[1]	Seasonal Period[2]: Calving				Summer				Breeding				All Transitions			
	NR (N=26)	%	R (N=16)	%	NR (N=56)	%	R (N=0)	%	NR (N=39)	%	R (N=1)	%	NR (N=75)	%	R (N=4)	%
Alder	21	45	10	25	50	50	0	-	38	45	1	30	67	45	2	20
Birch	11	31	6	36	42	22	0	-	24	22	1	30	62	31	4	46
Spruce	15	14	5	19	43	9	0	-	37	10	1	10	69	24	4	28
Cottonwood	1	70	15	49	2	15	0	-	1	T	0	-	5	14	1	33
Sedge	11	31	1	T	6	33	0	-	0	-	0	-	2	30	0	-
Grass	7	23	2	25	13	25	0	-	0	-	0	-	4	30	0	-
Sedge and/or grass	1	60	0	-	28	33	0	-	38	32	1	30	14	26	1	30
Willow	4	38	8	16	7	14	0	-	4	20	0	-	10	28	0	-
Fern	0	-	1	30	12	13	0	-	-	-	-	-	0	-	0	-
Devilsclub	-	-	-	-	4	15	0	-					1	20	-	-
Horsetail					0	-	0	-					0	T		
Muskeg					1	20	0	-					1	60		
Aspen					-	-	-	-					-	-		
Water																

[1] Terminology according to Viereck and Little (1972) and Anderson (1961).

[2] Calving = 14 May-17 June; Summer = 1 July-31 August; Breeding = 14 September-31 October; All transitions = remainder of time from 16 April to 15 October, excluding calving, summer and breeding periods. NR = non-riparian and R = riparian, within the outmost banks of the Susitna River; Percent = average for percents of canopy coverage at sites where present; T = trace, less than 10 percent per observation; and N = No. of sites.

spruce occurred at 46, 72 and 86 percent, respectively, of all relocation sites and averaged 25, 44 and 26 percent, respectively, for canopy coverage among seasonal period averages (Table 13); 2) willow and cottonwood occurred at 11 and 7 percent, respectively, of all relocation sites and rated an average of 27 and 24 percent, respectively among seasonal averages for canopy coverage; 3) devilsclub was observed at 29 relocation sites, 18 of those occurred during the summer period and accounted for 47 percent of the relocations within that period and in those observations devilsclub averaged 25 percent for among seasonal averages of canopy cover; 4) 54 of the 146 relocation sites contained sedge or grass and 5) muskeg type habitat occurred in 10 relocation sites.

Thirteen of 160 sites where male moose were relocated south of Talkeetna were in riparian type habitat. Alder, birch, spruce and willow occurred at 8, 8, 10 and 5 of those respective relocation sites. Cottonwood was observed at 6 of the riparian relocation sites but was rated as trace for canopy coverage at 2 of the sites.

Females Radio-collared South of Talkeetna

Prominent features of vegetative characteristics for 409 nonriparian relocation sites for 19 females radio-collared south of Talkeetna were the following: 1) alder, birch and spruce were noted at 40, 86 and 95 percent, respectively, of the relocation sites and averages among the within period seasonal averages for canopy coverage indicated ratings of 26, 46 and 27 percent, respectively for the same vegetative species (Table 14); 2) cottonwood occurred at 17 relocation sites, 12 of which were within the transition period; 3) willow was observed at 18 percent of all sites and 17 percent of those sites were within the calving period; 4) devilsclub occurred at 78 sites, 57 of those observations occurred during the summer period, where this vegetative type averaged 19 percent for canopy coverage; 5) muskeg occurred at 29 relocation sites, 14 were during the calving

Table 13. Occurrence and mean percent of canopy coverage for species of vegetation and habitat types (riparian or non-riparian) observed at relocation sites for 6 male moose captured and radio-collared along the Susitna River south of Talkeetna, Alaska and monitored during calving, summer, breeding and transitional periods from 16 March to 15 October 1981.

Vegetative type[1]	Seasonal period[2] Calving NR (N=30)	%	R (N=0)	%	Summer NR (N=38)	%	R (N=3)	%	Breeding NR (N=21)	%	R (N=4)	%	All transitions NR (N=58)	%	R (N=6)	%
Alder	10	20	0	–	25	24	3	30	17	34	2	80	15	21	3	31
Birch	22	52	0	–	29	45	3	37	12	33	3	23	43	47	2	30
Spruce	24	28	0	–	30	19	3	23	20	21	2	25	53	35	5	16
Cottonwood	1	40	0	–	2	31	1	T	3	13	1	T	5	22	4	73
Sedge	7	30	0	–	2	20	1	20	0	–	0	–	1	50	0	–
Grass	5	37	0	–	4	23	0	–	0	–	0	–	2	55	0	–
Sedge and/or grass	0	0	0	–	15	35	0	–	13	32	2	10	5	55	0	–
Willow	7	26	0	–	2	35	0	–	1	10	0	–	6	23	5	15
Fern	0	–	0	–	2	10	0	–	0	–	0	–	1	10	0	–
Devilsclub	1	30	0	–	18	21	1	10	2	20	0	–	6	23	–	–
Horsetail	2	T	0	–	0	–	–	–	0	–	0	–	0	–	0	–
Muskeg	1	50	0	–	2	15			4	50	1	50	3	47	0	–
Aspen	–	–	–	–	–	–			–	–	0	–	3	38	–	–
Water									0	–	1	50	–	–		

[1] Terminology according to Viereck and Little (1972) and Anderson (1961).

[2] Calving = 14 May-17 June; Summer = 1 July-31 August; Breeding = 14 September-31 October; All transitions = remainder of time from 16 April to 15 October, excluding calving, summer and breeding periods. NR = non-riparian and R = riparian, within the outmost banks of the Susitna River; Percent = average for percents of canopy coverage at sites where present; T = trace, less than 10 percent per observation; and N = No. of sites.

Table 14. Occurrence and mean percent of canopy coverage for types of vegetation and habitat types (riparian or non-riparian) observed at relocation sites for 19 female moose captured and radio-collared along the Susitna River south of Talkeetna, Alaska and monitored during calving, summer, breeding and transitional periods from 16 March to 15 October 1981.

Vegetative type[1]	Seasonal period[2]															
	Calving				Summer				Breeding				All Transitions			
	NR (N=78)	%	R (N=15)	%	NR (N=110)	%	R (N=16)	%	NR (N= 68)	%	R (N=17)	%	NR (N=153)	%	R (N=55)	%
Alder	12	27	9	34	64	28	12	41	51	27	14	34	37	27	16	31
Birch	50	56	7	34	107	40	11	36	57	41	8	38	137	48	18	41
Spruce	71	31	10	9	104	20	3	7	66	24	13	15	148	33	40	28
Cottonwood	1	60	10	55	2	10	12	35	2	10	9	43	12	31	40	63
Sedge	13	33	2	15	1	30	0	-	0	-	0	-	2	10	2	T
Grass	7	20	2	35	14	25	3	20	0	-	0	-	4	20	0	-
Sedge and/or grass	0	-	0	-	28	40	3	13	43	21	10	24	13	25	3	25
Willow	13	33	6	35	2	15	5	26	0	-	0	-	11	16	21	32
Fern	0	-	0	-	6	13	0	-	4	15	0	-	3	13	0	-
Devilsclub	1	10	0	-	57	19	1	10	5	12	0	-	15	21	3	13
Horsetail	2	0	0	-	0	-	0	-	0	-	0	-	2	T	0	-
Muskeg	14	50	0	-	4	43	0	-	9	52	1	50	2	45	0	-
Aspen	1	40	-	-	0	-	1	50	1	10	0	-	8	28	0	-
Water	-	-	-	-	-	-	-	-	-	-	1	50	-	-	-	-

[1] Terminology according to Viereck and Little (1972) and Anderson (1961).

[2] Calving = 14 May-17 June; Summer = 1 July-31 August; Breeding = 14 September-31 October; All transitions = remainder of time from 16 April to 15 October, excluding calving, summer and breeding periods. NR = non-riparian and R = riparian, within the outmost banks of the Susitna River; Percent = average for percents of canopy coverage at sites where present; T = trace, less than 10 percent per observation; and N = No. of sites.

period within which that vegetative type occurred at 17 percent of the sites and had an average rating of 50 percent for canopy coverage and 6) sedge and/or grass occurred at 30 percent of all relocation sites and averaged 10 to 33 percent for canopy coverage within seasonal periods.

Twenty percent of all observations of radio collared females south of Talkeetna were in riparian habitats. Noteworthy characteristics of the vegetative types observed at these 103 relocation sites were the following: 1) alder, birch, spruce and cottonwood occurred at 50, 43, 64 and 69 percent of all riparian sites, respectively, where each respective type rated an average of 35, 37, 15 and 49 percent for among season averages of canopy cover (Table 14); 2) willow occurred at 40, 31, 0 and 38 percent of the calving, summer, breeding and transition period relocation sites, respectively and within each period it averaged 35, 26, 0 and 32 percent, respectively, for canopy coverage; 3) sedge and/or grass were observed at 29 percent of all riparian relocation sites and had average canopy coverage ratings ranging from trace to 35 percent for any vegetative type x seasonal period category; and 4) devilsclub occurred at only 4 of the 103 riparian relocation sites and only 1 of the 16 sites observed during the summer period.

MAGNITUDE OF USE OF RIPARIAN HABITATS

Magnitude of use of riparian habitats along the Susitna River was derived primarily from three aerial moose composition censuses conducted in four zones along the Susitna River from Cook Inlet to Devil Canyon on 9 and 10 December 1981 (Table 15), 28 December 1981 and 4 January 1982 (Table 16) and 2 and 6 February 1982 (Table 17). Supplementary data were provided from relocations of moose radio-collared along the Susitna River.

Data gathered from aerial censuses along the Susitna River demonstrated variation between censuses in the total numbers of moose

Table 15. Sex, age composition and zone of location for moose observed on the first of 3 aerial censuses of the Susitna River from Devil Canyon to Cook Inlet, Alaska, 1981-82.

River zone[1]	Census 1 (9 and 10 December 1981)								
	Males[2]		Females[3]			Lone calves	Total		
	Ad	Im	W/0	W/1	W/2		Ads	Calves	Moose
I	6	2	12	8	0	0	28	8	36
II	2	1	4	3	1	0	11	5	16
III	3	7	55	32	5	3	102	45	147
IV	12	10	35	27	4	0	88	35	123
TOTAL	23	20	106	70	10	3	229	93	322

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

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

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

Table 16. Sex, age composition and zone of location for moose observed on the second of 3 aerial censuses of the Susitna River from Devil Canyon to Cook Inlet, Alaska, 1981-82.

	Census 2 (28 December 1981 and 4 January 1982)								
River zone[1]	Males[2]		Females[3]			Lone calves	Total		
	Ad	Im	W/O	W/1	W/2		Ads	Calves	Moose
I	2	1	7	4	0	0	14	4	18
II	2	0	8	4	0	1	14	5	19
III	5	5	87	42	3	1	142	49	191
IV	0	1	43	24	1	1	69	27	96
TOTAL	9	7	145	74	4	3	239	85	324

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

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

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

Table 17. Sex, age composition and zone of location for moose observed on the third of 3 aerial censuses of the Susitna River from Devil Canyon to Cook Inlet, Alaska, 1981-82.

Census 3

(2 and 6 February 1982)

River zone[1]	Males		Females			Lone calves	Total		
	Ad	Im	W/O	W/1	W/2		Ads	Calves	Moose
I	0	0	8	0	0	0	8	0	8
II	0	0	2	1	0	0	4	1	5
III	0	0	68	32	0	2	100	34	134
IV	0	1	54	17	1	0	73	19	92
TOTAL	0	1	132	50	1	2	185	54	239

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

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

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

observed, variation within and between censuses in the spatial distribution of moose observed and that at times over half of the moose observed on the river were calves and dams.

More specifically, these data indicated the following: 1) a maximum of 324 moose were observed along the Susitna River in census 2 (1.51 per km of river); 2) similar numbers of moose were observed in censuses 1 and 2, but 26 percent fewer moose were observed in census 3; 3) in all censuses densities of moose observed in Zones I and II were considerably less than those observed in Zones III and IV (Table 18); 4) Zone I had the lowest densities of moose observed for each zone x census category (0.10-0.45 moose per km of river); 5) the greatest density of moose was observed in Zone IV on census 1 (3.08 moose per km of river); 6) Zone I exhibited the greatest variation in density between censuses (78 percent) and Zone IV exhibited the least (25 percent); 7) though similar numbers of moose were observed on censuses 1 and 2, densities of moose recorded within Zones I-IV had undergone changes of -49, +19, +30 and -22 percent, respectively, a turnover involving 28 percent of the total moose counted; 8) 54, 50 and 44 percent of the moose observed on censuses 1 thru 3, respectively, were calves and dams (Table 15, 16 and 17); 9) 0.43, 0.40 and 0.25 calves per km of river were observed on censuses 1 thru 3, respectively, (Table 19); and 10) densities of calves for the 3 censuses averaged 0.05, 0.12, 0.65 and 0.68 for Zones I thru IV, respectively.

ASSESSMENT OF CONDITION FOR INDIVIDUALS IN RADIO-COLLARED SAMPLE

Assessment of the condition of moose ecologically associated with the Susitna River downstream from Devil Canyon was primarily derived from two sources of data collected from most individuals in the sample of 10 moose captured 17 April 1980 and 29 moose captured 10-12 March 1981 along the Susitna River from Devil Canyon to the Delta Islands.

Table 18. Density (No. moose/km of river) of moose observed on 3 aerial censuses in 4 zones of riparian habitat along the Susitna River from Cook Inlet to Devil Canyon, Alaska, 1981-82.

River zone[1]	Aerial census Number[2] 1	2	3
I	0.45	0.23	0.10
II	0.53	0.63	0.17
III	2.26	2.94	2.06
IV	3.08	2.40	2.30
All zones	1.50	1.41	1.11

1 I = Devil Canyon to Talkeetna, 80 km; II = Talkeetna to Montana Creek, 30 km; III = Montana Creek to Yentna River, 65 km and IV = Yentna River to Cook Inlet, 40 km.

2 1 = 9 and 10 December 1981, 2 = 28 December 1981 and 4 January 1982 and 3 = 2 and 6 February 1982.

Table 19. Density (No. calves/km of river) of calf moose observed on 3 aerial censuses in 4 zones of riparian habitat along the Susitna River from Cook Inlet to Devil Canyon, Alaska, 1981-82.

River zone[1]	Aerial census number[2]		
	1	2	3
I	0.10	0.05	0.00
II	0.17	0.17	0.03
III	0.69	0.75	0.52
IV	0.88	0.68	0.48
All zones	0.43	0.40	0.25

[1] I = Devil Canyon to Talkeetna, 80 km; II = Talkeetna to Montana Creek, 30 km; III = Montana Creek to Yentna River, 65 km, and IV = Yentna River to Cook Inlet, 40 km.

[2] 1 = 9 and 10 December 1981, 2 = 28 December 1981 and 4 January 1982 and 3 = 2 and 6 February 1982.

The general health of captured moose was assessed by assigning to each individual a rating of condition based on physical conformation (fatness, robustness, or lack thereof). Physical conformation was rated on a scale from 1 to 10; a rating of 7 or greater indicated that the animal was in average to better than average health (Franzmann and LeResche 1978).

The average of physical conformation ratings for 9 of the moose captured in 1980 indicates that they were in slightly less than average health (6.8 ± 0.75) but they had a higher average rating than 16 moose captured in 1981 (6.0 ± 0.73) (Table 20).

Condition related blood components, collected in late winter- "the critical season", have been used to assess the general health of populations of moose throughout Alaska (Franzmann and LeResche 1978). Franzmann and LeResche (1978) found that packed cell volume (PCV) was the single most valuable and consistent indicator of general condition, but that levels of hemoglobin (Hb), calcium, phosphorus and total protein (TP) were also found to vary in relation to physical condition and were not affected by the excitability status of the animal.

Data obtained from condition related blood components also indicate that moose captured along the lower Susitna River in 1980 and 1981 were in below average physical condition (Table 21). Though, the moose were in less than average physical condition according to certain related blood components, they still ranked well above a sample of moose from the population characterized by low productivity.

Only the average value for calcium indicated that the lower Susitna River moose (10.8 ± 0.50 gm%) were in average or better than average physical condition (10.4 gm%).

Contrary to information on body conformation, an examination of blood components on an individual basis reveals that the 1981 sample of moose were in better condition than moose in the 1980

Table 20. Ratings of body conformation and condition related blood components for moose captured and radio-collared along the Susitna River from Devil Canyon to the Delta Islands, Alaska, 1980-81.

Sex Location	No.[2]	Condition rating	Blood components[1] PCV (50%)	Hb (18.6 gm%)	Calcium (10.4 gm%)	Phosphorus (5.2 gm%)	Total protein (7.5 gm%)
Female							
Upstream	20*	6	-[3]	-	-	+	-
	28*	7	-	-	-	+	-
	29	NA	-	-	+	+	-
	42	NA	-	-	+	-	-
	63	5	-	-	+	+	-
	68	7	-	+	+	+	+
	69	NA	+	+	+	+	+
	73	5	-	-	+	+	-
	74	6	+	+	+	+	-
	81	6	NA[4]	NA	NA	NA	NA
Downstream							
Westside	19	NA	-	-	+	-	-
	37	NA	NA	NA	NA	NA	NA
	45	NA	NA	NA	NA	NA	NA
	56	7	-	-	+	-	-
	57	5	-	-	+	-	-
	59	NA	-	-	+	-	-
	62	NA	-	-	+	-	-
	71[5]	NA	-	-	+	-	-
	72[5]	NA	-	NA	NA	NA	NA
	82	7	-	-	+	-	-
	85	5	-	+	+	-	-
	88	7	-	+	+	-	-
	90	NA	-	-	+	+	-
	64	NA	-	-	+	-	-
	80	6	-	-	+	+	-

(continued)

Table 20 (cont'd)

Sex Location	No.[2]	Condition rating	Blood components[1] PCV (50%)	Hb (18.6 gm%)	Calcium (10.4 gm%)	Phosphorus (5.2 gm%)	Total protein (7.5 gm%)
Female							
Eastside	22*	8	-	-	-	+	-
	23*	6	-	-	+	+	-
	26*	8	-	-	+	+	-
	79	NA	-	+	+	-	+
Unknown	24*	NA	+	+	+	-	-
Male							
Upstream	66	6	-	+	-	-	-
	92*	7	-	-	+	-	-
Downstream							
Westside	58	6	-	-	+	-	-
	60	6	-	-	+	-	-
	65	6	-	+	+	-	-
	84	6	-	-	+	-	
	91*	6	-	-	+	-	-
	93*	NA	-	-	+	-	-
Eastside	27*	8	-	-		-	-

1 Upstream = moose radio-collared north of Talkeetna, Downstream = moose radio-collared south of Talkeetna, Westside = moose that spent the breeding season on the west side of the Susitna River, Eastside = moose that spent the breeding season on the east side of the river and Unknown = downstream but breeding location unknown.

2 * = individual captured in 1980, all other individuals captured in 1981.

3 According to Franzmann and LeResche (1978) adult moose with blood values equal to or greater than those noted in parentheses should be considered in average or better condition. + = value greater than that indicated, - = value less than that indicated.

4 NA = Data not available. Rating of 7 or higher = animal in average or better than average health.

5 Unsure which set of values goes with which individual.

Table 21. Comparison of condition related blood components from the sample of moose radio-collared along the Lower Susitna River (1980-81) to other populations of Alaskan moose at differing levels of productivity.

Blood values	Units	High productivity[1] Copper River Delta (Mar.) N = 44-46		Average or better[2] condition	Low productivity Moose Research Center (Feb., Mar., Apr.) N = 39		Lower Susitna[3] (Mar., Apr.) N = 35-36	
		Mean	SD[4]		Mean	SD	Mean	SD
Packed cell volume	%	53.2	4.2	50.	39.9	4.6	44.2	4.4
Hemoglobin	g/100ml	19.8	0.5	18.6	15.9	2.2	18.0	2.4
Calcium	mg/100ml	10.38	0.74	10.4	9.81	0.64	10.8	0.50
Phosphorus	mg/100ml	5.50	0.69	5.2	3.90	1.09	4.93	1.01
Total protein	g/100ml	7.07	0.57	7.5	6.60	0.44	6.80	0.55

1 Productivity ranking and blood parameters from Franzmann and LeResche (1978).

2 Adult moose with listed blood levels or greater considered by Franzmann and LeResche (1978) to be in average or better condition.

3 Data from sample of 10 moose captured 10 April 1980 and 26 moose captured 10-12 March 1981 along the Susitna River between Devil Canyon and the Delta Islands.

4 SD = Standard deviation.

sample (Table 20). For the sample of 10 moose captured in 1980, average values for PCV, Hb, Ca, P and TP were surpassed by 1, 1, 6, 5 and 0 individuals, respectively. A similar comparison for the 1981 sample of moose indicates that 2 of 26, 8 of 25, 23 of 25, 8 of 25 and 3 of 25 individuals had above average values for the same respective blood components.

Further examination of all blood components on an individual basis indicates that 3 of 10 moose (30 percent) in the 1980 sample had values for 2 or more components above the average level. Twelve of 25 individuals (50 percent) from the 1981 sample were found to have values for 2 or more condition related blood components above the average level.

Blood component profiles from female moose captured in 1981 indicate that 6 of 7 individuals (86 percent) from areas north of Talkeetna had values for 2 or more components that were above average levels. Five of 13 individuals (38 percent) from areas south of Talkeetna had values for 2 or more blood components above the average level.

Only 3 of 36 individual moose sampled along the Susitna River in 1980 and 1981 exhibited above average values for PCV, the single best condition related blood component (Franzmann and LeResche 1978).

Additional data on chemical components of blood and physical measurements from the 10 moose captured 17 April 1980 and the 19 moose captured 10-12 March 1981 appear in Appendices C - H.

ASSESSMENT OF PRODUCTIVITY FOR MOOSE IN RIPARIAN HABITATS

Results pertaining to estimates of productivity for moose ecologically associated with the Susitna River were primarily derived from 3 sources of data. Data on *in utero* pregnancy rates and calf production and/or survival were obtained from 5 and 24 female moose captured and radio-collared on 17 April 1980 and 10-12 March 1981, respectively. Additional data on calf production and/or survival for moose that utilize the Susitna River as winter range, were obtained during 3 sequential aerial river censuses conducted between early December 1981 and early February 1982.

Two of 5 (40 percent) and 14 of 24 (58 percent) female moose captured 1980 and 1981, respectively, were accompanied by calves at the time of capture (Table 22).

Table 22. Maternal status for 29 female moose captured and radio-collared along the Susitna River between Devil Canyon and the Delta Islands, Alaska, 1980-81.

Location	Individual No.	Year 1979[1]	1980[2]	1981[3]	Date of last observation
Downstream					
Westside	19		0	2	
	37		0	1	
	45		0PY	1	
	56		1PY	1	
	57		0	1	
	59		1PY	1	
	62		1PY	1	
	64		1	0	
	71		1PY	1	
	72		0PY	1	2 September 1981
	80		1PN	0	4 June 1981
	82		1PY	1	
	85		1PY	1	
	88		0PY	1	
	90		1	1	
Eastside	22	1PY	2*	2	
	23	0	0*	1	
	26	0	0*	0	
	79		2PY	0	
Upstream	20	0PN	0*	-	19 June 1980
	28	1PN	0*	-	27 June 1980
	29		2PY	0	
	42		0	1	
	63		0PN	1	
	68		1	2	
	69		1PN	1	
	73		0	1	
	74		1	0	
	81		1PY	1	
Totals:					
Productive females		2	13	21	
Young		2	16	24	
Females		5	29	27	

1 Maternal status determined by observation at capture or during subsequent radio-relocation surveys (1 = 1 calf, 2 = 2 calves) or by palpation at capture (PY = pregnant-yes, PN = pregnant-no). Sample captured in April 1980.

2 Same as above, except * = status determined only during radio-relocation surveys. Sample captured 10-12 March 1981.

3 Status determined entirely from observations during radio-relocation surveys.

Palpation for feti indicated that 3 of 5 (60 percent) and 12 of 15 (80 percent) female moose captured in 1980 and 1981, respectively, were pregnant. Palpation techniques also indicated that 2 of the 13 females determined to be pregnant were not subsequently observed with young during radio-relocation surveys. However, 1 of the 2 (No. 80) was found dead on 4 June, a time when most females are bearing calves. Therefore, a more conservative estimate of 1 of 12 (8 percent) could be used to access combined rates of abortion and neonatal mortality from the sample of captured and radio-collared moose that were also palpated.

Data gathered solely from routine aerial radio-relocation surveys indicate that 1 of 5 (20 percent) and 21 of 17 (78 percent) radio-collared female moose observed in 1980 and 1981, respectively, were accompanied by calves. Data collected during capture procedures and aerial relocation surveys together, indicate that 0 of 2, 3 of 13 (23 percent), and 3 of 21 females (14 percent) observed with young had twins. Obviously, due to the manner in which these data were collected, the calculated values must be considered as bare minimum estimates of twin calf production.

Data gathered for radio-collared females which were observed at least through June in a given year indicate that they were more likely to produce young in alternate years than in consecutive years. Seven of the 14 radio-collared females in areas downstream from Talkeetna and to the west of the Susitna River were observed with young in the winter of 1980-81 and were again observed with young in the spring of 1981.

Data for 3 radio-collared females, in the downstream eastside area, which were observed during one winter and 2 subsequent spring periods, indicate that one produced young in 3 consecutive years (twin young in two of those years). Another one was observed with a single calf in only one of those years, and the third female was never observed with young. One other female radio-collared in this area was accompanied by 2 young at the time of capture and was also determined to be pregnant but she was not observed with young during the following spring period.

Three of the 8 females radio-collared north of Talkeetna were observed with young in consecutive years. One other female was observed with a calf when captured and at the same time was determined to be pregnant; she was never observed with young the following spring.

Data gathered on 3 separate aerial river censuses conducted on the Susitna River from Cook Inlet to Devil Canyon on 9 and 10 December 1981, 28 December 1981 and 4 January 1982 and 2 and 6 February 1982 indicate ratios of 41, 36 and 29 calves per hundred adults, respectively (Tables 15, 16 and 17). During this same respective sequence of censuses, 10 of 80 (13 percent), 4 of 78 (5 percent) and 1 of 51 (2 percent) females observed with young had twins (Tables 15, 16 and 17).

In addition, if one considers the 4 physiographic Zones (I-IV) of the river, these same data reveal that 22, 31, 31 and 28 calves were observed per 100 moose in each Zone, respectively, on census 1. Ratios of 22, 26, 26 and 28, respectively, were observed in each Zone on census 2 and ratios of 0, 20, 25 and 21, respectively were observed in each Zone on census 3 (Table 23).

POPULATION PHENOMENA

These data summarize movements for the sample of 39 radio-collared moose and document different patterns of movement within and between each of the two subsamples of moose.

Data for the 10 and 29 moose radio-collared 17 April 1980 and 10-12 March 1981, respectively, within a narrow corridor along approximately 145 km of the Susitna River between Portage Creek and the Delta Islands and relocated through 15 October 1981 indicate that as a common population, they ranged throughout a 5102 km^2 area of adjacent habitat (Fig. 13). However, these sample data revealed several distinctly different patterns of movements

Table 23. Percent of calf moose observed on 3 aerial censuses of moose in each of 4 zones of riparian habitat along the Susitna River from Devil Canyon to Cook Inlet , Alaska, 1981-82.

River zone[1]	Aerial census number 1	2	3
I	22	22	0
II	31	26	20
III	31	26	25
IV	28	28	21
Mean for census	29	26	23

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

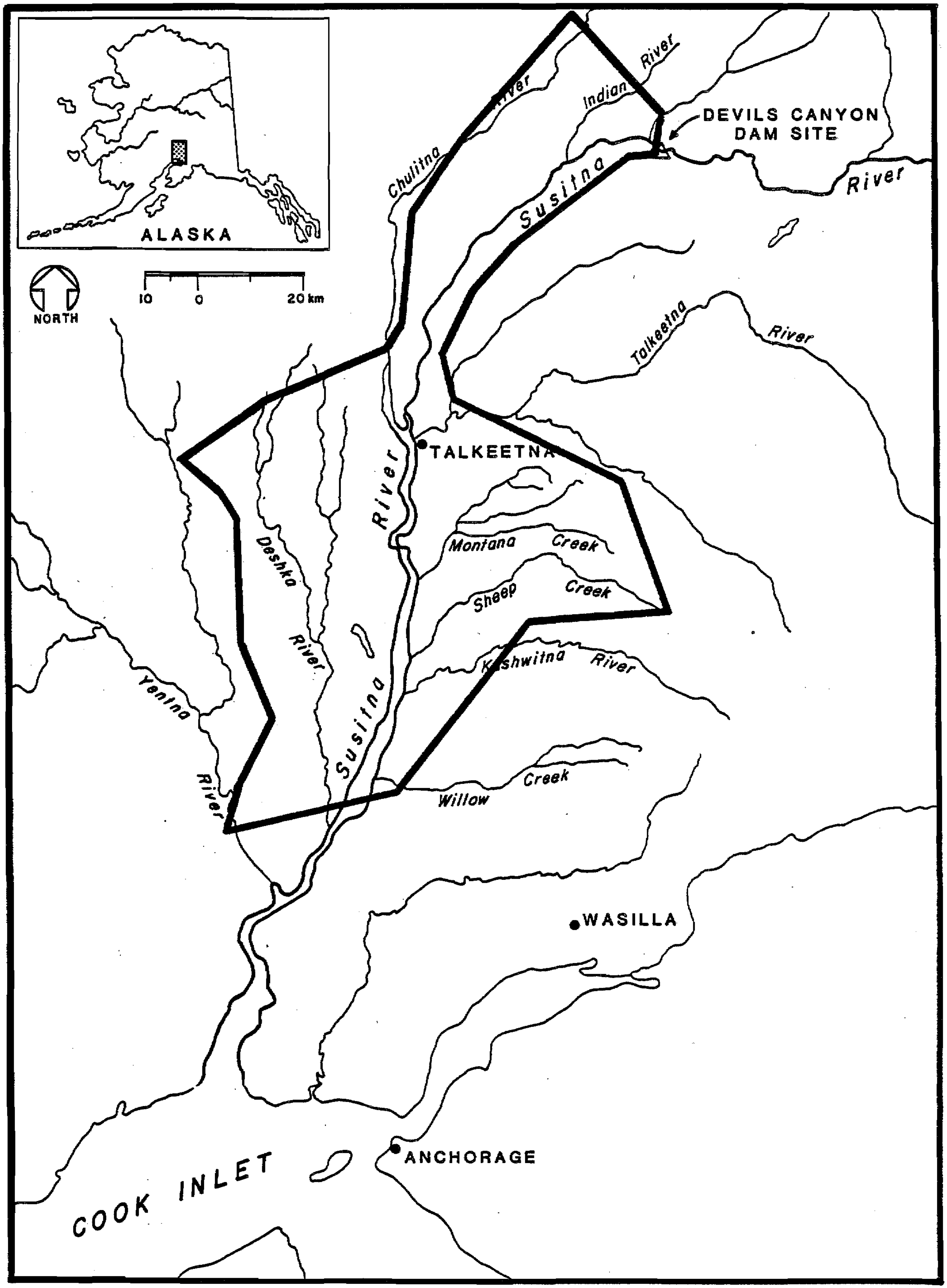

Figure 13. Polygon encompassing 1114 relocations for 10 moose radio-collared 17 April, 1980 and 29 moose radio-collared 10-12 March, 1981 on the Susitna River between Devils Canyon and the Delta Islands, Alaska, and monitered through 15 October, 1981. (inclusive area = 5102 km^2)

when the two subsamples were considered independently (Table 24).

Whereas the individual male radio-collared north of Talkeetna in 1980 primarily occupied ranges centered to the east-southeast of the Susitna River, most seasonal ranges for females radio-collared in this area in 1981 were centered to the north-northwest of the Susitna River, as were all seasonal ranges for the sole male radio-collared in the latter year.

The sample of female moose radio-collared in 1980 south of Talkeetna primarily ranged to the east of the Susitna River; males in that same sample appeared to disperse from the Susitna River wintering area in a more random fashion and occupied ranges on both sides of the river.

Female moose radio-collared in 1981 primarily dispersed to the west of the Susitna River where most all of their seasonal ranges were centered. One female (No. 79) departed to the east and behaved much like those females radio-collared in the 1980 sample.

Movement patterns for all 4 males radio-collared in 1981 were similar to those of the females; they too occupied seasonal ranges to the west of the Susitna River.

Table 24. Disparate distribution between male and female moose radio-collared 17 April 1980 and those radio-collared 10-12 March 1981 along the Susitna River between Devil Canyon and the Delta Islands, Alaska.

Location[1] Season[2]	Year of capture 1980 Males E[3]	W	Females E	W	1981 Males E	W	Females E	W
Upstream								
Winter	1	0	0	0	NA[4]	NA	NA	NA
Calving	1	0	0	1[5]	0	1	1	1[6]
Summer	1	0	0	0	0	1	0	8
Breeding	1	0	0	0	0	1	0	8
Downstream	E	W	E	W	E	W	E	W
Winter	1	1	3	0	NA	NA	NA	NA
Calving	1	2	1	2	0	3[7]	2	12[8]
Summer	1	2	2	1	0	3	2	11[8]
Breeding	1	2	3	0[9]	0	3	1	11[8]

1 Upstream = moose captured north of Talkeetna, Downstream = moose captured south of Talkeetna.

2 Winter = 1 Jan.-28 Feb.; Calving = 14 May-17 June; Summer = 1 July-31 August and Breeding = 14 September-31 October.

3 E = east or southeast side of Susitna River, W = west or northwest side of Susitna River.

4 NA = Data not available.

5 Moose subsequently shed collar; another individual on river and not included in sample.

6 Six of collared moose on river, not included in sample.

7 Another individual on river not included in sample.

8 Two of collared moose on river, not included in sample.

9 Though not indicated, pattern of behavior for moose collared in 1980 was the same in 1981; ie., observations could be doubled to represent 2 years of data for each individual.

DISCUSSION

SEASONAL DISTRIBUTION AND MOVEMENT PATTERNS

Winter Range Period

Data gathered on radio-collared moose during the entire winter period were relatively few but along with circumstantial evidence provide several noteworthy general hypotheses.

All 3 female moose radio-collared south of Talkeetna in 1980 were captured within the outmost banks of the Susitna, but none of these moose were relocated on the river in the winter of 1980-81 when numerous other moose were observed in riverine habitats. These few data suggest that a local population of moose which spends most other parts of the year in areas to the east of the Susitna River may, in some winters (e.g. 1979-80), utilize Susitna River riparian habitats and in other winters (e.g. 1980-81), may not.

These observations could have resulted from the relative infrequency with which relocation flights were conducted during the winter of 1980-81 or from environmentally induced differences between moose behavior in the two winters of study. Evidence supporting the latter contention is provided by observations of movement patterns exhibited by the sample of 21 moose captured and radio-collared on the Susitna River late in the winter of 1980-81. Only 1 of 17 females and none of 4 males in the 1981 sample frequented areas to the east of the Susitna River ("east-side"); the remainder dispersed to areas to the west after leaving riparian habitats ("westside"). From this relatively large sample of moose, I would have expected a more random directional dispersal of the moose from their capture sites on the Susitna River.

How then does one account for the disparate behavior observed for moose sampled from similar riverine habitat in two consecutive years? The apparent incongruent observations presented thus far may be explained by a combination of the following factors: 1) snowfall and/or snow cover; 2) vegetative phenology; 3) timing of sampling; and 4) differential behavior of local populations.

It is well known that occurrence of snow and its characteristics influence the timing and magnitude of movements by moose (Coady 1974). It is also common knowledge that in winters when large snowfall and persistent snowcover occurs in alpine areas of the western foothills in the Talkeetna Mountains, local populations of moose seek refuge and forage at lower elevations in riparian habitats along the Susitna River (Rausch 1958). To account for capturing "eastside" moose in Susitna River riparian habitats in the winter of 1980, I assume that prevailing snow conditions in the western foothills of the Talkeetna Mountains elicited the movement of that local population of moose to riverine habitats.

To account for the apparent failure to capture "westside" moose in the 1980 sample, I assume that local population of moose had already left their Susitna River wintering areas for spring ranges. I have previously presented data from the 1981 sample of moose indicating that a large portion of those radio-collared moose which moved to the west of the Susitna River did so before mid-April, or the time when the 1980 sample was obtained. Perhaps, by 17 April when the 1980 sample of moose was captured, "westside" moose had already departed from riverine habitats. It may be a general occurrence that local populations of moose from the "eastside" depart from riverine habitats at a later date than those local populations from the "westside". The apparent differences in timing of departure from wintering areas on the Susitna River by local moose populations may be justified biologically through local differences in snowcover and plant phenology.

If depth and persistence of snowcover is a key factor influencing the winter movements of moose from "eastside" areas to habitats along the Susitna River, its persistence on into spring may also deter a relatively early return movement back to those areas. Even if areas west of the Susitna River get amounts of snowfall equivalent to the foothills to the east (which is probably not the case), phenological conditions are probably more advanced to the west due to relatively greater and more intensive insolation and less extensive drifts from wind translocated snow. Topography protects areas east of the Susitna River from solar radiation more than areas to the west and the angle of incidence for absorption of radiant energy in the flat level lowlands lying west of the Susitna River is more desirable than in areas to the east. It would also seem that the strong easterly winds which commonly blow through the Talkeetna Mountains would carry large quantities of snow and redeposit it in drifts at lower elevations in the eastside foothills. In total, these factors may contribute to less snow accumulation and more solar insolation which result in lower snow depths and earlier resurgence in growth of forage, making habitats on the westside of the river more hospitable for moose at an earlier time in the spring than areas to the east.

My data would tend to indicate that in any year numerous moose from the "westside" populations over-winter in riparian habitats along the Susitna River.

In contrast to areas where moose were captured south of Talkeetna during the 1981 sampling period, in areas north of Talkeetna few moose were actually observed in riparian habitats, though most were captured within several hundred meters of the Susitna River. Data gathered from these moose, as for those captured south of Talkeetna, also indicate a nonrandom dispersal from the Susitna River and suggest preferential use of habitats on the north-northwest side of the river in comparison to those habitats to the south-southeast of the river. Though data are not available to discount the possibility that these observations were primarily the result of nonrandom sampling, I believe that they are more likely attributable to disproportionate densities of moose and/or preferential use of more desirable habitats with south southeast sloping exposures; either of which were probably mediated through species composition of the vegetative complex, snowcover and/or vegetative phenology.

I suspect that during a winter of above average snowfall and long lasting snowcover, in areas along the Susitna River north of Talkeetna, that considerably more moose would be found in the river bottom habitats of the Susitna River than where were found in March 1981 or during the aerial river censuses conducted in the winter of 1981-82.

Calving Range Period

Data collected from moose radio-collared north of Talkeetna indicated that most females moved to riparian and/or island habitats of the Susitna River during the calving period. In fact, 1 female (No. 80) radio-collared south of Talkeetna was relocated during the calving period about 16 km north of Talkeetna in similar riparian habitat along the Susitna River. I could not ascertain whether these moose moved to riparian areas before or after parturition. The former possibility seems more plausible because long movements of cows with new-born calves would be biologically inappropriate and inconsistent with the literature (LeResche 1974) and cow moose are known to travel great distances to specific calving areas (Didrickson, et al. 1977, and Didrickson and Taylor 1978). In fact, 2 of the moose radio-collared north of Talkeetna (No. 42 and 74), which did not return to Susitna River habitats during the calving period, made their longest movements, 25 and 70 km, respectively, between 17 and 22 June to riparian habitats along the Chulitna River. I assume these moose were returning to traditional calving areas.

Apparently, female moose radio-collared in areas to the north of Talkeetna elected to bear calves in riparian habitats, particularly those along the Susitna River. In Alaska, it is not uncommon for female moose calving sites to be near water or in areas where a large portion of the substrate is inundated with standing water (Bailey and Bangs 1980). Vegetation in moose calving areas has been generally characterized as a mosaic of islands of relatively open medium tall spruce interspersed with muskeg bog meadows (Rausch 1958). However, calving areas used by radio-collared moose north of Talkeetna had grossly different vegetative characteristics. Spruce was the least common and abundant of the 4 major tree types present and muskeg meadows were not even observed. Cottonwood was the most commonly occurring vegetative type and it also dominated in canopy coverage.

In comparing non-riparian with riparian habitat types used by females in this area during the calving period, willow more commonly occurred in the latter type birch and alder occurred equally between types, sedge and/or grass were much less common in the riparian habitats and alder was 45 percent less dense in the riparian habitat type.

Most female moose radio-collared south of Talkeetna departed from Susitna River riparian habitats by late April and did not return to riparian habitats during the calving period. However, several of the females which remained near the river through April, were frequently located on riverine islands or in riparian habitats throughout all seasonal periods. Calving ranges for 5 of the females which departed from riparian habitats were clustered in an area between Trapper Lake and the Susitna River; 2 of those individuals had come from areas to the east of the Susitna River where they were frequently relocated at other times of the year. Other females in this area were widely dispersed at varying distances from the Susitna River during the calving period.

Habitats frequented during the calving period, by female moose radio-collared south of Talkeetna, were more typical of those reported in the literature (Bailey and Bangs 1980 and Rausch 1958). Eighteen percent of the calving period relocation sites were characterized by 50 percent muskeg, a vegetative type never noted at calving sites located north of Talkeetna. In areas south of Talkeetna, spruce occurred at 6 times as many non-riparian calving period sites as did alder and was also more dominant in canopy coverage than alder. Alder was dominant in both categories for non-riparian calving period sites north of Talkeetna.

Except for spruce occurring at more riparian calving period sites in areas south of Talkeetna, vegetative characteristics of those sites were quite similar to riparian sites used by females in areas north of Talkeetna. In spite of this relative similarity between habitat types and the fact that females north of Talkeetna appeared to selected Susitna River riparian habitats, females in areas south of Talkeetna appeared to select and utilize areas more removed from Susitna River riparian habitats as calving sites and habitat types composed of comparatively different vegetative components.

The one feature common to riparian calving sites north of Talkeetna and riparian and non-riparian sites south of Talkeetna was their proximity to water. These data indicate that one of the most important attributes of a calving site may be the presence of water. It is more probable that moose seek wet areas during calving because of the availability of newly growing nutritious succulent herbaceous vegetation and not specifically because of the presence of water, since, it is probably important physiologically for lactating females and newly born calf moose to have a readily available source of easily digestible, highly nutritious forage plants. It is known that in early spring around calving time moose prefer to consume newly growing emergent marsh forbs, sedges or horsetail and that they have been observed to gather in groups on muskeg to consuming those vegetative types in preflower and early flowering stages (LeResche and Davis 1973). Feeding on aquatic plants in spring may also counteract any negative sodium balance which moose may incur while subject to high dietary potassium levels and increased water flux associated with feeding on newly growing succulent forbs (Weeks and Kirkpatrick 1976 and Fraser et al. 1980).

Avoiding predation (Ballard et al. 1980) or insect harassment (Mould 1979) may be a secondary consideration to food in selection of calving sites. Open muskeg areas would provide relief from insect harassment because of air movement, but air movement also may carry moose scent to predators such as black or brown bears or wolves. The relative openness also negates concealment from predators. Riparian habitats which are less open than muskeg would afford little relief from insect harassment but would provide considerably more concealment from predators and decrease the amount of windborn scent.

Summer Range Period

Summer ranges for radio-collared moose were found to be nearer to calving ranges than the latter were to winter ranges. Female summer ranges were larger than their calving ranges. This difference maybe attributed to local availability of food and/or sedentary behavior of cows with newborn calves.

All females radio-collared north of Talkeetna which were located in riparian habitats during the calving period, moved back up to the southwest facing slopes above the Susitna River basin where they spent the summer period.

Some moose radio-collared south of Talkeetna continued to be relocated in riparian habitats during the summer period. Two of these (No. 22 and 23), which had moved from eastside areas across the Susitna River to an apparent calving area near Trapper Lake, were relocated in riparian habitats while returning to eastside areas where they remained during the breeding season. The other radio-collared individuals (No. 37, 84, 85 and 90) which were relocated near riparian habitats during the calving season, were also frequently found in these habitats and/or on riverine islands in the Delta Island complex during other seasonal periods. Apparently, this island group was extensive and varied enough to provide habitats suitable for occupation during all seasons. I suspect that the Bell/Big Island complex in the Susitna River downstream from the Yentna River also is extensive and varied enough to furnish all habitats necessary to sustain moose year-round. Island systems north of Talkeetna may be too small to provide the variety of habitats necessary to sustain moose on an annual basis.

As indicated for non-riparian sites during the calving period, summer relocation sites used by moose to the north of Talkeetna were dominated in both occurrence and in canopy cover by alder. Spruce had approximately equal occurrence in both areas but rated more than twice as high in canopy cover south of Talkeetna. Since spruce is an important cover type used extensively by moose in the winter (Taylor and Ballard 1979), it will be interesting to see if moose north of Talkeetna seek spruce dominated habitats during the winter. Data for males in areas to the north of Talkeetna indicated that they used habitats containing an assemblage of spruce similar to those habitats frequented by males south of Talkeetna. However, these observations may mainly be attributed to the male (No. 92) which ranged on the south-southeast side of the Susitna River where spruce occurred more commonly than on the north side.

Breeding Range Period

The grouping and/or regrouping of moose into breeding harems, which occurs during the breeding season, determines the genetic composition or stability of future populations. The relative commonness or discreteness of resulting gene pools has been used to delineate local populations (Didrickson and Taylor 1978).

Aside from the 4 radio-collared moose downstream from Talkeetna that frequented Susitna River riparian habitats in all seasonal periods, few of the other radio-collared moose were located in riverine areas. Breeding ranges were generally farther from the Susitna River than were calving or summer ranges and breeding ranges were smaller than summer ranges for all sex x area categories of moose, except for the upstream females where breeding ranges were found to be larger than summer ranges. Movements of females during the rut have been shown to be negatively correlated with the ratio of bulls to cows (Houston 1968 and LeResche 1974). For similar reasons, it would seem that the extent of movements during the breeding season would also be negatively correlated with population density. These sorts of observations indicate that disparate sex ratios and or relatively low densities of moose may be present in areas along the Susitna River north of Talkeetna.

Radio-collared males in areas north of Talkeetna made the longest movements between summer and breeding ranges, but once on breeding ranges they were the most sedentary sex x area category. Perhaps these extensive transitory interval movements made by males indicate a relatively low density of females.

Knowing the traditional migratory behavior of moose reported in numerous studies (LeResche 1974) and documented for the 6 individuals monitored during 2 breeding seasons in this study, and the widespread spatial distribution of breeding areas observed for individuals that wintered in Susitna River riparian habitats, one can only begin to grasp the relative importance of the Susitna River riparian habitats to moose produced in the numerous local populations within the broad Susitna River valley.

Winter Range Period

Assuming that radio-collared moose return to their capture sites and/or centers of winter range, females downstream from Talkeetna would have to travel an average of 6 times as far (18 vs. 3 km) as those females in areas north of Talkeetna Breeding ranges for females in areas downstream from Talkeetna were an average of 2 to 3 times as far from the Susitna River as those females in areas upstream from Talkeetna. Though, biologically, movement patterns must have net reproductive or survival benefits for them to have evolved through natural selective process, it is difficult to comprehend how some moose, let alone cows and calves, derive a net gain in fitness by traveling such great distances to winter in Susitna River riparian habitats. Perhaps the net gain in fitness is less for moose in areas north of Talkeetna and accounts for their relatively small seasonal ranges in close proximity to each other and to winter riparian habitats. Whereas for moose in areas south of Talkeetna the gain from wintering in habitats along the Susitna River must be considerable to offset the costs of traveling such great distances to arrive at the river.

MAGNITUDE OF RIPARIAN USE

Data gathered in this study have identified the following major types of seasonal use of riparian habitats: 1) winter range for male and female moose north and south of Talkeetna; 2) calving range for female moose north of Talkeetna; 3) all seasonal ranges for some moose in the Delta Island area south of Talkeetna and 4) transitory interval range for moose that have seasonal ranges on both sides of the river.

Three sequential aerial censuses revealed 322, 324 and 239 moose in riparian habitats along the Susitna River from Cook Inlet to Devil Canyon, in the relatively mild winter of 1981-82. Numbers of moose observed on these censuses certainly do not represent maximum values for a number of years and may represent minimum values within the year. Substantially more moose would be expected to use riparian habitats in a more severe winter (Rausch 1958). Each river census represents the number of moose observed on the river for a particular day or days, they do not indicate the total number of <u>different</u> <u>individuals</u> that utilized those habitats during a particular winter day or period.

After additional data are collected on behavior of radio-collared moose which frequent riparian habitats in winter, reasonable projections estimating the daily, weekly and monthly turnover of individual moose will be possible. Estimates for the number of moose which would use riparian habitats in a severe winter can come only from direct observations during a severe winter.

Averages for 3 aerial river censuses indicate that less than 7 and 11 percent of the moose observed, were found between Talkeetna and Montana Creek, respectively, and Devil Canyon. In view of data presented elsewhere in this report, the occurrence of so few moose observed in riparian habitats north of Talkeetna is not surprising and may in part be attributed to the following: 1) lower densities of moose in adjacent habitats; 2) moose which come to winter in those riparian habitats are not drawn from as extensive an area as for riparian habitats south of Talkeetna and 3) moose in this general area prefer to winter in riparian habitats along the Chulitna River rather than those along the Susitna River and 4) floodplain and/or island riparian habitats are much less common and not extensive enough to support large numbers of moose. I also suspect that, during a severe winter, riparian habitats between Talkeetna and Montana Creek would attract and harbor many moose from the Talkeetna River, Sheep River and Montana Creek watersheds.

About 90 percent of the moose observed during each river census occurred between Montana Creek and Cook Inlet. In the Cook Inlet area 54 to 67 percent of the individuals were observed to the north of the Yentna River. Yet on 2 of the censuses more moose per mile of river were observed between the Yentna River and Cook Inlet. I suspect that quantity of riparian and island type habitat was the major factor contributing to the differences in densities recorded for these 2 areas. Variations in densities of moose observed within and between areas between censuses may in part be attributable to the affects of snowcover on visibility of moose but more probably indicate a flux and turnover in moose utilizing those areas. Additional insight into these occurrences will be gained following radio-collaring and subsequent observation of moose in the area between the Yentna River and Cook Inlet, Zone IV.

Observations from aerial censuses indicate substantial concentrations of moose in localized areas within river Zones III and IV. Characteristics of these particular areas will be more closely scrutinized after data for a complete winter period are compiled. Since dams and calves formed a substantial part of the populations of moose wintering along the Susitna River, numbers of moose using these areas will vary directly with calf production and survival prior to the winter period. In winters following high levels of production and good survival more moose, particularly calves, would be expected to occur in riparian habitats.

If moose seek Susitna River riparian habitats to avoid the deep and persistent snow cover in non-riparian habitats, it would seem that this behavior would be particularly important for calves who, because of their shorter legs would have more difficulty negotiating deep snow than adults.

CONDITION AND PRODUCTIVITY

Condition related blood parameters from samples of moose captured in riparian habitats along the Susitna River during the winters of 1979-80 and 1980-81 indicated that the moose sampled were in below average condition. Their blood profiles more closely resembled those of moose from a low productivity population. Since samples of blood in the present study were obtained from moose that had experienced several consecutive mild winters, I suspect their blood profiles would have been rated in considerably poorer condition had sampling occurred after an average or severe winter.

Blood profiles for samples of moose from another population of Alaskan moose have also indicated below average condition (Franzmann et al. 1980). Since moose in their sample had given birth to calves 1 to 3 days before, low levels for the blood parameters were attributed to stresses of pregnancy, calving and lactation. However, in the present study blood samples were obtained from moose captured in late winter; the time period Franzmann and LeResche (1978) had recommended for ascertaining condition of moose. Perhaps condition related blood parameters are very area specific and comparisons or evaluations of condition should only be made at a local level within a particular population.

Data gathered from 5 and 24 female moose, at the time of their capture on 17 April 1980 and 10-12 March 1981, respectively indicate that at least 40 and 63 percent of those individuals, respectively had produced calves which had survived to that date. Data collected from palpation for feti and/or from subsequent radio-relocation surveys during the spring and summer of 1981 indicated that 23 of 26 females (81 percent) were actually observed with young. Since 3 of the females were observed with twins, these data imply that at least 93 calves may have been produced for every 100 cows in the population sampled.

Three consecutive aerial censuses conducted along the Susitna River between December and early February 1981-82 indicated that 29, 26 and 23 percent of all moose observed were calves. However, it is likely that these calf proportions are low estimates for population values since these censuses were conducted where moose are concentrated in relatively open habitat and it has been documented that cows with calves do not occur in large numbers in areas where moose concentrate in the winter (Novak and Gardner 1975) nor do they venture far from cover or shelter (Thompson and Verkelich 1981). I will be able to more adequately examine these hypotheses after observing the behavior of the presently radio-collared females through the winter of 1981-82.

Data gathered from fall composition surveys conducted in the Matanuska Valley, Alaska for 16 different years between 1955-72 indicated that those populations contained an average of 28.7 percent calves (Bishop and Rausch 1974). Assuming that the distribution of sex and age classes during fall composition surveys and my riparian habitat censuses was similar, these data would indicate that the population of moose along the Susitna River were not in below average condition. In fact, productivity/ survival values for moose in my study are substantially above the averages of 24.6, 14.1, 19.7, 19.2 and 19.9 percent for calves observed on fall composition surveys conducted for 8 years on the northern Kenai Peninsula, 5 years on the middle Kenai Peninsula, 9 years on the lower Kenai Peninsula, Alaska, 19 years in the Nelchina Basin, Alaska and for 16 years in the Tanana Flats, Alaska (Bishop and Rausch 1974).

Contrary to these contentions, it is possible that browse conditions along the Susitna River are deteriorating in spite of mild winters and that the general condition of moose in the area is changing but has not yet evidenced itself in decreased productivity.

The percent of calves observed in each of the 4 riparian habitat zones decreased between each census. In parallel with the general decrease in percent of calves, the proportion of cows observed with twin calves decreased from 12.5 to 5.1 to 2.0 percent of all cows with calves, respectively, for the three sequential censuses. At the present time, it is not known whether the decrease in the percent of calf moose observed on the sequential riparian habitat censuses was a result of mortality or redistribution of the age and sex classes of moose in those habitats.

PREDATION

It is unlikely that the apparent loss of calf moose during the winter was attributable to predation, since bears are denned at that time and, in spite of the number and extent of aerial surveys conducted, neither wolves nor their sign have been observed in the study area. Coyotes (*Canis latrans*) were frequently observed in riparian habitats between Talkeetna and the Delta Islands and foxes (*Vulpes vulpes*) have occasionally been sighted. The latter carnivores, of course, posed no great threat to seven-month-old calf moose.

It is rather surprising that wolves have not taken advantage of the moose resource in this area, particularly during winter when moose concentrate in riparian habitats along the Susitna River.

During the nondenning periods bears are probably the major predators on moose in the study area. Black bears occur commonly throughout the Susitna River Valley and people traveling in boats on the Susitna River and its tributary streams to the west frequently report sighting black bears along the river banks. Black bears are known to frequent river shores, lake shores, and other wet habitats in spring and early summer to feed on early growing herbaceous vegetation (Erickson 1965 and Hatler 1972). In the present study, those sorts of habitats were commonly used by moose during the calving season and though direct evidence is lacking, circumstances here are similar to those on the Kenai Peninsula where black bears and brown bears occurred in moose calving areas and commonly preyed on the calves (Chatelain 1950 and Franzmann et al. 1980). A parallel situation existed in Idaho where elk cows and black bears were attracted to a common habitat to feed on early growing herbaceous plants and in the process of foraging for their primary food source, vegetation, the bears would come up on and kill elk calves (Schlegel 1978). However, the possibility that catching and feeding on elk calves was a learned response was not discounted.

Circumstantial evidence indicates that moose and black bears may also frequent similar habitats during the summer period. Data gathered on the Kenai Peninsula indicate that black bears make extensive movements in the summer to specific habitats to feed on devilsclub (Schwartz and Franzmann 1981, and pers. com.). If black bears in the lower Susitna River Valley behave as those on the Kenai Peninsula, they may again be utilizing the same habitats as moose since devilsclub was observed at 51 percent of the non-riparian summer period relocation sites for all moose radio-collared south of Talkeetna and had an average canopy coverage rating of 20 percent. It is possible that black bear predation on moose calves continues through the summer period in this area.

Brown bears occur throughout the study area but are probably more abundant in the foothills of the Talkeetna Mountains and the Chunilna Hills than in the lowland areas to the west of the Susitna River. No instances of predation by bears have been observed in either portion of the study area.

In the fall, black and brown bears are commonly observed in alpine areas of Mt. Susitna, Little Mt. Susitna and Beluga Mountain, where they concentrate to feed on berries and where many probably den. Future studies planned for radio-collaring a sample of moose south of the Yentna River will provide additional information on the interaction of moose and bears in those habitats.

POPULATION PHENOMENA

Thirty-nine moose captured and radio-collared late in the winters of 1979-80 and 1980-81 along the Susitna River from Portage Creek to the Delta Islands, a linear river distance of approximately 155 km, had by 15 October 1981 ranged over more than 5000 km^2 of habitat adjacent to the Susitna River. Apparently, riparian habitats along the Susitna River serve as winter range for moose which are very widely distributed at other times of the year. It is not uncommon for several populations of moose to share a common winter range (LeResche 1974 and Van Ballenberghe 1977).

Considering general patterns of movement documented for radio-collared moose, large geographical units where radio-collared moose were never relocated and areas along the Susitna River where data have yet to be collected, I have hypothesized the existence of 9 geographical units which contain moose that utilize the Susitna River riparian habitat at some time during an "average" year (Fig. 14). Moose within each geographical unit: 1) behave similarly in their use of riparian habitats; 2) have peculiarities in their life history and/or environment which distinguish them from moose in other units and/or 3) may not necessarily visit those riparian habitats every year.

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

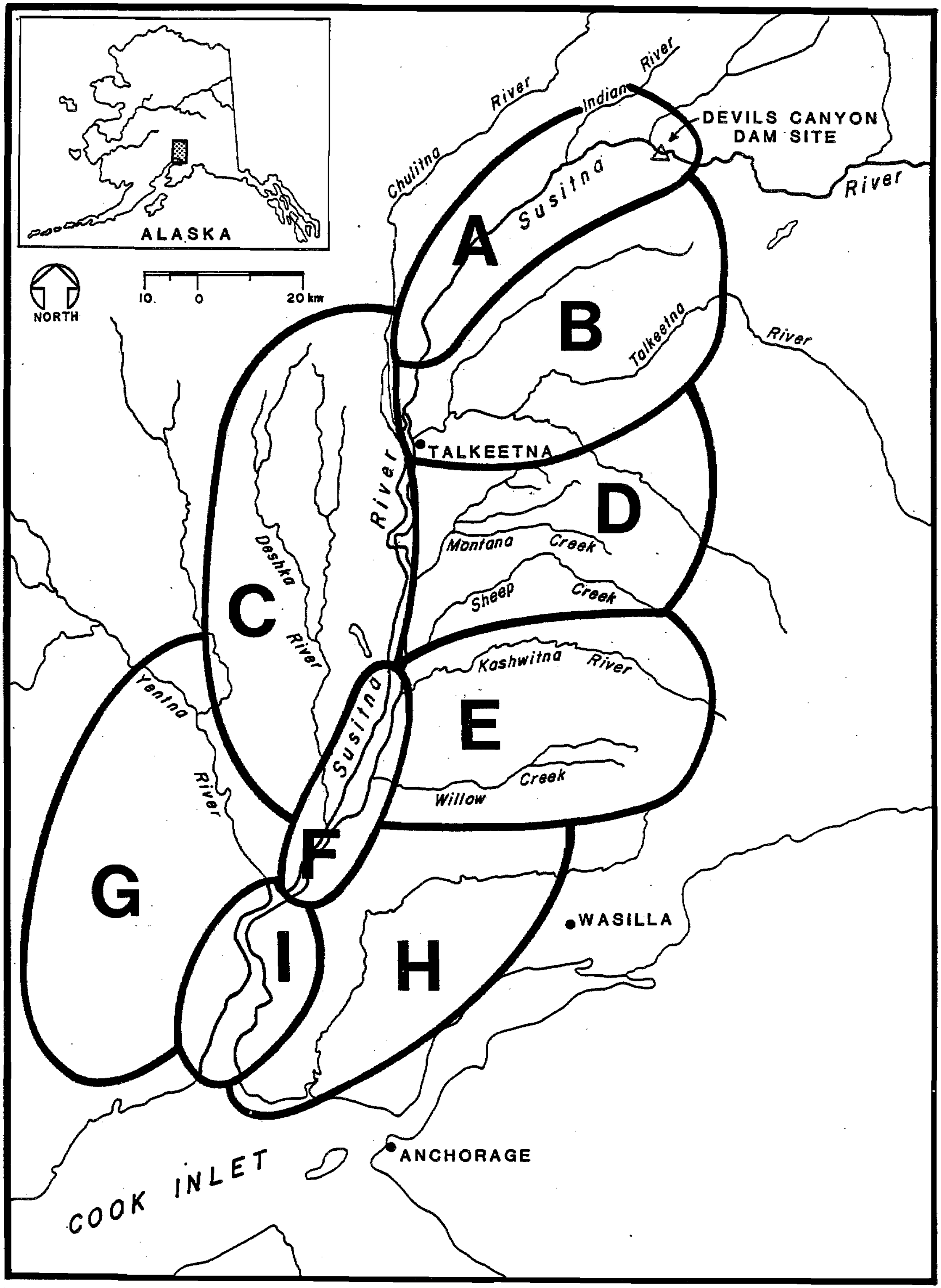

Figure 14. Spatial relationships for hypothetical subpopulations of moose in the Susitna River watershed between Devils Canyon and Cook Inlet, Alaska.

The following annotated list characterizes the 9 hypothetical geographical units:

A - Upper Susitna River: Moose inhabiting this unit seldom ranged far from the Susitna River. Females used riparian habitats during the calving seasonal period. Apparently, island systems are not large and varied enough to sustain moose during all seasonal periods. Alder was the dominant vegetative type observed at non-riparian relocation sites. Few relocation sites occurred to the south-southeast of the Susitna River; indicating a very low density of moose in that area or perhaps another geographical unit to be considered. In some years this unit may receive extreme amounts of snowfall which probably forces most moose into riparian habitats. Topography in this unit may be generally characterized as a 1-3 km river gorge paralleled by mountains rising 500 m above that plain.

B - Talkeetna River/Chunilna River: Few radio-collared moose were relocated in this unit. Extensive river systems must harbor substantial numbers of moose. If so, in severe winters moose from this unit may funnel out of these watersheds to winter on the Susitna River. Lowland areas in this unit grade into mountainous terrain within 10 km of the Susitna River.

C - Deshka River/Trapper Lake: Most moose radio-collared south of Talkeetna utilized this unit during the calving, summer and breeding seasonal periods. This unit contains extensive areas of the spruce island/wet muskeg type habitat commonly used by females during the calving period. A particular concentration of radio-collared moose was noted east of Trapper Lake during the calving period. Many moose from this area wintered along the Susitna River. Basically, a lowland type habitat occurs throughout the area with topography gently grading up from 30 m at the Susitna River to 300 m at the western boundary.

D - Montana Creek/Sheep Creek: Moose in this unit may only utilize Susitna River riparian habitats in severe winters. All female moose captured in 1980 utilized this unit during the breeding seasons of 1980 and 1981. Only one of the females captured in 1981 used this unit during the breeding season of that year. Two females from this unit were near Trapper Lake during the calving period. Topography in the unit grades away from the Susitna River lowlands into foothills and mountains to the east within 10 and 20 km, respectively.

E - Kashwitna River/Willow Creek: Very few relocations of radio-collared moose occurred in this unit though many were radio-collared on its western boundary. Moose from this unit probably utilize the Susitna River riparian habitats during severe winters. Topography in this unit grades away from Susitna River lowlands into foothills and mountains to the east within 10 and 15 km, respectively.

F - Delta Island complex: This unit contains an extensive system of large islands. Several radio-collared moose occurred in the unit during all seasonal periods. Apparently islands are extensive and varied enough to provide moose with all seasonally required habitats. The unit is shared with many moose from other units during the winter period.

G - Yentna River/Mt. Susitna: Only one relocation from moose radio-collared in the Delta Island unit occurred to the west of the Yentna River. Use of this unit probably similar to the Deshka River/Trapper Lake unit but by moose which winter on the Susitna River between the Delta Islands and Cook Inlet. Topography is basically a lowland type and similar to that of Unit C, except for the occurrence of 3 separate mountains (Beluga, Little Susitna and Susitna) which rise rapidly from the lowlands to over 1000 m.

H - Little Susitna River/Big Lake: No radio-collared moose were relocated in this unit but none were collared in adjacent riparian habitats. Many moose from this unit probably winter on the Susitna River. Due to typically windy conditions, snow cover in open areas may not be as problematic as in units to the north and due to the availability of alternative winter ranges, moose in this unit may not be as obligated to winter on the Susitna River as moose in more northern units. The unit contains considerable amounts of wet lowland muskeg habitat and elevations seldom reach 100 m.

I - Big Island/Bell Island complex: No moose were radio-collared in this unit. This unit contains an extensive system of large islands which probably serve as wintering areas for moose from adjacent units (G and H) and sustain other moose during all seasonal periods. It is typically a very windy area and snow accumulations in open areas are considerably less than for most riparian habitats to the north.

In the future, research will be directed at gathering data to test the real existence of discrete subpopulations of moose in the aforementioned geographical units. Moose will be radio-collared between the Delta Islands and Cook Inlet to examine the general patterns of movement for moose in this and adjacent geographical units.

However, some of the hypotheses regarding moose in the mountainous areas to the east of the Susitna River (Units B, D and E) can best be addressed by radio-collaring and monitoring a sample of moose in the appropriate Susitna River riparian habitats and simultaneously conduct a series of sequential aerial censuses along riparian habitats of the Susitna River during a severe winter. Only then will we gain a true understanding of the magnitude and extent of use of Susitna River riparian habitats by those specific subpopulations of moose.

POTENTIAL IMPACTS OF THE PROPOSED SUSITNA RIVER HYDROELECTRIC PROJECT ON POPULATIONS OF MOOSE DOWNSTREAM FROM THE IMPOUNDMENTS

Much of the potential for impacts on populations of moose downstream from the impoundments will result from the affects of altered and/or controlled flow regimes on riparian vegetative communities.

Affects need not be direct; as in spring I have observed moose feeding on trees felled by beavers and should altered flow regimes have a negative affect on populations or distribution of beavers, secondary effects will be transmitted to moose. Likewise, activities of beavers falling trees may open the canopy and encourage new growth of forbs and other understory vegetative types consumed by moose. Trees killed by beavers also lead to instability of stream banks and result in erosion which may secondarily bring about changes in vegetative succession that are favorable to moose. Dams built by beavers create favorable conditions for lush growth of aquatic plants, an important forage for moose.

The value of the Susitna River to moose is founded on its innate instability which results in continual creation and maintenance of seral vegetative communities; any change that would bring about stability and not interfere with normal successional processes would tend to have a negative impact on the types of riparian habitats that are of value to moose.

Predications of project impacts on moose are in part, dependent on predications of the affects of water levels on vegetative communities which, in part, depend on predications of water occurrence and levels which in part, depend on regulation of flow regimes and contours and depths of the river bottom. Due to the unavailability of those sorts of data, at present, I will attempt to point out areas, habitats and/or seasonal periods which appear to be of particular importance to moose and which may be affected by the proposed project.

Though a relatively low density of moose appear to occur in the Susitna River valley north of Talkeetna, the island and riparian habitats appeared to be particularly important to females during the calving season. Loss of these habitats, in that area, could seriously affect production, survival and recruitment into that local population of moose.

If the timing of calving for moose in areas north of Talkeetna is adaptive and indirectly sychronized to occur in parallel with plant phenology for nutritional reasons, and the warmer water temperatures of the Susitna River resulting from hydroelectric development accelerate the growth and development of aquatic and riparian vegetation, moose would have to alter their behavior accordingly, or be confronted with diets of different composition and probably of lower quality.

Though few moose north of Talkeetna appeared to use riparian habitats during seasons other than calving, I suspect that during a severe winter, and knowing the extreme quantity of snowfall which can occur in this locality, that those habitats may be relatively more important to moose in that area than are similar habitats to moose in areas downstream from Talkeetna.

If the Susitna River is ice-free year-round down to Talkeetna, as projected, I envision this as having a detrimental impact on the local population of moose. During cold parts of the winter, the warm open water may lead to the formation of ice fog and result in a tremendous buildup of frost or ice on all vegetation in the river basin. I do not know if moose can metabolically tolerate the increase in energy required to warm the frost and to process the increase in dietary water.

The fact that thin ice and ice flows or jams will not occur during the early spring period prior to calving, probably will decrease the mortality of female moose as they travel to island or riparian habitats or cross the river during this time period. However, the occurrence of open water during the cold parts of winter when air temperatures may reach -35 to -45°C, may prevent moose from efficiently utilizing riparian habitats and preclude all use of island habitats and all crossings of the river. I question whether moose would enter water or swim under such extreme environmental conditions or if they could survive from the exposure if they did.

Since many more moose are ecologically affiliated with the Susitna River downstream from Talkeetna than upstream, impacts in the former area will affect a larger number of moose, and because of their more extensive patterns of movement, effects will be realized at much greater distances from the Susitna River. Impacts in this area will generally occur directly or indirectly through the response of vegetative communities to altered and relatively stable hydrologic flow regimes. Elimination of extreme peaks of water levels will lead to stabilization of those plant communities which will not be periodically inundated and result in habitats of lesser value to moose as plant succession progresses. For the same reasons, a decrease in water levels in other areas will create habitats similar to the type lost. One ultimate result of this process is the localization or centralization of riparian habitats to a point more near the main channel of the river. Since moose are traditional in their use of particular local habitats, I do not know if they would readily be aware of and/or make use of newly created habitats in different areas along the river.

Consequences of changes in flow regimes will be drastically different in the narrow deep channeled portion of the Susitna River north of Talkeetna compared to those in the very broad shallow watered channels, sloughs and marshes which occur between Talkeetna and Cook Inlet. Increases or decreases in water will may affect many more times as much land surface area in the Delta

Islands as would similar changes in water levels at Portage Creek.

Though some moose in the extensive large island complexes utilize riparian habitats year-round, many more moose use the riparian habitats along the Susitna River exclusively during the winter. Even during the mild winters of 1979-80 and 1980-81, substantial numbers of moose used these riparian habitats. During severe winters the same habitats probably harbor 2 to 3 times as many moose.

Not only are more moose using riparian habitats during late winter, but late winter-early spring is also a critical time, a time when both sexes of moose are most dependent on riparian habitat for high quality browse. Pregnant females must maintain themselves in good nutritive condition to meet the demands required for fetal growth; a low quality diet would affect not only the condition of the pregnant females but also the number and quality of young they produced. Males, on the other hand, are at this time attempting to recover condition lost in the rigors of the rut.

Since there is no reason to believe that empty niches or surplus foods are presently available in riparian habitats, any decrease in distribution or abundance of riparian habitats, caused by altering natural flow regimes of the Susitna River, will likewise decrease the numbers of moose that can presently be maintained in good nutritive condition.

Activities associated with construction of impoundments and transmission line facilities also pose potential impacts on populations of moose. Past projects in Southcentral Alaska indicate that construction of vehicular or transmission line corridors will probably temporarily discourage moose from using those immediate areas during the active construction phase and subsequently will encourage their use of these areas through creation of habitats that favor growth of preferred moose winter browse.

In winter, moose will gather and feed in these disturbed areas as long as early successional stages and associated vegetative types persist. If transmission line corridors are "maintained", these preferred habitats would be available indefinitely.

It is important not to create such facilities in areas immediately near present highway systems or the Alaska Railroad right-of-way, since numerous moose are killed by trains or vehicles in these areas every year. In severe winters when numerous moose are attracted to these habitats, trains alone have been reported to kill about 500 animals annually (Rausch 1958).

Of course these habitats may act as a substitute to replace, in quantity, not location, riparian habitats that may have been lost through altered flow regimes.

It is not known whether the "hum" characteristic of high voltage transmission lines will discourage moose from using transmission line corridors.

Another potential impact on moose may secondarily result from the development of an access network for construction and maintenance of the impoundments and transmission line structures. Impacts resulting from increased access into the now remote areas north of Talkeetna may be relatively greater in magnitude than in areas south of Talkeetna where a substantial amount of access and development is already present.

If access into these areas remains open for the public following the construction phase, the intensity of human activities and moose hunting in the respective areas will increase substantially. A level of management more precise than is presently necessary will be required for those populations of moose.

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APPENDIX A

Dates and number for radio relocation flights represented in this report.

Flight No.	Date	Lapsed days [1]	Flight No.	Date	Lapsed days
1	29 April 1980	12[2]	30	22	2
2	6 June	38	31	23	1
3	19	13	32	28	5
4	27	8	33	7 May	6
5	8 July	11	34	8	1
6	17	10	35	14	6
7	28	11	36	21	7
8	11 August	14	37	4 June	14
9	19	8	38	10	6
10	30	11	39	17	7
11	10 September	11	40	22	5
12	18	8	41	1 July	9
13	25	7	42	22	21
14	3 October	8	43	27	5
15	16	13	44	3 August	7
16	31	15	45	4	1
17	14 November	14	46	10	6
18	28	14	47	17	7
19	15 December	17	48	24	7
20	5 January 1981	21	49	2 September	6
21	22	17	50	3	1
22	13 February	22	51	8	5
23	26	13	52	9	1
24	16 March	18	53	14	5
25	23	7	54	21	7
26	3 April	14	55	28	7
27	6	3	56	8 October	7
28	14	8	57	15	7
29	20	6			

[1] Days between each relocation flight.

[2] Days between capture and first relocation flight.

APPENDIX B

Proximity of relocations to the Susitna River for 9 male (M) and 29 female (F) moose radio-collared in different locations along the Susitna River between Devil Canyon and the Delta Islands, Alaska, 1980-81.

		No.		Distance of relocations from river (mi)							
Location[1]	Sex	Individuals	Relocations	River	0-1	1-3	3-5	5-10	10-15	15-20	20+
Upstream											
	M	2[2]	74	3	36	29	6				
	F	10	222	21	82	90	22	6	0	1	
Downstream Westside											
	M	6[3]	162	13	10	55	21	43	0	19	1
	F	15	403	101	41	67	14	87	74	19	
Eastside											
	M	1[4]	45	0	0	2	1	0	9	11	22
	F	4[5]	166	5	4	17	32	77	22	9	

1 Upstream = moose captured north of Talkeetna, Downstream = moose captured south of Talkeetna, Westside = captured moose that spent the breeding season to the west of the Susitna River and Eastside = captured moose that spent the breeding season to the east of the Susitna River.

2 One individual studied 1½ years.

3 One individual studied 1½ years.

4 Individual studied for 1½ years.

5 3 individuals studied for 1½ years.

APPENDIX C

Morphometry (cm) of moose captured along the Susitna River between Devil Canyon and the Delta Islands, Alaska, 1980-81.

Moose No.[1]	Total length	Height at shoulder	Girth	Head length	Neck circumference
19F	NA	NA	NA	NA	NA
20F*	274	82	198	69	75
22F*	287	87	198	79	85
23F*	261	NA[2]	200	85	78
24F*	274	NA	200	76	79
26F*	264	84	184	69	84
27M*	266	86	187	68	81
28F*	183	84	186	75	87
29F	320	NA	211	79	79
37F	NA	NA	NA	NA	NA
42F	NA	NA	NA	NA	NA
45F	293	79	NA	74	NA
56F	321	84	190	78	72
57F	300	82	214	76	80
58M	313	91	198	81	81
59F	301	86	198	76	NA
60M	314	86	206	81	88
62F	289	81	NA	75	84
63F	299	70	272	75	92
64F	291	83	198	74	NA
65M	313	83	218	84	89
66F	249	77	182	68	71
68F	288	NA	NA	77	67
69F	263	81	240	76	84
71F	300	82	NA	78	NA
72F	281	78	244	72	92
73F	261	77	176	74	71
74F	288	NA	212	79	82
79F	300	74	246	76	94
80F	299	NA	NA	78	80
81M	307	78	NA	84	85
82F	301	82	188	77	79
84M	289	82	NA	75	NA
85F	296	NA	218	75	74
88F	310	84	208	80	75
90F	285	83	NA	69	70
91M*	299	85	206	84	103
92M*	281	NA	174	76	80
93M*	303	67	198	86	65

1 F = female, M = male, * = individual captured in 1980.

2 NA = Data not available.

APPENDIX D.

Elemental components of blood sera sampled from moose captured along the Susitna River between Devil Canyon and the Delta Islands, Alaska, 1980-81.

Moose No.[1]	Sex [4]	Date of collection	No. cemental annuli	Phosphorus mg/dl	Calcium mg/dl	Sodium meq/l	Potassium meq/l	Chloride meq/l	Electrolyte balance
19	F	3-10-81	6	3.8	10.5	128	15.4	98	-2.0
20	F	4-17-80	3	6.7	10.1	142	4.2	96	26.0
22	F	4-17-80	6	7.0	10.3	139	4.9	101	16.0
23	F	4-17-80	3	5.2	11.3	139	4.7	95	27.0
24	F	4-17-80	2	4.0	10.9	144	3.6	93	32.0
26	F	4-17-80	3	6.6	11.3	142	6.1	94	14.0
27	M	4-17-80	3	3.8	10.7	137	4.4	94	14.0
28	F	4-17-80	4	5.4	9.8	142	4.4	96	21.0
29	F	3-11-81	10	5.4	10.5	142	5.6	102	21.0
42	F	3-12-81	4	4.5	10.6	140	8.2	98	12.0
56	F	3-10-81	18	3.9	10.5	137	11.4	99	22.0
57	F	3-10-81	11	4.0	11.5	142	13.9	QNS[6]	QNS
58	M	3-10-81	12	3.6	10.4	132	14.8	92	16.0
59	F	3-10-81	15	4.1	11.4	139	12.2	90	26.0
60	M	3-10-81	12	5.0	10.8	139	13.6	92	29.0
62	F	3-10-81	17	3.8	11.0	135	12.9	95	22.0
63	F	3-11-81	5	6.6	10.5	139	8.4	98	13.0
64	F	3-10-81	17	3.6	10.9	132	13.5	89	13.0
65	M	3-11-81	10	4.1	11.0	137	7.7	93	15.0
66	M	3-12-81	1	4.9	9.7	140	7.4	95	7.0
68	F	3-11-81	NA[5]	5.3	11.0	135	8.8	98	10.0
69	F	3-12-81	21	5.9	11.0	138	11.1	97	14.0
71[2]	F	3-10-81	12	3.9	11.5	141	7.8	99	11.0
73	F	3-11-81	2	5.7	10.4	137	6.2	95	14.0
74	F	3-11-81	13	6.8	10.9	138	7.5	99	20.0
79	F	3-10-81	12	4.6	11.7	130	17.6	97	10.0
80	F	3-11-81	5	5.8	10.6	134	8.8	95	16.0
82	F	3-11-81	9	4.7	11.6	145	5.2	96	33.0
84	M	3-10-81	9	4.8	10.6	133	12.8	92	23.0
85	F	3-10-81	15	4.1	10.6	131	17.6	101	-1.0
88	F	3-10-81	7	4.2	11.2	138	13.8	99	21.0
90[3]	F	3-10-81	9	5.6	10.8	1.35	10.1	91	27.0
91	M	4-17-80	5	5.6	11.6	142	5.7	92	36.0
92	M	4-17-80	3	5.0	10.4	139	4.1	95	21.0
93[3]	M	4-17-80	4	4.6	11.2	140	4.2	94	17.0

1 No data available for individuals No. 37, 45 and 81.

2 Not known whether sample is from No. 71 or No. 72.

3 Not known which sample is from No. 90 and which is from No. 93.

4 F = female, M = male

5 NA = Data not available.

6 QNS = Quantity nonsignificant.

APPENDIX E

Electrophoretic fractions of protein from blood sera sampled from moose captured along the Susitna River between Devil Canyon and the Delta Island, Alaska, 1980-81.

Moose No.[1]	Sex[2]	Date of collection	No. cemental annuli	Total protein g/dl (gm%)	Albumin %	Albumin gm%	Globulins Total %	Total gm%	Alpha 1 (%	gm%)	Alpha 2 (%	gm%)	Beta (%	gm%)	Gama (%	gm%)	A/G ratio
19	F	3-10-81	6	6.6	70	4.6	30	2.0	7	0.4	4	0.3	6	0.4	14	0.9	2.3
20	F	4-17-80	3	6.1	77	4.7	23	1.5	2	0.2	8	0.4	7	0.5	6	0.4	3.4
22	F	4-17-80	6	6.5	66	4.3	34	2.2	2	0.2	9	0.5	7	0.5	16	1.0	1.9
23	F	4-17-80	3	6.4	70	4.5	30	1.9	2	0.2	8	0.5	7	0.4	13	0.8	2.4
24	F	4-17-80	2	7.3	71	5.2	29	2.1	2	0.2	7	0.5	7	0.5	13	0.9	2.5
26	F	4-17-80	3	6.1	70	4.3	30	1.8	2	0.2	9	0.5	7	0.4	12	0.7	2.3
27	M	4-17-80	3	5.9	70	4.1	30	1.7	4	0.2	7	0.4	7	0.4	12	0.7	2.3
28	F	4-17-80	4	6.4	71	4.5	29	1.9	2	0.2	9	0.5	7	0.5	11	0.7	2.4
29	F	3-11-81	10	6.9	70	4.9	30	2.1	2	0.2	6	0.4	7	0.5	15	1.0	2.4
42	F	3-12-81	4	6.5	74	4.0	26	1.7	2	0.2	6	0.3	9	0.6	9	0.6	2.9
56	F	3-10-81	18	7.1	71	5.1	29	2.1	2	0.2	7	0.3	8	0.6	14	1.0	2.5
57	F	3-10-81	11	7.2	72	5.2	28	2.0	2	0.2	7	0.5	5	0.4	13	0.9	2.6
58	M	3-10-81	12	6.7	68	4.6	32	2.2	5	0.3	6	0.4	7	0.5	14	1.0	2.1
59	F	3-10-81	15	6.7	70	4.7	30	2.0	2	0.2	8	0.5	7	0.4	13	0.9	2.3
60	M	3-10-81	12	6.8	69	4.7	31	2.1	2	0.2	6	0.3	8	0.6	15	1.0	2.2
62	F	3-10-81	17	6.9	74	5.1	26	1.9	2	0.2	8	0.5	5	0.4	11	0.8	2.8
63	F	3-11-81	5	6.8	73	5.0	27	1.9	2	0.2	8	0.5	7	0.5	10	0.7	2.7
64	F	3-10-81	17	6.7	66	4.4	34	2.3	2	0.2	11	0.6	6	0.4	16	1.1	1.9
65	M	3-11-81	10	7.4	70	5.2	30	2.3	4	0.3	6	0.5	6	0.4	14	1.1	2.3
66	M	3-12-81	1	6.3	71	4.5	29	1.8	2	0.2	8	0.4	9	0.6	10	0.6	2.5
68	F	3-11-81	NA[3]	7.5	72	5.4	28	2.0	2	0.2	7	0.4	7	0.5	12	0.9	2.6
69	F	3-12-81	21	8.5	70	6.0	30	2.5	2	0.2	7	0.6	6	0.5	14	1.2	2.4
71[4]	F	3-10-81	12	7.1	67	4.8	33	2.3	2	0.2	9	0.6	7	0.5	15	1.0	2.1
73	F	3-11-81	2	6.2	75	4.6	25	1.7	2	0.2	7	0.5	6	0.4	10	.6	2.8
74	F	3-11-81	13	7.4	73	5.4	27	2.0	2	0.2	8	0.5	7	0.5	10	0.8	2.7
79	F	3-10-81	12	7.6	70	5.3	30	2.9	2	0.2	7	0.5	6	0.5	16	1.7	2.3
80	F	3-11-81	5	6.1	66	4.0	34	2.1	2	0.2	23	1.3	4	0.2	6	0.4	1.9
82	F	3-11-81	9	7.3	70	5.1	30	2.3	2	0.2	9	0.6	8	0.6	12	0.9	2.3
84	M	3-10-81	9	6.6	63	4.2	37	2.4	5	0.3	6	0.4	7	0.5	19	1.2	1.7
85	F	3-10-81	15	7.1	72	5.1	28	2.0	2	0.2	8	0.5	6	0.4	13	0.9	2.5
88	F	3-10-81	7	6.9	71	4.9	29	2.1	2	0.2	8	0.5	7	0.5	13	0.9	2.4
90[5]	F	3-10-81	9	6.3	70	4.4	30	2.0	2	0.2	10	0.6	6	0.4	12	0.8	2.4
91	M	4-17-80	5	7.2	71	5.1	29	2.2	2	0.2	6	0.5	6	0.5	14	1.0	2.4
92	M	4-17-80	3	6.0	74	4.4	26	1.7	3	0.2	4	0.3	8	0.5	11	0.7	2.8
93[5]	M	4-17-80	4	6.7	66	4.4	34	2.3	4	0.3	6	0.4	8	0.5	16	1.1	2.0

1 No data available for individuals No. 37, 45 and 81.
2 F = female, M = male.
3 NA = No data available.
4 Not known whether sample is from No. 71 or No. 72.
5 Not known which sample is from No. 90 and which is from No. 93.

APPENDIX F

Carbon dioxide and enzymes and other nitrogenous components in blood sera sampled from moose captured along the Susitna River between Devil Canyon and the Delta Islands, Alaska, 1980-81.

Moose No.[1]	Date of Collec-tion	Age	Carbon dioxide (meq/L)	LDH (U/L)	SGOT (U/L)	SGPT (U/L)	Alkaline p'tase (U/L)	Creatinine (mg/dl)	BUN (mg/dl)	Creatinine/ BUN	Uric acid (mg/dl)	Total protein (g/dl)	Albumin (g/dl)	Globulin	A/G	Total bilirubin (mg/dl)
19	3-10-81	6	22	216	50	28	36	2.5	5.0	.50	0.1	6.6	4.0	2.6	1.5	0.1
20	3-17-80	3	10	274	70	48	96	2.6	7.0	.37	0.3	6.1	4.1	2.0	2.1	0.1
22	4-17-80	6	12	269	81	39	55	2.9	5.0	.58	0.2	6.5	4.0	2.5	1.6	0.4
23	4-17-80	3	7	296	55	46	54	2.2	5.0	.44	0.3	6.4	3.8	2.6	1.5	0.1
24	4-17-80	2	9	270	71	44	65	2.3	8.0	.29	0.3	7.3	4.3	3.0	1.4	0.1
26	4-17-80	3	24	269	50	29	50	2.4	6.0	.40	0.2	6.1	3.8	2.3	1.7	0.1
27	4-17-80	3	19	279	56	29	62	2.4	6.0	.40	0.2	5.9	3.6	2.3	1.6	0.1
28	4-17-80	4	15	267	63	41	75	2.6	14.0	.19	0.2	6.4	4.0	2.4	1.7	0.2
29	3-11-81	10	9	283	66	36	65	2.9	7.0	.41	0.3	6.9	4.1	2.8	1.5	0.1
42	3-12-81	4	20	251	73	33	73	2.9	8.0	.36	0.4	6.5	4.1	2.4	1.7	0.2
56	3-10-81	18	6	265	58	28	56	2.5	6.0	.42	0.2	7.1	4.2	2.9	1.4	0.1
57	3-10-81	11	1	344	87	37	39	2.6	7.0	.37	0.4	7.2	4.5	2.7	1.7	0.1
58	3-10-81	12	14	342	102	60	56	2.3	9.0	.26	0.3	6.7	4.1	2.6	1.6	0.1
59	3-10-81	15	13	245	70	33	36	2.2	3.0	.73	0.2	6.7	4.1	2.6	1.6	0.1
60	3-10-81	12	8	258	67	49	27	2.3	4.0	.58	0.3	6.8	4.0	2.8	1.4	0.1
62	3-10-81	17	8	270	54	31	44	2.7	5.0	.54	0.4	6.9	4.3	2.6	1.7	0.1
63	3-11-81	5	18	200	66	27	85	3.0	15.0	.20	0.3	6.8	4.4	2.4	1.8	0.1
64	3-10-81	17	20	247	66	27	52	2.4	8.0	.30	0.5	6.7	3.7	3.0	1.2	0.1
65	3-11-81	10	19	393	86	48	25	2.2	4.0	.55	0.3	7.4	4.5	2.9	1.6	0.1
66	3-12-81	1	28	293	114	50	76	2.1	5.0	.42	0.2	6.3	4.0	2.3	1.7	0.1
68	3-11-81	NA[2]	17	258	151	37	127	3.4	17.0	.20	0.3	7.5	4.7	2.8	1.7	0.2
69	3-12-81	21	17	217	59	30	42	2.7	5.0	.54	0.2	8.5	5.1	3.4	1.5	0.2
71[3]	3-10-81	12	21	270	66	31	38	2.1	3.0	.70	0.2	7.1	4.2	2.9	1.4	0.1
73	3-11-81	2	18	253	73	35	35	2.2	5.0	.44	0.4	6.2	4.0	2.2	1.8	0.1
74	3-11-81	13	9	323	80	56	46	2.7	6.0	.45	0.4	7.4	4.7	2.7	1.7	0.1
79	3-10-81	12	13	310	79	41	73	2.4	4.0	.60	0.3	7.6	4.5	3.1	1.5	0.1
80	3-11-81	5	13	269	NA	NA	26	2.6	4.0	.65	0.4	6.1	4.6	1.5	3.1	0.1
82	3-11-81	9	6	316	73	38	49	3.0	6.0	.50	0.3	7.3	4.6	2.7	1.7	0.1
84	3-10-81	9	8	323	83	53	37	2.5	6.0	.42	0.3	6.6	3.6	3.0	1.2	0.1
85	3-10-81	15	21	312	85	42	69	2.1	5.0	.42	0.3	7.1	4.4	2.7	1.6	0.1
88	3-10-81	7	8	280	60	42	69	2.1	5.0	.42	0.3	7.1	4.4	2.7	1.6	0.1
90[4]	3-10-81	9	7	288	109	68	237	2.4	4.0	.60	0.3	6.3	4.0	2.3	1.7	0.1
91	4-17-80	5	4	311	61	42	32	2.6	8.0	.33	0.3	7.2	4.2	3.0	1.4	0.1
92	4-17-80	3	13	301	54	51	111	2.2	6.0	.37	0.3	6.0	3.7	2.3	1.6	0.1
93[4]	4-17-80	5	4	328	50	31	41	2.5	4.0	.63	0.3	6.7	3.9	2.8	1.4	0.1

1 No data available for individuals No. 37, 45 and 81.
2 Not known which sample is from No. 90 and which is from No. 93.
3 NA = No data available.
4 Not known whether sample is from No. 71 or No. 72.

APPENDIX G

Hemoglobin and hematocrit for whole blood sampled from moose captured along the Susitna River between Devil Canyon and the Delta Islands, Alaska, 1980-81.

Moose No.[1]	Sex[2]	Date of capture	Percent packed cells (Vol %)	Hemoglobin (g/100ml)
19	F	3-10-81	40.3	17.0
20	F	4-17-80	49.5	18.5
22	F	4-17-80	41.1	16.1
23	F	4-17-80	41.2	15.5
24	F	4-17-80	50.8	19.1
26	F	4-17-80	42.0	16.5
27	M	4-17-80	38.6	16.6
28	F	4-17-80	49.3	17.5
29	F	3-11-81	42.3	17.7
42	F	3-12-81	46.5	16.7
56	F	3-10-81	42.2	17.4
57	F	3-10-81	43.4	17.6
58	M	3-10-81	43.3	17.8
59	F	3-10-81	41.9	17.7
60	M	3-10-81	42.2	17.1
62	F	3-10-81	42.4	16.3
63	F	3-11-81	41.7	16.0
64	F	3-10-81	40.0	16.4
65	M	3-11-81	49.2	20.0
66	M	3-12-81	45.0	22.2
68	F	3-11-81	49.2	24.8
69	F	3-12-81	56.2	26.4
71[3]	F	3-10-81	49.2	16.4
72[3]	F	3-10-81	41.2	NA[4]
73	F	3-11-81	39.8	17.0
74	F	3-11-81	51.2	19.5
79	F	3-10-81	48.5	19.3
80	F	3-11-81	44.0	17.8
82	F	3-11-81	41.8	16.6
84	M	3-10-81	35.8	16.6
85	F	3-10-81	45.9	19.3
88	F	3-10-81	45.9	19.3
90	F	3-10-81	36.6	14.8
91	M	4-17-80	45.6	17.1
92	M	4-17-80	44.2	16.5
93	M	4-17-80	44.0	18.0

[1] No data available for individuals No. 37, 45 and 81.

[2] F = female, M = male

[3] Not known which sample is from which individual.

[4] No data available.

APPENDIX H

Organic components of blood sera from moose captured along the Susitna River betweem Devo; Camupm and the Delta Islands, Alaska 1980-81.

Moose No.[1]	Sex[2]	Date of collection	Glucose (mg/dl)	Cholesterol (mg/dl)	Triglycerides (mg/dl)
19	F	3-10-81	155	79	11
20	F	4-17-80	167	68	3
22	F	4-17-80	109	87	0
23	F	4-17-80	185	72	10
24	F	4-17-80	115	77	17
26	F	4-17-80	175	59	19
27	M	4-17-80	212	62	0
28	F	4-17-80	117	74	0
29	F	3-11-81	132	54	4
42	F	3-12-81	148	82	7
56	F	3-10-81	137	71	12
57	F	3-10-81	146	86	41
58	M	3-10-81	162	85	9
59	F	3-10-81	117	99	27
60	M	3-10-81	162	60	9
62	F	3-10-81	123	89	21
63	F	3-11-81	150	78	10
64	F	3-10-81	146	97	11
65	M	3-11-81	112	54	3
66	M	3-11-81	96	64	5
68	F	3-11-81	92	101	0
69	F	3-12-81	116	80	26
71[3]	F	3-10-81	68	99	17
73	F	3-11-81	164	73	0
74	F	3-11-81	86	91	1
79	F	3-10-81	66	92	21
80	F	3-11-81	140	113	4
82	F	3-11-81	131	98	26
84	M	3-10-81	175	87	15
85	F	3-10-81	71	79	13
88	F	3-10-81	135	66	14
90[4]	F	3-10-81	130	80	181
91	M	4-17-80	202	57	13
92	M	4-17-80	136	63	14
93[4]	M	4-17-80	139	80	12

[1] No data available for individuals No. 37, 45 and 81.

[2] F = female, M = male.

[3] Not known whether the sample is from No. 71 (as noted) or No. 72.

[4] Not known which sample is from No. 90 and which is from No. 93.