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SUSITNA HYDROELECTRIC PROJECT

FINAL REPORT

VOLUME I MOOSE - DOWNSTREAM

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SUMMARY

Recent demand for non-fossil fuel energy in southcentral Alaska has stimulated public interest and initiated formulation of a proposal to develop the hydroelectric potential of the Susitna River. The proposal is based on construction of two 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 capacity.

Feasibility of the proposed project will be determined by evaluating environmental impacts as well as economics. Environmental impacts may be linked to alterations in hydrological characteristics of the Susitna River or to other, non-hydrological, factors associated with construction and maintenance of the proposed project.

Impacts resulting from alterations in river hydrology can be divided into 2 categories: 1) those occurring upstream from the impoundments and 2) those occurring downstream from the impoundments. Impacts upstream from impoundments will primarily involve immediate loss of habitats through inundation. Impacts occurring downstream from impoundments will probably involve gradual and less dramatic changes in riparian environments through altered flow regimes and characteristics of the water itself. Altering hydraulics of the Susitna River may affect wildlife directly or indirectly through several intermediate environmental components.

Ultimate impacts of direct or indirect effects of hydroelectric development on migratory species of wildlife may occur quite distant, in time and space, from their proximate cause.

In a 215 km course from Devil Canyon to Cook Inlet, the Susitna River and its tributaries drain about 800,000 km^2 of watershed in the Susitna River valley. Perhaps the innate value of the Susitna River floodplain as wintering habitat for moose (*Alces alces gigas* Miller) is unsurpassed elsewhere in the State.

The general objective of this study was to determine the probable nature and approximate magnitude of impacts of the proposed Susitna River hydroelectric project on moose subpopulations downstream from the prospective Devil Canyon dam site. To accomplish this, one must understand how moose subpopulations utilize habitats on the Susitna River floodplain (i.e., What is the ecological value of these habitats to moose?) and other more distant habitats that may be indirectly altered by the proposed hydroelectric project. Ecological values of floodplain environments to moose must be identified and understood before impacts of the proposed hydroelectric development can be knowledgeably evaluated.

Specific study objectives were the following: 1) determine timing, duration and magnitude of moose use of floodplain habitats along the Susitna River downstream from Devil Canyon; 2) identify moose subpopulations that are ecologically affiliated with the Susitna River downstream from Devil Canyon; 3) determine seasonal distribution and

movement patterns for identified moose subpopulations; 4) identify mechanisms through which proposed hydroelectric development will impact moose subpopulations; 5) determine probable nature and approximate magnitude of impacts on identified moose subpopulations; 6) delineate a geographical zone encompassing moose subpopulations impacted by proposed hydroelectric development; 7) discuss potential options for mitigating impacts from hydrological development with moose and 8) quantify potential of various mitigation options.

This report is primarily based on data from relocations of radio-marked moose collected between 4 April 1980 and 19 June 1985 and from supplemental moose censuses and surveys conducted from 9 December 1981 through 24 December 1986. Pertinent findings detailed in Phase I progress (Arneson 1981) and final reports (Modafferi 1982) and Phase II progress (Modafferi 1983) and annual reports (Modafferi 1984) are also included.

Timing, duration and magnitude of seasonal and annual moose use of floodplain habitats were primarily assessed from 6, 11, 7 and 11 aerial censuses conducted conducted during 5 five winter periods between December 1981 and April 1985, respectively.
Patterns of movement, habitat use, productivity, survival and identity of moose subpopulations ecologically affiliated with the Susitna River floodplain were determined primarily from relocations 18 male and 51 female radio-marked moose. Moose were radio-marked along the Susitna River floodplain between April 1980 and January 1985 along the Susitna River floodplain. Five moose marked in 1980 were recaptured in 1984 and collared with new radio-transmitters.

Some moose used Susitna River floodplain habitats throughout the year. Large numbers of moose occurred on the floodplain in winter when snow and foraging conditions became unfavorable to subpopulations in adjacent habitats. Numbers of moose utilizing floodplain habitats were closely related to severity of climatic conditions in the surrounding watersheds. Findings presented here must be considered cautiously, since they are only representive for winter weather conditions in which sampling and surveys occurred. During the study, annual winter weather conditions varied widely.

In the mild winter of 1981-82, a maximum of 369 moose were observed on 6 censuses of Susitna River floodplain habitats downstream from Devil Canyon. During relatively inclement winters, maxima of 934 and 819 moose were observed on similar censuses in November 1982 and March 1984, respectively. In 1985, following extremely heavy snowfall, a portion of the floodplain contained 50 percent more moose then were observed in the previous 3 winters. Because other data indicate that moose may not utilize the floodplain daily and annually, numbers of different moose affiliated with the floodplain are probably greater than the projected estimate.

Within and between year variations in moose occurrence on the floodplain in winter were primarily associated with affects of snowfall on moose behavior. Number of moose observed on the floodplain correlated with snowpack depth in adjacent areas. Moose rapidly responded to large increases and decreases in snow depth.

Theoretically, gradual increases in snowpack depth would promote maximal moose use of the floodpain winter range. Abrupt heavy snowfall may impede moose migrations to traditional lowland winter ranges. Winter mortality and other factors which affect population levels may contribute to annual variation in moose use of floodplain wintering areas.

Data from individuals radio-marked on the floodplain in winter were used to identify areas that these moose subpopulations utilized during open hunting season, calving and summer seasonal periods. These data were used to predict where impacts to moose from hydroelectric development would become evident during various seasonal periods. Radio-marked moose ranged far from the floodplain during non-winter seasonal periods.

Lowest winter moose densities on the floodplain occurred in mature forested habitats where forage was limited and snow was deep. Greatest moose densities occurred in open forest habitats on high relief islands near Cook Inlet where prevailing winds precluded accumulation of a deep snowpack. Largest numbers of moose were observed in low relief floodplain areas where dynamic river flow regimes maintained early successional plant communities which provided high quality moose forage.

Moose from fourteen different subpopulations were identified to utilize the Susitna River floodplain in winter. Behavior patterns for moose that utilized floodplain habitats varied within and between subpopulations. Some moose of each sex migrated up to 25 km from summer/fall range to winter on the floodplain. Summer/fall ranges of other moose of each sex occurred sympatric with floodplain winter ranges.

Many female moose radio-marked downstream from Talkeetna utilized wet muskeg habitats west of the floodplain during parturition. Most females radio-marked north of Talkeetna departed the floodplain in early spring but returned at the time of parturition. Movements in both areas may be related predator avoidance and/or availability of high quality herbaceous forage for both females and offspring.

The Susitna River was not a barrier to moose movements. Moose commonly crossed the river. Many moose had activity centers on both sides of the floodplain. Moose north of Talkeetna crossed the floodplain most frequently during May and June. Moose south of Talkeetna crossed mostly between February and April.

Moose north of Talkeetna generally had smaller annual ranges than moose south of Talkeetna. Some moose in large islanded habitats south of Talkeetna seldom moved off the floodplain and had small annual ranges that lacked descrete activity centers. Other moose exhibited two activity centers; a winter one on the floodplain and another one removed from the floodplain. Data from a few individuals indicated 3 or 4 seasonal activity centers. Most moose consistently utilized the same activity centers annually. Some moose exhibited movements that were "extraordinary" with respect to documented activity centers.

Mortality of moose in the lower Susitna River valley was attributed to a variety of causes. Large numbers of moose were killed by collisions with trains and vehicles in the Alaska Railroad and highway right-of-ways, respectively, when snowpacks became deep in adjacent areas and surrounding uplands. In winter 1984-85, 325 moose were reported killed by trains in the project impact area. About 100 moose may be killed by highway vehicles in the same sized area. Mortality rates varied along right-of-ways and between different moose subpopulations. Use of deicing salts on roadways may attract moose and increase mortality rates from collisions with vehicles. Five of 21 moose radio-marked north of Talkeetna were subsequently killed by trains.

Death of 6 radio-marked moose was attributed to winter kill, a catch all category for moose that died in winter presumably from inadequate nutrition.

Mortality of other radio-marked moose was attributed to slipping on glare ice; falling through open water leads or thin ice while crossing frozen rivers; drowning while attempting to cross sections of open water, log jams or ice jams; and injuries sustained from intraspecific fights during the rut or from bullets during the open hunting season.

One radio-marked moose was killed in defense of life and property. Inclement winter weather conditions can stress moose and cause them to become aggressive towards humans. During inclement winters, it is not uncommon for moose to be killed in defense of life and property.

About 50 percent of the radio-marked male moose were subsequently killed by hunters during open hunting season.

Although brown and black bears occurred throughout the area and wolves occurred north of Talkeetna, predation on adult radio-marked moose in the project area was negligible. Brown and black bear predation on neonate moose was suspected to be a significant mortality factor in the project area. Death of only one radio-marked adult moose was suspected to be the result of brown bear predation.

Losses to habitat or wildlife from the proposed hydroelectric development were to be mitigated by increasing or maintaining moose carrying capacity above projected levels through habitat enhancement or habitat protection, respectively. For habitat enhancement to be a successful mitigation procedure, target moose subpopulations must be limited by winter forage. Enhancement of moose winter range would be ineffectual in increasing carrying capacity if the target moose subpopulations are limited by predation. If subpopulations are limited by forage in winter, dead moose should be observed in relatively severe winters. Surveys determining distribution of dead and live moose and snowpack depth were used to identify areas that are acceptable for mitigation.

Observations of extensive "winter kill", poor femur marrow fat indices, and low calf:cow ratios in wintering areas on the lower Susitna River floodplain and several tributary streams suggested that range quality was inadequate during inclement winters and limited moose subpopulation growth. These data indicated that habitat enhancement would be an acceptable mitigation procedure.

Moose distribution/abundance surveys conducted 13-15 and 18 March 1985 identified important winter range in a 10,600 km^2 area of the lower Susitna River valley. Seventy percent of the moose observed occurrred in 18 percent of the area surveyed. Areas with high moose densities were identified as potential replacement lands and areas adjacent to replacement lands should be considered for implimenting habitat enhancement procedures (enhancement lands).

Surveys assessing snowpack depth patterns in the lower Susitna River valley watershed were conducted 24-27 March 1985. During this inclement winter, snowpack depth measurements varied from 25 to 225 cm. Snowpack depths greater than 76 and 90 cm were considered critical for survival of calf and adult moose, respectively. More than 80 percent of 12,000 km^2 area surveyed had snowpack depths considered unacceptable for moose winter range. Moose distribution and mortality were related to snowpack depth. Snowpack depths were used to delienate areas unacceptable for mitigation.

Periodic moose surveys in 2 alpine areas, on floodplains of 3 Susitna River tributary streams, in 6 areas on the Susitna River floodplain and 3 areas characterized by disclimax plant communities provided baseline information for quantifying the potential of habitat protection and habitat enhancement for mitigating with-project losses in wildlife or wildlife habitat with "units" of moose carrying capacity. These surveys also provided information on moose use of those habitat types.

Six surveys on 3 Susitna River tributary streams indicated that a maximum of over 23,000 moose days use occurred during a 140 day period from late November to mid-April 1984-85 on an estimated 17 km^2 of winter range habitat along Alexander Creek. Dead moose were commonly observed in this wintering area.

Nineteen surveys conducted over a 4 year period on Bell Island, a 12.5 km^2 island on the Susitna River floodplain, indicated that over 10,700 moose days use occurred during a 139 day period between late November and mid-April 1984-85. Dead moose were seldom observed in this wintering area.

Eight surveys in 2 alpine areas indicated that a maximum of over 45,000 moose days use occurred during a 196 day period from late October to mid-April 1985-86 on an estimated 73 km^2 of winter range habitat on Bald Mountain Ridge. Dead moose were seldom observed in this wintering area.

Eight, 23, 21 and 19 moose surveys were conducted in winter 1981-82, 1982-83, 1983-84 and 1984-85, respectively, on sites where activities of man had altered climax vegetation to favor regrowth of early successional disclimax plant communities. One 2.5 km^2 disclimax site, provided over 6,200 moose days use during a 162 day period between late October and mid-April, 1982-83. Several dead moose were observed at this site.

These data suggest that prime alpine habitats (Bald Mountain Ridge) may provide about 600 moose days carrying capacity per km^2 per winter, prime riparian habitats may provide about 1,400 moose days carrying capacity per km^2 per winter, prime habitats on the Susitna River floodplain may provide about 900 moose days use per km^2 per winter and about 2,500 moose days use could be provided on 2.5 km^2 of selected lands through habitat enhancement techniques.

Follow-up field studies would be necessary to evaluate level of success of mitigation on compensation lands. If moose use and/or carrying capacity on compensation lands is determined to be lower than projected, additional (secondary) mitigation will be necessary.

Bald eagle nest sites were located throughout the study area. Federal law prohibits activities might cause eagles to desert traditional nest sites. Locations with eagle nest sites should not be considered for habitat enhancement.

The following hydrological mechanisms were identified as having the potential for negatively impacting moose subpopulations downstream from Devil Canyon: flow regimes, innudation, open water, ice formation, water temperature, silt, tree debris, fog, dissolved nutrients and salt water encroachment. Potential negative effects of these variables were discussed in relation to specific moose subpopulations. Most variables would impact moose by alterating species composition of plant communities preferred by moose for winter range. Some variables could directly result in moose mortality.

Knowledge about life history, biology, environment, and management for moose subpopulations identified to utilize the Susitna River floodplain downstream from Devil Canyon were summarized in naratives. Subjects discussed in narratives included: size and range of moose subpopulation, human interaction in the area, significant subpopulation movement patterns, noteworthy subpopulation behavior patterns, significant mortality factors affecting subpopulation and concerns and potential with-project conflicts for the subpopulation. In this section relavant research findings are partitioned by indentified moose subpopulations.

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 to Engineers indicated that the proposed project was economically feasible and that environmental impacts would not be of sufficient magnitude to affect its authorization.

More recently, in response to an anticipated demand for a non-fossil fuel source of energy, previous ideas and plans were rejuvenated in 1976 as attention was again focused on a Sustina 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 environmental impacts of the project were not adequately addressed in initial technical field research studies 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 hydrological categories: 1) impacts upstream and 2) impacts downstream from the proposed Devil Canyon impoundment. Initial environmental impact assessments emphasized concern in the pre-impoundment area; concern in the post-impoundment area was considerably less and environmental assessments were "token" in nature. Perhaps, conceptually, acute effects involving loss of habitats through inundation were considered to be more significant than indirect, long-term, chronic type effects that would occur in habitats downstream as a result of altered characteristics of the water and hydrologic flow regimes.

Though impoundments will be located in the upper portion of the Susitna River, environmental impacts resulting from altered flow regimes will be realized along the 215 km section of downstream floodplain. Indirect effects may occur in a much wider corridor of terrestial habitats adjacent to the river and removed from the floodplain. An assessment of the types and magnitude of influence of the Susitna River hydraulics on environments at perpendicular distances from the floodplain is as important to determine as those impacts that occur within the riverbed. For migratory species of wildlife, ultimate effects of proximate impacts may be geographically distant and less 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, watershed of the Susitna River encompasses roughly 800,000 km^2 of extremely productive habitat for many species of wildlife. Perhaps, the potential year-round carrying capacity of the lower Susitna River Valley for moose and the innate value of the Susitna River floodplain as winter habitat for moose (<u>Alces alces gigas</u> Miller) are 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 the same time period, some wintering areas were said to sustain moose at concentrations greater then $22/km^2$ (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 the late winter early/spring period and obscure browse species (Rausch 1959). Such dense winter aggregations are the probable result of moose from numerous subpopulations, some, as remote as 30-40 km (LeResche 1974) to perhaps more than 110 km away (Van Ballenberghe 1977), gathering to seek refuge and forage in lowland habitats. It appears that many moose, from an extensive area and numerous subpopulations, utilize winter range in the Susitna River Valley and on the Susitna River floodplain.

In addition to the occurrence of preferred lowland riparian winter range on the Susitna River floodplain, it is said that the desireability of the Susitna River Valley for moose in the early 1950's was greatly enhanced by early successional stages of vegetation which resulted from wildfires, mild winters, and abandonment of lands cleared for homesteads, highway and railroad construction and rights-of-way (Chatelain 1951).

By the early 1970's, browse available on previously cleared land had been lost through succession and strict fire suppression efforts precluded replacement of fire subclimax plant communities. In response to the decreased availability of winter browse, moose populations had begun to decline. Several severe winters and possibliy a low proportion of males in the population (Bishop and Rausch 1974) compounded the decline in moose numbers. Presently, many habitats in the Susitna River Valley have reverted to the pre-1930 pristine state where floodplains and riparian areas provide the majority of winter browse for moose. Moose populations have adapted accordingly and now exist at lower levels. Lower moose population levels do not mean that the area is any less important to moose than it was in the early 1950's. It simply indicates that fewer moose are using the area now because of present land management policies. Different land management practices could increase moose populations to levels higher than those previously documented.

It appears, that in the past, results of activities of man, as wildfire and extensive land clearing, were the dominant factors involved in creation and maintenance of young second-growth species for moose browse. During that same time period, other ("natural") phenomena, as beaver activity, periodic flooding, ice scouring, riparian erosion, and aluvial or loess translocation of soil, which also stimulated growth of moose browse were viewed as insignificant because they were primarily restricted to riparian habitats and acted on a smaller less dramatic scale.

In the near future, habitats in the Susitna River Basin may again experience a broad ecological perturbation if flow regimes and other hydrologic characteristics of the Susitna River are altered to accommodate hydroelectric development and production of electric power. Alterations in the flow regime and other hydrologic characteristics of the Susitna River (temperature, turbidity, substrate erosion and deposition, ice formation and scouring, ice fog, icing of vegetation, ice free channels, dissolved nutrients, tree debris, and etc.) could impact moose in a number of ways. Impacts to moose would be most profound if vegetative communities which occur along the floodplain were altered so that critical seasonal habitats and/or winter browse species were no longer available to various subpopulations of moose.

A mitigation option under consideration by the Alaska Power Authority include compensation for with-project losses to wildlife and wildlife habitat includes implementing habitat management techniques on preselected lands in the lower Susitna River valley. Habitat management programs would be designed to increase and/or maintain higher moose carrying capacity then presently exists on designatd lands.

The present research study was implemented: 1) to assess the impact of the proposed Susitna River hydroelectric project on moose subpopulations between the Devil Canyon damsite and Cook Inlet and to suggest possible actions to mitigate those impacts, and 2) to identify and evaluate lands in the lower Susitna River Valley on which habitats could be protected or enhanced to mitigate for loss of moose or other wildlife carrying capacity elsewhere.

Primary objectives of first part of this study were: 1) to identify and delineate moose subpopulations that are ecologically affiliated with the Susitna River downstream from Devil Canyon; 2) to determine how, when, where and at what magnitude those subpopulations interface, directly and indirectly, with the Susitna River; 3) to identify mechanisms through which with-project impacts may be transferred to moose subpopulations; 4) to determine the probable nature and approximate magnitude of identified impacts on each particular moose subpopulation and 5) to determine and suggest potential options for actions to mitigate negative with-project impacts.

Objectives of the second part of this study were: 1) to identify lands in the lower Susitna River valley watershed on which high moose carrying capacity could be maintained through habitat protection (replacement lands) or on which low moose carrying capacity could be increased through habitat management (enhancement lands); 2) to develop criteria for selecting and evaluating replacement and enhancement lands and 3) to quantify the potential for mitigation on replacement and enhancement lands.

Knowledge and understanding of moose subpopulation distribution, mortality factors, behavior patterns, habitat use, and limiting factors acquired during study of the primary objectives, in part, facilitated fulfillment of the secondary study objectives.

The following final project report contains relevant findings from the Annual Progress Report Phase I (Arneson 1981), the Phase I Final

Report (Modafferi 1982), the Phase II Progress Report(Modafferi 1983), the 1983 Annual Report (Modafferi 1984) and through August 1986 field studies. This report includes a discussion of findings pertinent to the primary and secondary study objectives. More detailed and specific accounts of the Study Area, Methods and Findings pertinent to data collection and data available occur in aformentioned reports.

STUDY AREA

Susitna River Floodplain

The Devil Canyon damsite lies about 215 km upstream from where the Sustina River empties into Cook Inlet (Fig. 1). While traversing that distance the river descends from about 300 m in elevation to sea level. In its course to Cook Inlet, characteristics of the river, the adjacent floodplain, plant communities and associated habitats for moose undergo a pattern of change. These changes can be roughly separated into four (I-IV) physiographic zones along the rivercourse (see Fig. 2 and Table 1.):

Zone I:

An 80 km section of river from Devil Canyon to Talkeetna. Through this stretch, the river changes elevation from 300 to 105 meters and maintains a narrow (generally less than 150 m wide) channel, interrupted by relatively few widely separated, seldom abreast, islands. Along the northern 3/4 of this route, the river is flanked on each side by mountains commonly ranging over 700 m. Further downstream as the river approaches Talkeetna, these mountains grade into a lower altitude plateau. Cottonwood and alder dominate the river margin. A spruce/birch vegetative complex occurs in the river basin. Extensive stands of alder dominate the steep valley slopes which at higher elevations grade into a moist tundra plant community of sedge, alder, willow and dwarf birch. Several islands immediately north of Talkeetna support stands of second growth willow and cotonwood.

Zone 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 floodplain terrain. It is here that the Susitna first exhibits a "braided" character where many small islands break up and divert the mainstream flow. Apparently, these islands form from combined silt loads of the 3 converging rivers and a reduced general flow rate from the more gradual elevational descent. Seasonal purges by high volume water flows cause these first islands to be relatively small and temporary. The Susitna River maintains this braided character, as it drops only about 30 m in elevation from Talkeetna to its confluence with Montana Creek. Wet treeless, sedge and grass bogs and open black spruce/paper birch forests combine to dominate the vegetative complex on the flat plateau which extends roughly 25 km west of the floodplain. Beyond this distance slight increases in elevation are accompanied by a disappearance of open bogs and an increase in the overall size, density, tree size of the spruce/birch forests. East of the Susitna River, open bogs occur less commonly, spruce/birch forests are more dense and tree size increases before giving way to dwarf birch, willow and ericaceous shrub dominated alpine tundra plant communities about 25 km away in the western foothills of the Talkeetna Mountains.

Zone III:

A 65 km section of river between Montana Creek and the Yentna River. Through this stretch of the Susitna River floodplain extensive tributary streams enter from the East and West. Several of the eastside tributaries originate 40 km or more away at elevations near 1700 m in the Talkeetna Mountains. Apparently, a further decrease in gradient and flow rate of the Susitna River and cummulative silting from upstream and local tributaries have acted, together, to form very extensive and relatively permanent island systems. Here the floodplain frequently exceeds 5 km in breadth, the river occassionally braids into 15 or more channels and islands larger than 2 km^2 are common. Vegetative types adjacent to the west side of the river in this zone are similar to those in Zone II but the extensive wet treeless bogs are less common and are replaced by spruce/birch forests in both the lower half and the more remote parts of this Zone. Wet treeless bogs are common east of the floodplain. In the north, the treeless bogs give way to spruce/birch forests as elevations begin increasing about 10 km from the floodplain. Superimposed within the former habitats and within a 5 km band along the east side of the river south to Willow Creek are an abundance of sites where climax vegetation has been reverted to more seral plant communities incidental to construction of the Alaska Railroad, the Parks Highway, farms, homesteads and other land developments.

Alpine tundra becomes a prominent vegetative type 20 km east of the Susitna River floodplain at 650 m elevation in the Talkeetna Mountains. Tributary streams originating in the Talkeetna Mountains are commonly paralleled by a mix of cottonwood, alder, willow, spruce and birch vegetative components.

Vegetation in the southeastern part of this Zone is characterized by a combination of open treeless bogs, numerous small lakes and open spruce/birch forests. These habitat types prevail up to 30 km from the floodplain, as the latter begins to track to the west at the southern extent of the Talkeetna Mountains.

Zone IV:

A 40 km section of river from the Yentna River to Cook Inlet. The islanded and braided characteristics of the Susitna River are temporarily obliterated after its confluence with the Yentna River. For about 15 km downstream from this confluence the Susitna River becomes a single channeled river less than 1 km wide. However, in the terminal 25 km, the Susitna River again becomes very braided, attains 18 km width and contains a series of very large islands with surface areas exceeding 65 km^2.

Vegetation in the northeastern part of this Zone is a continuation of the open treeless bogs and open 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 west of the river on Mount Susitna, which rises abruptly to over 1300 m elevation. Habitats adjacent to the Susitna River, in the lower half of Zone IV, are characteristically wet grass/sedge marshes interspersed with shallow bog ponds.

Fig. 3. schematically illustrates the location and distribution of various habitat types within the study area. A more complete characterization of vegetation that occurs in these habitat types, appears in Table 2. A more specific discription of plant species which comprise these habitat types is available in Viereck and Little (1972).

<u>Climate</u>

Historical climatic records for the lower Susitna River Valley vary from extensive and complete to spotty and scanty, depending on the specific locality. Records for Anchorage and Talkeetna, which are probably representative of areas near Cook Inlet and more interior areas, respectivley, 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 where continental weather patterns become more dominant, at Devil Canyon.

Summaries of precipitation and temperature records are presented in Tables 3 and 4, respectively. These data document general weather characteristics and demonstrate the gradient from a moderated, maritime climate to a more harsh and extreme continentally influenced climate, as one moves inland from Cook Inlet (Zone I) and up the Susitna River to more interiorly located areas near Devil Canyon (Zone IV) (Fig. 4).

Climatic regimes are known to have direct and indirect affects on moose (Bishop and Rausch 1974, Coady 1974). It can be expected that ameliorated maritime climatic patterns near Cook Inlet are more favorable for moose populations than the characteristically interior weather patterns encountered as one moves farther up the Susitna River toward Devil Canyon.

One would expect that thermoregulation may be less problematic for moose subpopulations near Cook Inlet than for subpopulations in more interior areas where ambient temperatures are more extreme.

Similarly, direct and indirect effects of snowfall on moose must increase substantially as one moves away from Cook Inlet, north, to more interior regions where snowfall is greater and snowcover more persistent.

Strong prevailing cold northeasterly winter winds from the Matanuska River valley eliminates the snowcover in most areas between Palmer, the Yentna/Susitna River confluence and the mouth of the Susitna River. Warm southeasterly winter winds from the Knik and Turnagain Arms frequently cause snowpacks in Zone IV to melt and settle unseasonably early . Lack of snow cover makes portions of this area very favorable for moose winter range.

Project Impact Area

The study area for assessing impacts of Susitna River hydroelectric development on moose was delineated by the extent of movements documented for moose which were known to utilize habitats on the Susitna River floodplain.

It was assumed that moose which utilize Susitna River floodplain habitats in any manner, during any seasonal period, for any length of time, may be impacted by hydroelectric development. Ultimately, that area encompassing all relocations of moose radio-marked on the Susitna River floodplain was considered as the zone where impacts could potentially occur.

Substudy Locations

Information on specific aspects of moose ecology were collected from isolated geographical areas located within the overall study area.

Comparisons of Moose Density and Age Composition:

Data for comparing densities and age composition of moose wintering in different geographical areas and habitats were collected from 2 predominantly small islanded, low relief, floodplain areas and 4 primarily large islanded, high relief, floodplain islands located on the Susitna River south of Talkeetna (Fig. 5).

Moose Use of Disclimax Habitats:

Data for determining moose use of habitats where "natural" plant succession had been altered by man, were collected from 12 sites located adjacent to the Susitna River floodplain south of Talkeetna (Fig. 6).

Moose Distribution on the Susitna River Floodplain:

Data for delineating moose distribution and quantifying use of the Susitna River floodplain, data were gather for 4 subsections (Zones) of the floodplain (Fig. 4).

Other Important Riparian Wintering Areas and Moose Mortality:

Data for identifying and locating important non-Susitna River riparian moose wintering areas and for documenting moose winter mortality were gathered from 4 Susitna River tributary streams (Fig. 4). These tributary streams originate from extensive watersh ds west of the Susitna River floodplain.

Moose Use of Alpine Wintering Areas:

Data for determining moose use of alpine winter range areas were gathered from 2 locations in the western foothills of the Talkeetna Mountains (Fig. 7). These areas were located about 25 km east of the Susitna River floodplain..

Important Non-Susitna River Wintering Areas:

Data for identifying and generally locating important non-Susitna River floodplain moose wintering areas were gathered from a 10600 km^2 area including most of the Susitna River watershed downstream from Devil Canyon (Fig. 8).

Snowpack Depth in Lower Susitna River Valley:

Data for assessing snowpack depth were gathered from an approximately 12000 km^2 area in the Susitna River valley downstream from Devil Canyon (Fig. 8).

Moose Mortality in Highway and Railroad Right-Of-Ways:

Data for moose killed by collisions with trains or vehicles in Alaska Railroad or highway right-of-ways, respectively, were gathered and analyzed primarily for sections of railroad between Wasilla and Chulitna Pass and for section of the highway in Game Management Subunits 14A and 14B, respectively (Fig. 3).

METHODS

Subpopulation Identity, Behavior, Ecology and Mortality Factors

Radio-marking:

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

To provide identifiable individuals that could be periodically relocated, samples of moose were captured by immobilization and marked with visual and radio-transmitting collars. Each collar featured a discrete visible number and radio frequency.

Moose were typically immobilized with an Etorphine (M-99):Rompum gathered from 4 Susitna River tributary streams (Fig. 4). These tributary streams originate from extensive watersheds west of the Susitna River floodplain.

Moose Use of Alpine Wintering Areas:

Data for determining moose use of alpine winter range areas were gathered from 2 locations in the western foothills of the Talkeetna Mountains (Fig. 7). These areas were located about 25 km east of the Susitna River floodplain..

Important Non-Susitna River Wintering Areas:

Data for identifying and generally locating important non-Susitna River floodplain moose wintering areas were gathered from a 10600 km^2 area including most of the Susitna River watershed downstream from Devil Canyon (Fig. 8).

Snowpack Depth in Lower Susitna River Valley:

Data for assessing snowpack depth were gathered from an approximately 12000 km^2 area in the Susitna River valley downstream from Devil Canyon (Fig. 8).

Moose Mortality in Highway and Railroad Right-Of-Ways:

Data for moose killed by collisions with trains or vehicles in Alaska Railroad or highway right-of-ways, respectively, were gathered and analyzed primarily for sections of railroad between Wasilla and Chulitna Pass and for section of the highway in Game Management Subunits 14A and 14B, respectively (Fig. 3).

METHODS

Subpopulation Identity, Behavior, Ecology and Mortality Factors

Radio-marking:

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

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Moose were typically immobilized with an Etorphine (M-99):Rompum (xylazine hydrochloride) mixture (10-12cc:1cc @ 9 mg and 100 mg/cc, respectviely) administered intramuscularly with Palmer Cap-Chur equipment by personnel aboard a hovering Bell 206B helicopter. Immobilized moose were revived with an intravenous injection of Diprenorphine (M50-50, 10-12cc @ 2 mg/cc).

While immobilized moose were collared, measured, marked with ear tags, their age was estimated by incisor tooth wear, their sex was determined and for females associations with young were noted.

Ten, 29, 18, 7 and 12 moose were captured and marked in winter on the ice and snow covered Susitna River floodplain between Sheep Creek and Sherman in 1980 (Arneson 1981), between Delta Islands and Portage in 1981 (Modafferi 1982), between Delta Islands and Cook Inlet in 1982 (Modafferi 1983), at the Montana West "disclimax" site in 1983 and between Talkeetna and Chase in 1984, respectively (Fig. 9). Due to the relatively unavailability of moose on the floodplain north of Talkeetna in 1980 and 1981, some individuals were captured up to 400 m off the floodplain.

Radio-marked moose were relocated with Cessna 172, 180 or 185 aircraft equipped with a Yagi or "H" type antenna on each wing. Relocation surveys were conducted at intervals of about 3 weeks in 1980 and about every 2 weeks thereafter. Inclement weather occasionally altered this schedule.

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

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

Some individual moose provided over 150 points of relocation.

River Censuses:

River censuses were conducted to compliment data on relocations of individual radio-marked moose by providing more quantitative data on behavior patterns for moose subpopulations.

Moose were known to use the Susitna River floodplain year-round. Previous research indicated that the magnitude of use was significantly greater during winter and, particularly so during winters characterized by deep snowpacks which persisted for a long period of time (Rausch 1958). In consideration of this a priori knowledge, periodic aerial censuses were conducted over the Susitna River floodplain from Devil Canyon to Cook Inlet, to assess the magnitude, delineate timing and determine location and spatial distribution of moose use of floodplain habitats. These surveys were conducted throughout the winter period as snow cover permitted observation of moose.

I did not initiate river censuses in the winter of 1980-81. When I became familiar with this project, in early 1981, radio-marked moose had already begun to abandon the Susitna River floodplain and censuses at that time would have been futile. In the winters of 1981-82, 1982-83, 1983-84, 1984-85, respectively, 6, 11, 7 and 11 river censuses were conducted. In winter 1984-85, censuses were limited to portions of the Susitna River floodplain near Caswell, Kashwitna, Delta Islands, Bell Island and between Devil Canyon and Sunshine Bridge. River Zones I and IIa correspond to that portion of the Susitna River floodplain between Devil Canyon and Sunshine Bridge (see Fig. 4).

Aerial river censuses were conducted with a PA-18 aircraft flown at low elevation in a parallel transect pattern between opposing banks of the Susitna River floodplain and upstream from Cook Inlet to Devil Canyon. Though limitations of aerial moose survey techniques were known (LeResche and Rausch 1974), the object of river censuses was to count <u>all</u> moose on the Susitna River floodplain (including interconnecting sloughs) in the designated survey area.

River censuses were conducted over a time period to encompass the buildup, peak and decline in moose use of winter range on the Susitna River floodplain. During river censuses, moose observed were assigned to the following categories: antlered moose, antlerless moose, females with 1 calf, females with 2 calves and lone calves. Locations for all moose observations were noted on 1:63,360 scale USGS topographic maps.

Weather and numbers of moose observed affected duration of individual censuses. Inclement weather and inadequate snowcover for observing moose frequently disrupted continuity within and between surveys.

To account for obvious variation in ecological characteristics of the Sustina River floodplain between Devil Canyon and Cook Inlet, results of river censuses were reported for 4 physiographic zones (Fig. 4.). To facilitate comparison of moose densities between physiographic zones, surface area of terrestrial and aquatic habitat available on the floodplain within each physiographic zone was visually estimated from 1:63,360 scale USGS topographic maps. Surface areas of 28 and 31; 23 and 21; 65 and 104; and 65 and 29 km^2. were estimated for aquatic and terrestrial habitats, respectively, in Zones I, II, III and IV, respectively.

<u>Variation In Moose Use Among Areas on the Susitna River Floodplain</u>:

After conducting aerial river censuses over several years, it appeared that moose were not distributed evenly throughout the Susitna River floodplain. Moose use (moose density) appeared to vary between different areas and habitat types on the floodplain.

To examine this contention and to identify and substantiate the distribution of moose use of floodplain habitats. These surveys were conducted throughout the winter period as snow cover permitted observation of moose.

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To examine this contention and to identify and substantiate the relative importance of different geographical areas and/or habitat types for moose winter range on the Susitna River floodplain, data on moose density collected on river censuses in 1981-82, 1982-83, 1983-84 and 1984-85 were compared between 2 predominantly small islanded, low relief, braided floodplain areas (Caswell and Kashwitna) located north of the Kashwitna River and 4 higher relief, large islanded, more deeply channeled floodplain areas (Delta, Bell, Alexander and Beaver) located south of the Kashwitna River (see Fig. 5).

Ecological Basis of Subpopulation Behavior:

The ecological basis of moose subpopulation behavior and movement patterns was assessed by relating inclusive calendar dates for significant moose life history events to seasonal timing for documented moose movements. This methodology enabled me to relate the timing of moose use or nonuse of Susitna River floodplain habitats with significant events in moose life history. A description of life history events utilized in this analysis and assigned inclusive calendar dates are presented in Table 5.

Time periods for life history events did not encompass the entire calendar year. Transitory intervals were delineated between range use periods to accomodate movement or transition from one range or period to another. To remove affects of transitory movements on identifying locations of seasonal ranges, a very narrow spread of calendar dates was used to encompass life history events. Data provided from this analysis may be interpreted to illustrate how and where impacts from hydroelectric development would most likely be realized in relation to moose subpopulation geography and ecology (i.e., with-project losses to moose or winter habitat on the Susitna River floodplain may impact hunters in a particular area, affect fall moose sex/age composition surveys in another area and alter results of spring and winter calf composition surveys in yet other geographical areas.). These data also provided indirect information on the ecological importance of floodplain habitats to moose (i.e., Why do moose utilize floodplain habitats?, what do floodplain habitats provide to moose subpopulations?, etc.).

Moose Mortality in the Alaska Railroad and Highway Rights-of-Way

Hydroelectric development of the Susitna River will involve transporting large quantities of equipment and materials on freight trains and highway vehicles from Anchorage and more southern sea ports, northward along the Alaska Railroad and highway rights-of-way, respectively, to the prospective dam sites. During construction of this project, amount and frequency of train and vehicular traffic will increase greatly.

Large numbers of moose have reportedly been killed by collisions with trains and and vehilces in the Alaska Railroad and highway rights-of-way, respectively, (Rausch 1958 and ADF&G Files., respectively). Mortality of moose from from these sources is particularly great during winters characterized by deep and persistant snowpacks which cause moose to concentrate in lowland areas near rights-of-way.

Alaska Railroad Right-of-Way: To obtain information on moose mortality in the Alaska Railroad right-of-way, historical train dispatch record files were obtained and reviewed (Alaska Railroad files). Accuracy of dispatch records for numbers moose killed by collisions with trains, prior to acquisition of the railroad by the State of Alaska have been questioned. Kill estimates may be inaccurate and inordinately low (Rausch 1958). Kill records and the recording system utilized after state acquisition (1983) of the then federally-owned railroad, is considered to be more accurrate.

The Alaska State Department of Transportation dispatch records for train killed moose between Seward and Fairbanks from 1963 through 1986 were reviewed and analyzed by year, winter period and location. Coincidentally, the 1984-85 winter was characterized by a very deep snowpack which persisted well into April, caused large numbers of moose to concentrate in lower areas, and resulted in a large moose kill by collisions with trains. Available data were analyzed to document the timing, location and magnitude of the moose kill by trains in the railroad right-of-way. The resulting data also provided baseline information from which to make recommendations for minimizing this with-project source of moose mortality.

Highway Right-of-Way: Moose killed by collisions with vehicles in highway rights-of-way are reported to the Alaska State Troopers. Data on moose mortality in highway rights-of-way are provided to the Alaska Department of Fish and Game by the Alaska Department of Public Safety. The actual number of moose killed by collisions with vehicles is more than that which is reported and recorded. Many moose are hit, injured, and die undetected away from the roadway. Other moose that are hit and killed, are not reported. Data on moose killed by collisions with vehicles in highway rights-of-way in Game Management Subunits 14A and B from 1970 through 1986 were obtained from Department of Fish and Game files. Game Management Subunits 14A and B extend from the Knik River, south of Wasilla, northward parallel with the Susitna River to Talkeetna (see Fig. 1).

Mitigation

Hydroelectric development of the Susitna River will eliminate and/or alter wildlife habitat and result in an overall decrease in wildlife carrying capacity of the Susitna River valley.

To address this possibility, the Alaska Power Authority initiated a process of identification and evaluation of "compensation lands" which could be managed to offset unavoidable "with-project" losses in wildlife carrying capacity. Under this plan, compensation for "with-project" losses in wildlife carrying capacity would involve 1) securing and protecting productive habitats from future alteration as "replacement lands" or 2) securing less productive habitats and secondarily increasing their carrying capacity as "enhancement lands".

Replacement lands are lands that, in their present state, because of location or habitat type, are determined to be important to moose. Preservation or protection of such lands from alternate or different land uses which would degrade their value to moose, would in fact, be an acceptable form of mitigation. Replacement lands may be lands used by moose for calving, winter range, or rutting (etc.) and for those reasons protection of them is determined important for maintaining and sustaining the integrity of specific moose subpopulations.

Enhancement lands are lands where moose carrying capacity could be maintained at high levels or increased to higher levels through habitat management techniques. The net affect of habitat management (enhancement) would be a positive gain in moose carrying capacity. Considering the present state of knowledge on habitat enhancement, enhancement activities would be limited to lands with potential for moose winter range (Harza-Ebasco Susitna Joint Venture 1984). In the absence of high levels of predation, quantity and/or quality of winter range (usually browse quality) affects annual recruitment to moose subpopulations. Long-term moose population levels are limited by interaction of severe winter weather conditions (depth and persistence of the snowpack) and range quality. If winter range quality can be improved or maintained through habitat manipulation to increase the carrying capacity, then greater numbers of moose will survive severe winter weather conditions and long-term subpopulation levels will be elevated.

To provide information on migitation options, studies were intitiated in the Susitna River valley downstream from Talkeetna to: 1) develop criteria for selecting and evaluating replacement and enhancement lands; 2) identify potential replacement and enhancement lands; and 3) quantify mitigation potential for replacement and enhancement options.

Selecting and Evaluating Compensation Lands:

Land Ownership and Regevegetation Potential. Related but independent studies were undertaken to identify ownership status (LGL Consutants, files) and revegetation potential of lands (Harza Ebasco Susitna Joint Venture 1984) in the lower Susitna River valley consideration. Information on ownership status was used identify lands that could be considered for procurement and alternative managment patterns. Information on revegetation was utilized to further identify lands that did or did not have potential for vegetative enhancement.

Moose Subpopulation Ecology and Behavior. In this study, criteria and procedures for selecting and evaluating the enhancement and replacement potential of specific lands in the lower Susitna River valley were primarily gleaned from information on behavior and movement patterns of radio-marked moose and from observations on distribution and habitat use of unmarked moose obtained from aerial surveys. Additional information was obtained from secondary analyses of data gathered for other aspects of this study.

Abundance Stratification Survey. Enhancement and replacement potential of specific lands was appraised by quantifying distribution and abundance of moose in winter. Lands which were utilized by large numbers of moose in winter were assumed to have a high innate carrying capacity and a high potential as replacement lands. It was further assumed that lands which were utilized by large numbers of moose in winter were probably at or near carrying capacity and would be "relatively unresponsive" to enhancement techniques. However, lands adjacent to areas which were utilized by large numbers of moose in winter were considered to have a high enhancement potential.

To identify specific lands which had enhancement or replacement potential a moose distribution and abundance survey was conducted in a 10600 km^2 portion of the Susitna River watershed downstream from Devil Canyon (Fig. 8).

Procedures for conducting the moose distribution and abundance survey were similar to those utilized for stratifying sample units in a stratified random census method developed for moose (Gasaway et al. 1985). The survey area was divided into 30-40 km^2 sample units discernable from low flying aircraft (Appendices A and B). Sample units were surveyed for moose and moose tracks. A " moose track" was indicated by fresh moose tracks in the snow. "One" moose track theoretically indicated that <u>one</u> moose was present in the sample area but was not observed. The survey was conducted at low level flying in Cessna 180/185 aircraft with a crew of a pilot, navigator and 2 observers. Observations of moose and moose tracks were "called out" to the navigator who recorded them on 1:63,360 scale USGS topographic maps. The navigator also directed the pilot through the survey area and plotted the flight path on the same topographic maps. Sample unit boundaries were delineated on the survey map so that none were overlooked. Typically, the search effort lasted two-three minutes and involved two-three aerial transects through representative habitat types in each sample unit.

Because sample units in size (3-23 sq mi), raw survey data were adjusted. To obtain adjusted estimates of moose use among different size sample units, values for moose and moose track density were calculated for each sample unit by dividing the number of moose and moose tracks observed by area of the sample unit. Area for sample units was calculated with computer software from data of computer digitized sample unit boundaries.

Because overstory and habitat type affect observability of moose, these survey procedures fail to enumerate "all" moose present in particular sample units. However, for many sample units in alpine tundra or low shrub habitats, almost all moose present were observed and counted.

Number of "moose tracks" in sample units with high moose density are of little value because when moose were readily observed "track calls" were neglected. However, in sample units where few moose or no moose were observed, "track counts" accurately reflect previous moose use or movements through the area. Sample units or habitats of the later type are probably much more important to moose than areas where both few moose and few tracks were observed.

This survey technique provided an economical means of delineating distribution and relative abundance of moose throughout a major portion of the lower Susitna River valley. Results of this survey, also contributed circumstantial evidence that was used, in part, to make estimates of moose subpopulation size.

Non-Susitna River Floodplain Wintering Areas. To refine identity and location of important non-Susitna River floodplain moose wintering areas, aerial surveys were conducted along floodplains of Susitna River tributary streams (see Fig. 4) and in alpine areas of the western foothills of the Talkeetna Mountains (see Fig. 7). Tributary stream floodplain areas surveyed were the Yentna River and Alexander, Kroto and Moose Creeks. Alpine areas surveyed were Bald Mountain Ridge and Willow Mountain. Twelve and 8 periodic moose surveys were conducted in tributary stream floodplain and alpine areas, in winter 1984-85 and 1985-86, respectively. One moose survey was conducted in alpine areas in winter 1986-87. Survey procedures and data recorded were similar to those for river censuses.

Snowpack Depth Survey. Snowpack depth affects the quality of moose winter range. Deep snow impedes movements of moose, buries forage, reduces availability of forage and increases energetic costs of obtaining forage. Regardless of forage availability, areas that traditionally have a deep and persistant snowpack are of little value as moose winter range. Ideal moose winter range may be characterized by a shallow snowpack and an abundance of forage. To evaluate the enhancement or replacement potential of specific lands with respect to snowpack conditions, a survey was proposed to determine snowpack depth over an extensive portion of the Susitna River watershed downstream from Devil Canyon (see Fig. 8).

A technique based on systematic sampling design was utilized to assess snow depths throughout the study area. This technique involved measuring and recording snow depths in a grid pattern defined by the points of intersection of range/township coordinate lines on 1:250,000 scale USGS topographic maps. This methodology provided snow depth measurements at about 10-14 km intervals in the area sampled. It was believed that this sampling intensity would adequately describe snowpack configuration throughout the study area.

At locations of particular interest, the Bell Island area, the Chijuk Creek area and the Chulitna-Susitna River "triangle" area, additional representative sampling sites were selected during field operations. Sampling was intensified in the former area because it was known to be a heavily utilized moose wintering area. The latter two areas were sampled intensively because they were specifically being considered for enhancement in the Susitna Hyrdoelectrical Project Moose Mitigation Plan (LGL Consultants, files).

In theory, sampling sites were indicated by the point of intersection of range/township coordinate lines on 1:63360 scale USGS topographic maps. In the field, sampling sites were located by reference to topographic map features. A Bell 205B helicopter was used to navigate two field personnel as near as possible to each predetermined sampling site. When vegetation or topography precluded landing helicopter at the predetermined sampling site an alternate site was selected. Alternate sites were the next nearest area where the helicopter could be landed. In most cases, sampling occurred within 200 m of the preselected site. Since glaciation affected actual snow levels on lakes and waterways, sampling over those substrates was avoided and an alternate site was selected.

At each sampling site, snow depth was measured with a graduated two piece, 250 cm length of 2 cm width aluminum U stock. This aluminum probe was "jabbed" through the snow pack until its tip contacted a firm substrate. Frequently the probe had to be forced through compacted and/or crusted layers of snow before a solid substrate was reached. Five snow depth measurements, spaced about 30 cm apart were obtained and a recorded at each sampling site. In most cases, measurements were taken from aboard the helicopter or in forest openings less than 50 m in diameter. Results of each series of measurements were called out to and recorded by the person navigating the pilot to sampling sites.

A single value for snow depth was ultmately associated with each sampling site. To obtain this value the high and low values were discarded. If 2 or 3 of the remaining measurements were common, that value was utilized; if not, the arithmetic mean of the three measurements was calculated and utilized. The resulting number was associated with the sampling site.

Field sampling was timed to correlate with both annual maximum snow accumulation in the study area and the time period when most moose subpopulations are distributed on "late winter" winter ranges. Data obtained during earlier phases of this study indicated that some moose subpopulations do not move to winter range until late January. Field survey procedures were conducted on 24-26 March 1985. Circumstantial evidence indicated that seasonal and annual timing of the snowpack depth survey coincided with maximum snowdepths recorded for the study area in a ten-year period (SCS 1985).

Food-Related Winter Moose Mortality. Habitat enhancement techniques are usually designed to produce additional winter food for moose. For habitat enhancement techniques to be affective in increasing moose carrying capacity, "target" moose subpopulations must be directly or indirectly limited by winter food resources. Habitat enhancement targeted for a moose subpopulation that is limited by factors other than winter browse (as predation) would be inappropriate mitigation. Before habitat enhancement is considered an acceptable method of mitigation for a moose subpopulation, it should be demonstrated that the moose subpopulation is limited by availability of winter forage or that availability of additional forage will have positive affects on moose carrying capacity.

Inadequate winter range conditions are typically evidenced by: an overall scarcity of browse, browse available above the snow level is primarily large diameter branches and evidence of feeding on tree bark may be obvious. Inadequate winter range may initially affect moose nutritive condition and productivity. As quality of the winter ranges deteriorates further dead moose are observed in wintering areas. Moose mortality is particularly evident during winters with deep and persistant snowcover. Moose that die from inadequate winter browse (quality or quantity) are typically calves and/or individuals with low bone marrow fat content.

To evaluate if habitat enhancement would be considered an affective form of mitigation in the lower Susitna River valley, preliminary investigations were conducted to determine if moose subpopulations in the lower Susitna River valley were limited by inadequate winter range. Moose mortality was documented, availablity and condition of browse on winter range was assessed subjectively, and nutritive condition and age composition of moose that died on winter range were determined.

To document and quantify moose mortality in wintering areas, observations and locations of dead moose (carcasses) were recorded on all moose surveys.

To appraise status of winter range browse and to determine nutritive condition and age of moose that died during the winter, field excursions were conducted to moose wintering areas in April and May of 1985. Wintering areas visited were Alexander Creek, Moose Creek, Kroto Creek, Lake Creek and the "Caswell" and "Kashwitna" floodplain portions of the Susitna River floodplain (see Figs. 1, 5 and 7). Winter forage conditions were subjectively appraised by looking for sign typical of winter range inadequacy: evidence indicating utilization of large diameter browse, utilization of tree trunk bark and utilization of browse that is out of normal browse level. Browse was broken-down before being consumed constituted evidence in the later category.

Calf Composition and Moose Mortality Data on numbers of dead moose (carcasses) and percent calves observed at 4 locations on river censuses were used to identify potential replacement and enhancment lands on the Susitna River floodplain (see Fig. 5). Two locations represented habitats on large, relatively high relief floodplain islands and 2 locations represented habitats on small low relief floodplain islands. The former locations were near to Cook Inlet and the latter areas were located about 85 km upstream (north).

These data were also used to illustrate that some floodplain areas contained potential replacement lands whereas other floodplain areas contained potential enhancement lands.

Bald Eagle (Haliaeetus leucocephalus) Nest Sites. Bald eagle nest sites occur commonly along the Susitna River floodplain. Federal law prohibits disturbances and alteration of habitat within about 90 m of an eagle nest. Because mitigation procedures may invlove manipulation of vegetation, it was important to identify location of eagle nests in areas where habitat enhancement might occur. Locations of eagle nests observed on all aerial surveys were noted on 1:63,360 scale topographic maps. Each year observations of nest locations were consolidated onto one map. After all field research terminated, observations of nest locations for all years were combined and indicated on a single map. Combining nest location data from numerous maps resulted in some nests being in close proximity to others. In some instances, such "duplicate" observations obviously represented the same nest that had not been precisely located on the map; in other instances the observations may have represented two different nest sites. I know of several locations that had two different nests in very close proximity.

Quantifying the Compensation Potential of Mitigation Lands:

Losses of wildlife or wildlife habitat that result from hydroelectric development of the Susitna River will be compensated for through mitigation. The mitigation plan under consideration is designed to compensate with-project losses with sustained increases in moose carrying capacity on replacement lands or enhancement lands.

I used moose densities to indicate areas (habitats) that had a high liklihood of being important. These data do not indicate others areas were unimportant. Supplementary data on life processes (reproduction, seasonal nutrition) and factors that might influence these processes (eg. snowpack depth) were used to construct a rationale supporting the concept of that these areas were important. Quantification of value of compensation lands might have required further investigation.

Enhancement Lands. Enhancement lands are lands where moose carrying capacity can be maintained at high levels or increased to higher levels through habitat management of winter range. The goal of habitat management (enhancement) would be to increase the size of a moose subpopulation by increasing winter range carrying capacity. If winter carrying capacity is increased, then greater numbers of moose would survive through severe winter conditions and long-term subpopulation levels would be elevated. Success of enhancement procedures would be evaluated by quantifying long term increases in numbers of moose utilizing a given winter range.

The potential for increasing moose winter range carrying capacity through habitat management (enhancement) was assessed by studying and quantifying moose winter use of sites where activities of man had disturbed natural plant succession ("disclimax sites") and resulted in regrowth of early successional, disclimax plant species preferred by moose for winter browse. It was assumed that similar disturbances to like habitats would result in similar winter range with comparable moose carrying capacity. If a specific size disturbed site supported (provided range for) 50 moose throughout winter, then creation of a similar size site would likewise be expected to provide winter range for 50 moose. It could be assumed that such a site would compensate for a loss of 50 moose or winter range for 50 moose.

To document and quantify moose use of disclimax sites, data were collected from 6 sites in 1981-83 and from 7 additional sites in 1983-85. Eight, 23, 21 and 19 periodic moose censuses were conducted on "disturbed" sites during the 1981-82, 1982-83, 1983-84 and 1984-85 winters, respectively. "Disclimax" sites studied were located adjacent to the Susitna River floodplain dkownstream from Talkeetna (see Fig. 6).

To census moose on "disclimax" sites, aerial surveys were conducted by flying low-level transects over each area in a PA-18 aircraft. A 100 m band around the perimeter of the site was also surveyed, to include moose which were utilizing the area but were "bedded down" in denser adjacent vegetative cover when the survey was conducted. Moose observed were classified into sex and age catagories similar to those utilized on river censuses.

Numbers of moose observed on periodic censuses of 2 disturbed sites (Montana west and Montana middle, Fig. 6) along the Susitna River floodplain were utilized to calculate monthly and accumulative days of moose use. Numbers of moose utilizing sites during intervals between consecutive surveys were estimated by assuming that numbers of moose observed on sequential surveys also occupied the site prior to and after the midpoint day between any two consecutive surveys (i.e., if 50 moose were observed on a site 1 Novemeber and 75 moose were observed on 30 November, I assumed that 50 moose occupied the site from 1-15 November and that 75 moose occupied the site from 16-30 November). It was assumed that habitat management techniques similar to original "disturbances" in similar habitats would produce like second growth vegetative communities and provide winter browse for like numbers of moose.

Replacement Lands. Lands with replacement potential are lands which in their present state, because of location or habitat type are determined to be important to moose. These lands may be of significant importance to a particular moose subpopulation for calving, rutting, or winter range, etc.. If these habitats are important to moose and future land uses may degrade that importance, then protection and preservation of such lands would be judged critical for maintaining and sustaining the integrity of specific moose subpopulations and be considered acceptable mitigation.

Potential replacement lands identified in the lower Susitna River valley include moose winter and post-rutt ranges. Specific habitat types utilized by parturient female during calving were identified but their importance of a unit of land based on density of moose utilizing them, was significantly less than for winter and post-rut ranges.

Benefits derived from this type of mitigation can be estimated by quantifying moose use of the specific parcel of replacement land. One must assume that if the parcel of land were not acquired ("set-aside") solely for management of a particular moose subpopulation that its habitat could be altered immediately and its value to moose would be degrade entirely. If 50 moose utilized a partilcular parcel of "potential replacement land", then preventing degradation of that land parcel could compensate for a with-project direct loss of 50 moose or indirect loss of habitat (carrying capacity) for 50 moose.

"Time frames" (years) for compensation would have to be established for various mitigation measures. Perhaps "moose years" is a useful unit for which to calculate "credit and debit" accounts for moose carrying capacity. The Susitna Hydroelectric project would have a life of 50 years. Environmental impacts could be realized throughout that entire 50 year time period or for shorter time periods. Likewise individual mitigation measures may be relavent for life of the project or only a portion of the life. Some forms of habitat degradation might not occur for 20 years but mitigating that degradation would still have some compensatory value.

Densities of moose observed on periodic censuses conducted in 6 areas on the Susitna River floodplain and in 2 areas above timberline in the western foothills the Talkeetna Mountains east of the Susitna River were utilized as indicators of probable value of habitats and as a quantifier of potential habitat carrying capacity for replacement lands. Numbers of moose observed on these periodic censuses were used to calculate monthly and accumulative monthly moose days use for specific habitats and potential replacement lands.

Numbers of dead moose (carcasses) and percent calves observed on censuses at 4 locations from two areas of the Susitna River floodplain were also used as indicators of probable habitat value for consideration when identifying potential replacement and enhancement lands. These data were also used to illustrate that some floodplain areas contain potential replacement lands and other floodplain areas contain potential enhancement lands.

__Parallel Data on Impact Assessment and Mitigation Planning From Other Disciplines__

Impact assessment and mitigation planning should not be based solely on information gathered from wildlife populations. Wildlife populations can be used as an indicator of downstream impacts and for selection of compensation lands.

Ideally, parallel data on downstream impacts and mitigation planning should be provided from hydrological, botanical, demographical, socialogical, etc. research studies. Data from all disciplines should then be integrated to provide a unified assessment of potential downstream impacts and options for mitigation planning. The later data were not available when project environmental assessment studies were precluded.

__Moose Subpopulation Naratives__

Naratives describing behavior patterns, mortality factors, interfaces with human activities, geographic settings, potential with-project impacts, and other outstanding or peculiar ecological factors were prepared for moose subpopulations identified to utilize the Susitna River floodplain. In these accounts, I discuss information that I believe is pertinent and needed for assessing with-project impacts to moose.

A large part of these accounts are based on circumstantial, or substantiated data obtained in other aspects of this study. However, other portions of the accounts are largely unsubstantiated and are my best "guesses" or "estimates" as to the exact situation or its magnitude (i.e., mortality factors, subpopulation size). Because of the latter fact and the non-technical format of the subpopulation naratives, they are included in the Appendix (E) section of this report.

__Limtations of Samples and Sampling Effort__

Samples are only representative of the population from which they are drawn. Moose subpopulation use of the Susitna River floodplain is greatly influenced by winter conditions, photoperiod (seasonal time) and location. Radio-marked moose are only samples of groups of moose using specific areas on specific dates, during specific types of winters. Subpopulations which winter on the Susitna River floodplain but were not present on those dates or utilize the floodplain during other seasonal periods may not have been adequately sampled.

Only a small sample of radio-marked moose was maintained north of Talkeetna, where impacts from hydroelectric development were expected to be greatest. A high proportion of moose from this subsample were lost due to mortality by hunters (1), trains (4), winter kill (2), and natural accidents (2). Additional moose were radio-marked in this area in January 1984, but only one additional year of data was obtained from those individuals and some succumbed to similar mortality factors. For these reasons, I believe that baseline data presently available to identify and assess habitat use for moose subpopulations which use this portion of the Susitna River floodplain may be inadequate.

DRAFT

FINDINGS AND DISCUSSION

Timing, Duration and Magnitude of Floodplain Use

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

Some moose use Susitna River floodplain habitats throughout the year but greatest use of the floodplain occurs in winter when snow and foraging conditions become unfavorable to moose subpopulations in adjacent habitats (Rausch 1958). A shallower snowpack and greater availability of high quality browse encourage large numbers moose to immigrate great distances to winter on the floodplain. Timing, duration and magnitude of moose use of the Susitna River floodplain as winter range are strongly influenced by snowpack depth in the surrounding Susitna River Valley. However, I believe that activities and movements associated with rutting (pre-winter) and calving (post-winter) would preclude the effects of extreme variation in weather and snowpack depth on timing of moose migratory behavior. Considering these factors, early winter migratory behavior would not occur until until late October when the rut is completed and early spring migratory behavior which preceeds calving would not be delayed later then late April.

Periodic censuses of moose in floodplain habitats within a given winter and during several winters provide information on: 1) timing of moose use of these habitats; 2) habitats or areas that are most attractive to moose; 3) numbers of moose that utilize floodplain habitats; 4) numbers of moose that floodplain habitats may potentially support; 5) sex and age composition of moose which use specific riparian habitats, and 6) duration of moose use of these haibtats. Surveys conducted prior to and/or after a major migration of moose may provide indirect information on numbers of moose and identity of subpopulations which are year-round "residents" to floodplain habitats.

Information obtained from 35 moose censuses, gathered during contrasting annual winter weather conditions, in floodplain habitats along the Susitna River between Devil Canyon and Cook Inlet (Table 6 and Fig. 10) substantiated observations of Rausch (1958) and others (Chatelain 1951 and LeResche 1974) about affects of weather on behavior of "railbelt" moose subpopulations and their use of winter range along the Susitna River. Six censuses were conducted from 9 December through 12 April during the relatively mild and snow-free winter of 1981-82. Eleven censuses were conducted from 29 October and 13 April during the relatively early and inclement winter of 1982-83. Seven censuses were conducted from 17 Novemeber through 15 March during the relatively late and severe winter of 1983-84. Eleven censuses were conducted from 27 Novemeber through 17 April during the relatively late but long and very deep-snow winter of 1984-85. Snowpack depth in the lower Susitna River Valley in winter 1984-85 was greater than that recorded in the previous ten years (Soil

Conservation Service 1985).

During the mild winter of 1981-82, a maximum of 369 moose were observed along the entire length of the floodplain and a maximum of 36 moose were observed between Devil Canyon and Talkeetna.

Following substantial snowfall early in winter 1982-83, a maximum of 934 moose were observed on the entire floodplain in early January. At that time, eighty-four moose were observed in the survey area between Devil Canyon and Talkeetna. From late January through the remainder of the winter, numbers of moose observed on the floodplain decreased in response: 1) to absence of additional major accumulations of snow, and 2) to settling of the accumulated snowpack. On eight of the ten surveys conducted that winter, more moose were observed than on any survey conducted in a previous year.

River surveys provided evidence that large numbers of moose can and do rapidly respond to an early and extensive accumulation of snow and a gradual dissipation of the snowpack with migrations to and from the floodplain, respectively. In 1982 deep snowpacks in October initiated a major movement of moose to floodplain habitats. In 1985, persistence of a snowpack into April apparently resulted in large numbers of moose remaining on the floodplain in mid-April.

In winter 1983-84, little snowfall occurred in the study area prior late December. However, from January through February the snowpack increased substantially. Extremely mild and warm weather in early March, rapidly dissipated the snowpack. Data obtained from moose surveys indicated that few moose were observed on the floodplain through early January. Between January and early March numbers of moose observed on the floodplain increased dramatically (from about 350 to 819). By mid-March numbers of moose on the floodplain had decreased sharply and most survey areas contained few moose and snowcover was insufficient for intensive moose counts.

In winter 1984-85, other field activities precluded conducting moose surveys along the entire Susitna River floodplain downstream from Devil Canyon. Only floodplain areas between Devil Canyon and Sunshine Bridge (Zone I and part of Zone II) were periodically surveyed.

Snowfall in the lower Susitna River Valley in winter 1984-85, was the greatest recorded in the previous ten years. By February, the snowpack was nearly twice the normal depth (Soil Conservation Sevice 1985). A sustantial snowpack remained in most areas through mid-April. Numbers of moose observed in Zone I on 18 January were 50 percent higher than for any previous survey (132 vs. 88). Though only a portion of Zone II was surveyed, the number of moose observed on 18 January was the second highest number observed for that entire zone on any previous survey. Large numbers of moose continued to be observed in both those floodplain zones through mid-April.

I suspect that moose subpopulations in the lower Susitna River valley, in general, were at lower levels in winter 1984-85 than prior years due to mortality incurred during the previous two relatively inclement winters. Therefore, I believe that many more moose would have been observed on the floodplain in winter 1984-85, had subpopulations not sustained relatively high mortality in winter 1982-83 and 1983-84. In addition loss (death) of moose to starvation (inadequate nutrition), and collisions with highway vehicles and trains, in winter 1984-85, also contributed to reduce the number of moose moose available for observation that winter.

In total, data from wiver surveys suggest that about 150-200 moose are resident to the Susitna River floodplain between Devil Canyon and Cook Inlet. Other moose observed on the floodplain are migrants from adjacent subpopulations, which move into the area to utilize floodplain habitats for winter range. The data suggest that even without a significant accumulation of snow, an additional and equal number of moose, move to the floodplain by mid-December. Large amounts of snowfall and the accumulation of a deep snowpack in adjacent areas can initiate a major immigration of moose from other subpopulations to the floodplain. The latter immigration occurs in response to snowfall and snowpack depth and may occur as early as mid-November. If this immigration movement occurred any earlier than this date, it may interfer with and cause moose to prematurely abandon normal fall rutting behavior and associated activities. I doubt if this migratory behavior would take precedence over and preclude rutting activities.

Timing and progression of snowfall may affect the number of moose that immigrate to the Susitna River floodplain for winter range. If snowfall occurs in numerous small storms over an extended period of time, I believe that more moose will be physically able to immigrate to the floodplain. A gradual increase in the snowpack will stimulate moose to immigrate and yet not hinder or prevent their migration because of extreme snowpack depths. Conversely, a rapid increase in the snowpack to a deep level may impede moose movements and preclude a typical and desireable (as far as moose are concerned) migratory pattern. Settling or dissipating of a deep snowpack probably would stimulate those moose subpopulations that immigrate in response to excessive snowfall to emigrate from the floodplain. The number of moose utilizing the Susitna River floodplain in a winter characterized by a small incremented, but deep snowpack is probably three times that number which may utilize the floodplain in a winter with little snowfall and six times as many as are resident to the floodplain. In the inclement 1984-85 winter nearly four times as many moose were observed on the floodplain in Zone I as were observed in the mild 1981-82 winter.

Moose captured and radio-marked in late winter on the Susitna River floodplain exhibited within and between year differences in timing of return movements to floodplain areas in subsequent winters (Fig. 11). In most winters, many moose did not move to floodplain areas before January and timing of immigrations of moose radio-marked on the floodplain varied among years. In winter 1982-83, most radio-marked moose had returned to floodplain winter range by December. The former movement was preceded by substantial snowfall in late October and early November. In contrast, few radio-marked moose returned to floodplain wintering areas by December in winter 1981-82, 1983-84 and

1984-85. These data indicate that local weather conditions (snowfall and snowpack depth) strongly influence the timing of moose immigration to the Susitna River floodplain and secondarily affect affect the duration of time moose spend in floodplain wintering areas.

In most winters, many radio-marked moose did not immigrate to floodplain wintering areas before January, most moose were usually on floodplain winter ranges by February, and relatively more moose were on floodplain wintering areas in March than in January (Fig. 12). These data may be "atypically" skewed by the late winters (snowfall and snowpack) in 1982-83 and 1984-85. However, evidence provided by this study indicates that "winter" and use of winter range for most moose in the lower Susitna River valley did occur until February or March. Depending of timing and extent of winter snowfall, moose in the lower Susitna River valley may utilize winter range on the Susitna River floodplain as early as November, or as late as February through March, for periods of five and two months duration, respectively.

Numbers (magnitude) of moose utilizing the floodplain in winter is, in part, dependent on the standing crop of moose subpopulations. If subpopulation levels are down from a series of inclement winters (or for whatever other reason), fewer moose will be observed in floodplain areas merely because of depressed subpopulation levels. If importance of floodplain habitats to moose is based on magnitude of use, invalid interpretations could result if infromation was gathered after an (or several) inclement winters.

Variation in Floodplain Use Between River Zones

Considering the quantity of habitat available in each river zone along the Susitna River floodplain, the calculated magnitude of use of was similar for Zones I-III. Moose densities in the former zones were considerably lower than for Zone IV. Maxima calculated densities for moose observed in river Zones I-IV were 4, 5, 4, and 14 moose per km^2 of floodplain habitat, respectively (Table 7).

I believe that three environmental factors, account, in part, for differences in densities of moose observed wintering on different sections of the Susitna River floodplain between Devil Canyon and Cook Inlet. In its course toward Cook Inlet physiography of the Susitna River changes greatly (see Table 1). As the streambed gradient lessens, the instream flow rate decreases, the floodplain widens and the main channel braids into many smaller subdivisions. These factors result in the occurrence of high relief, relatively stable islands upstream from Talkeetna; numerous shallow relief, relatively instable islands from there downstream; and another series of large, high relief and stable islands near Cook Inlet.

Early successional browse plants preferred by moose in winter occur more commonly on the wide, braided, shallow relief portions of the floodplain nearer to Cook Inlet. Other important nonbrowse food plants occur as under story vegetation on the more permanent larger high relief islands.

Snowfall and snowpack persistence decrease from Devil Canyon to Cook

Inlet (Table 3). Effects of these parameters (snowfall and snowpack) appear to override the influence of habitat type on moose distribution. Though the quality and quantity of winter moose browse (second-growth vegetation) were likely more desireable in the braided, low relief sections of the floodplain, densities of wintering moose were found to be greater on large islanded habitats nearer Cook Inlet (Table 8). Annual snowfall is less and the snowpack is less persistent on the latter downstream floodplain areas.

Of the floodplain areas intensively studied, moose densities were lowest on the Delta Islands (Table 8). Dense, mature cottonwood forests and a relatively deep snowpack probably contribute to make the Delta Islands relatively undesireable winter habitat for moose.

Subpopulation Behavior and Movement Patterns

Information on moose behavior and movement patterns was gleaned from 3,852 relocations of 18 male and 51 female radio-marked moose studied from April 1980 through July 1985.

Annual Range for Moose that Winter on the Susitna River Floodplain:

Data presented in Fig. 13 illustrate spatial distribution of radio-relocations for all moose captured and radio-marked along the Susitna River floodplain between Devil Canyon and Cook Inlet. It may be interpreted that these data indicate the minimum area or zone within which impacts incurred by moose that utilize the Susitna River floodplain may be realized. More specifically, these data show that impacts to moose on the Susitna River floodplain between Devil Canyon and Cook Inlet may ultimately become obvious in areas as far west as Beluga Lake, Little Peters Hills, the Chulitna River; as far north as Hurricane; or as far east as Chunilna Creek, Sheep River, the headwaters of Sheep Creek, Palmer and Big Lake. This "impact zone" broadens widely in areas south of Talkeetna, where it is apparent that impacts to moose, from hydroelectric development of the Susitna River, are likely to be realized in areas up to 30 km from where they were incurred on the floodplain.

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

In October through December, large numbers of moose (probably over 1,500) have been observed in areas east of the Susitna River floodplain in the foothills of the Talkeetna Mountains between the Little Susitna River and the Kashwitna River (ADF&G, files). I am unsure why moose no moose in the radio-marked sample later utilize habitats in that area (ie. Why did moose from that subpopulation(s) not utilize the Susitna River floodplain as winter range?). Perhaps moose from this subpopulation: 1) do not winter on the floodplain; 2) winter on the floodplain but for periods of time not coincident with sampling; or 3) winter on the floodplain only when a deep snowpack occurs i that portion of the Talkeetna Mountains but the latter conditions did not occur during this study.

Figs. 12 and 13 illustrate points of relocation for female and male radio-marked moose, respectively. These data indicate that the extent and spatial relationships of impacts will, in part depend on sex of affected moose. Though the sample of radio-marked males (18) was considerably less than for females (51), males appeared to range over the same, similar sized area as females. The "bounds" or maxima for movements of both sexes was similar but since the extremes in range size for females was displayed by a smaller sample of males, distance of male movements varies more between individuals.

Changes in environmental conditions along the Susitna River floodplain as a result of hydroelectric development may affect productivity of some moose subpopulations. The affects may be direct by mortality of productive females, or indirect by affecting quality of floodplain habitats which in turn affects female nutritive condition and reduces female reproductive success. In either case, decreased productivity may result in reduced moose densities near or distant from the floodplain. Likewise, mitigation measures that improve calving environment or winter range on the floodplain may increase productivity and sizes of moose subpopulations within that same extensive area. However, it should be noted that resulting increases in moose subpopulation size may subsequently place additional "stress" on environmental components used by these moose subpopulations during other seasonal periods.

Seasonal Ranges for Moose that Winter on the Susitna River Floodplain:

Calving Range. Fig. 16 illustrates locations where female moose captured and radio-marked in winter on the Susitna River floodplain were relocated during the calving period (May-June). These data indicate that most female moose south of Talkeetna leave the floodplain in spring to calve, that female moose north of Talkeetna return to the floodplain to calve and that females inhabiting large islanded areas south of Talkeetna may remain in those areas (on the floodplain) for calving.

Previous studies in the lower Susitna River valley (Modafferi 1982) indicated that radio-marked female moose south of Talkeetna were commonly located in "typical" moose calving habitat (Bailey and Bangs 1980 and Rausch 1958) composed of black spruce, sedge and muskeg by mid-May. This type of habitat was not readily available to female moose north of Talkeetna where Susitna River floodplain habitats were used during parturition.

One feature common to floodplain 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 possible that female moose seek wet areas during calving because of the availablity of newly growing, succulent, nutritious herbaceous vegetation and not specifically because of the presence of water. It is probably important for lactating females and neotate moose to have a readily available source of easily digestible, highly nutritious forage plants. It has been reported that in early spring near parturition moose prefer to consume newly growing emergent marsh forbs, sedges or horsetail and that they have been observed to gather in groups on muskegs to consume those types of vegetation in preflower and early flowering stages (LeResche and Davis 1973). Feeding on aquatic plants in spring could also counteract any negative sodium balance which moose may incur while subjected 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 and Schwartz and Franzmann 1981) or insect harassment (Mould 1979) may be a secondary consideration to food quality in selection of calving sites. Open muskeg areas would provide relief from insect harassment because of air movement, but air movement may also carry moose scent to predators such as black or brown bears or wolves. The relative openness of these habitats precludes concealment from predators, reduces desireability of the habitat for black bears (Modafferi 1982 and Swartz and Franzmann 1981) but promotes visual observation of approaching predators. Riparian habitats utilized by moose uptream from Talkeetna are less open than muskeg calving habitats and would provide little relief from insect harassment, but would provide considerably more concealment from predators and decrease the amount of windborn scent. Wolves are not commonly observed, but occur along the Susitna River downstream from Devil Canyon. Brown and black bears occur commonly in the area between Talkeetna and Devil Canyon and are known to utilize mid-elevations on south-facing slopes during this seasonal period (Sterling Miller, per. comm.). Predation from bears could be responsible for parturient female moose moving from ridges and midslopes to lower elevations along the floodplain, as was hypothesized by Edwards (1983) for female moose in association with wolves at Isle Royale. High rates of predation by brown and black bears on neonatal moose calves have been documented for a moose subpopulation several miles upstream from Devil Canyon (Ballard et al. 1985).

Coyote harassment and predation on moose calves is not documented but coyotes are abundant throughout the entire study area and may be involved in prompting female moose to move to floodplain or muskeg areas during parturition.

Edwards (1983) believed that diet diversity was inversely related to diet quality (ie. increased diversity in dietary constituents decreased overall diet quality). However, it may be that understory vegetation in riparian habitats provides a variety of nonbrowse plant species which at any given time occur at different stages of phenological development, but when considered over time they could, in combination, provide a continuous supply of young tender, highly digestible and nutritious phenological stages of vegetation. Collins (pers. comm.) has observed in late May and early June that ferns on some floodplains and islands north of Talkeetna were heavily browsed by moose. He also believed that ferns (particularly at the fiddlehead stage) were an excellent source of nitrogen (see Modafferi 1984:100 for chemical analysis of fern fiddleheads and rhizomes collected in

January).

For a period of time after calving, female moose with neonates remain relatively sedentary. By July, moose have generally started moving to summer range areas where they remain until rutting activities start in late September.

<u>Summer Range</u>. It is probably during the summer period when numerous people are traveling afield picnicing, camping, fishing, boating and recreating outdoors that nonconsumptive values of moose in the lower Susitna River Valley are greatest. Impacts of the proposed Susitna River hydroelectric project may be expected to influence summer distribution and abundance of moose in areas similar to those illustrated in Fig. 17. The greatest impact on nonconsumptive use of the moose resource will likely occur in the aforementioned areas.

<u>Fall Range</u>. Consumptive use of the moose resource by hunters occurs primarily during the month of September. Hunting seasons are generally only open to the taking of male moose. Fig. 18 illustrates where male radio-marked moose were relocated during September. These data indicate locations where impacts of the proposed hydroelectric project on moose subpopulations will be realized by hunters. The data further illustrate that moose subpopulations which winter on the Susitna River floodplain provide for consumptive use throughout an extensive area and include locations up to 30 km from the floodplain.

<u>Frequency and Seasonal Timing of Moose Crossing the Floodplain</u>

Information on frequency and seasonal timing of river crossings by moose is important to assess potential impacts of the proposed hydroelectric development if flow and ice regimes of the Susitna River will be altered "with project". Mortality of unmarked and radio-marked moose was attributed to river crossings during spring breakup flows and ice jamming, summer peak flows, and slush (soft) ice cover in winter. With-project alterations in river conditions during these time periods may have positive or negative "direct" impacts on moose subpopulations by affecting moose mortality rates. The net effects of these direct impacts must be considered along with "indirect" impacts of altered flow regimes. Decreased flow regimes in summer may facilitate moose movements across the floodplain, but the lower and relativley stable flows may negatively affect colonization of the floodplain by early successional plant communities.

Data in Fig. 19 further substantiate similarities and differences between behavior patterns of moose subpopulations north and south of Talkeetna. River crossing for moose south of Talkeetna peaked in late winter (February through April) whereas crossings for moose north of Talkeetna exhibited a small peak in early winter and a much larger peak in May and June during parturition. River crossings for moose from both areas were minimal from July through November. These data along with that presented in "Affinity for the Susitna River Floodplain" suggest that direct moose mortality could be minimized and moose would benefit from a solid river ice cover during winter and subdued peak flows during parturition (May and June).

Size, Shape and Spatial Arrangement of Ranges for Individual Radio-Marked Moose

Information on size, shape and spatial arrangement of annual ranges for moose is useful in identifying subpopulations, in assessing how individuals and subpopulations utilize resources and habitats available on and off the Susitna River floodplain, in considering and selecting compensation lands and in anticipating how moose might respond to habitats on enhancement lands.

Data presented in Figs. 20, 21 and 22 illustrate relative size, shape and spatial arrangements of ranges for radio-marked male and female moose studied for 1.5 to 5.5 years. These data show that the Susitna River is not a boundary or an impassible barrier to moose movements. Many moose utilized areas on both sides of the floodplain (No. 87 and 22 in Fig. 20, No. 84 in Fig. 21 and No. 23 in Fig. 22). Some moose ranged farther eastward of the floodplain (No. 26 in Fig. 20, No 100 in Fig. 21 and No. 791 in Fig 22) and others ranged farther westward (No. 93 in Fig. 20, No. 713 in Fig. 21 and No. 93 in fig. 22). Ranges of some moose centered on the floodplain (Nos. 37, 68 and 95 in Fig. 21), abutted the floodplain (No. 97 in Fig. 20, No. 99 in Fig. 21 and Nos. 88 and 94 in Fig. 22) or paralleled the floodplain (No. 92 in Fig. 22).

Most radio-marked moose ranged west and/or north of the Susitna River when not on the floodplain. Moose radio-marked north of Talkeetna ranged over considerably smaller areas than moose south of Talkeetna. Ranges of moose in the former area were more "circular" in shape compared to the "oblong" shape for ranges of moose from the latter area. I suspect this phenomenon is a function of the distance between different seasonal habitats. Suitable seasonal habitats or ranges (ie., winter and summer, etc.) are apparently more dispersed for moose south of Talkeetna or circumstances are such that some moose may have the "option" to travel further to encounter required seasonal habitats. Lesser snowpack depths south of Talkeetna may enable moose to travel greater distances between fall/winter and winter/spring ranges. If this contention is correct, then winter ranges which are surrounded by areas with relatively shallow snowpacks (as the Susitna River floodplain south of Talkeetna) would attract moose from greater distances (and a larger area) than winter ranges which are surrounded by deeper snowpacks and the former ranges would exhibit much greater moose densities.

Movement Patterns and Spatial Relationships Between Seasonal Ranges for Individual Radio-Marked Moose

Figs. 23, 24, 25 and 26 exhibit movement patterns and spatial relationships between seasonal ranges (activity centers) for individual moose radio-marked along the Susitna River floodplain.

Figs. 23 and 24 illustrate variation in range size and differences in spatial relationships between seasonal ranges or activity centers for radio-marked moose. Some moose appear to have a relatively consolidated annual ranges in which all seasonal ranges or activity centers are in close proximity (No. 81 in Fig 23). Other moose exhibited a more extensive annual range which encompassed two (No. 99 in Fig. 24), three (No. 23 and 93 in Fig. 23) or four (No. 41 in Fig. 24) spatially separated seasonal ranges or activity centers.

Individual moose Nos. 81 (Fig.23), 29, 69 and 99 (Fig. 24) exhibited increasing degrees of spatial separation and discreteness between seasonal ranges or acitivity centers. Radio-relocations for No. 81 do not indicate the exixtence of spatially discrete seasonal ranges. Relocations for moose Nos. 29 and 69, respectively, illustrate partial and nearly complete separation between seasonal ranges. The scarcity of relocation points between spatially separated activity centers suggest that moose No. 99 moved rapidly between an activity center (winter range) on the Susitna River floodplain and a non-winter activity center near the Yentna River. In contrast, radio-relocations between spatially distinct activity centers suggest that moose No. 93 moved more "leisurely" between winter range on the Susitna River floodplain and another seasonal activity center about 40 km westward or utilized transitional ranges in between.

Frequently, moose which had more than two activity centers utilized areas early in winter or during mild winters that were discrete from areas utilized later in winter or during inclement winters (Nos. 41, 23 (Fig. 23), 65 (Fig. 25) and Nos. 27 and 45 (see Fig. 28). With few exceptions (No. 22, Fig. 25) radio-marked moose had late and/or inclement winter ranges located on the Susitna River floodplain.

Several moose radio-marked on the Susitna River near the mouth of Kroto Creek (Nos. 84, 87 and 100) were known to winter east of the Susitna River around human settlements near Wasilla. Whether this area was their only wintering area or an alternative wintering is unknown.

Female moose No. 22 utilized a winter range above timberline between Sheep Creek and South Fork Montana Creek in five consecutive years. Each year before parturition, this moose migrated about 80 km southwest across the Susitna River to near Witsol Lake. After parturition this individual moved about 40 km north to Trapper Lake for a month and then returned to her calving area until the end of September when she returned to a winter range above timerline in the Talkeetna Mountains. Apparently, she was captured in late winter/early spring while crossing the Susitna River floodplain in route to the calving area.

Consistency in Use of Annual Ranges

Figs. 26 and 27 illustrate consistency and variation, respectively, in use of annual ranges for radio-marked moose. Annual movement patterns of some individuals (Nos. 23, 88, 40 and 93) indicated some individual moose ranged over the same area for three to four consecutive years (Fig. 26). Size and shape of annual ranges for these individuals were consistently similar. Movements for other individual moose (Nos. 42, 63, 27, 45, 37 and 95) indicated that they ranged over grossly different areas in consecutive years (Fig. 27). I believe that relatively mild conditions in winter 1981-82 may explain the "inconsistent" patterns of annual range use for moose Nos. 27, 45 and perhaps 95. Under mild winter conditions moose Nos. 45 and 27 did not migrate to the Susitna River floodplain. Apparently, these individuals ranged over smaller areas and utilized "alternate" areas in mild winters. In the 1983-84 winter, moose No. 27 and 45, respectively, remained in the foothills of the Talkeetna Mountains and near Kroto Creek instead immigrating to the Susitna River floodplain. Moose No. 95 also ranged less in that year, perhaps for the same reason.

Some moose that consistently ranged over small areas (Nos. 63 and 37) also exhibited inconsistent patterns in annual range use.

Inconsistent use of annual ranges by females may have profound implications on subsequent development of behavior patterns in their progeny. Female moose which exhibit inconsistent patterns in annual range use will expose progeny born and rearer in different years and spatially different habitats. Depending on weather patterns in their birth year, dependent calf moose will be exposed to and learn different annual movement patterns. Such variation in behavior by female moose promotes the incorporation of potentially adaptive variability in moose subpopulation behavior. Survival rates for moose with different learned migratory behavior will be influenced by similarity (or dissimilarity) of environmental conditions between their first year of life and subsequent years. During severe winter conditions, female moose may undertake different movements and expose their young to different winter ranges than during milder winters. When exposed to severe winter conditions it would seem that moose "knowledgeable" of those ("severe winter") movement patterns and alternate winter ranges would be favored to survive. In contrast, during mild winter conditions moose that do not undergo extensive ("unnecessary") migrations would probably be "selectively favored" to survive.

Apparently "Erratic" Movements for Radio-Marked Moose

Some moose exhibited movements that were "erratic" or extraordinary compared to documented centers of activity. Moose Nos. 42, 64 and 95 exhibited "erratic" movements (Fig. 26). The extraordinary movements for females Nos. 42 and 64 were recorded in July (after the normal time for paturition) of different years. Male No. 95 made an "erratic" movement during winter. Because extraordinary movements for females occurred after parturition, those forays may have been associated with the loss of neonatal young. The movement of the male may have been in response to extreme winter conditions as it occurred in winter 1982-83 when a deep snowpack was present in early November. Other moose are know to have altered movement patterns in response to winter conditions. Perhaps these forays were not extraordinary, and if these individuals had been studied for a longer period of time, the same movements would be repeated under similar environmental conditions.

Affinity for the Susitna River Floodplain

Figs. 29, 30, and 31 illustrate moose affinity by sex, area and month for the Susitna River floodplain and its associated riparian habitats.

Most female moose radio-marked on the Sustina River floodplain in winter had migrated 5-15 miles from the west to winter on the floodplain (Fig. 29). These data indicate that some females originated from distances over 15 miles. Few migrant females originated from areas 3-5 miles distant from the floodplain. About one-third of the females migrated less than 3 miles to utilize winter range on the Susitna River floodplain. Some individual females remained on the floodplain year-round and did not have to migrate to a winter range. Migrant females typically began arriving on the floodplain in November and most all immigrants were present on the floodplain by January. Emigration commenced after March and was completed by May. Female emigration from wintering areas is probably timed so they arrive in calving areas by mid-May when parturition commences. The emigration of females from the floodplain to spring-summer ranges must be a rapid direct movement since radio-marked individuals that traveled relatively long distances (Nos. 41 in Fig. 23, 99 in Fig. 24 and 22 in Fig. 25) were not frequently relocated "between" winter and calving range activity centers.

As for females, few males radio-marked downstream from Talkeetna emigrated from 3-5 miles to winter on the Susitan River floodplain. Similar to females, a small portion of males that occur on the floodplain in winter are probably non-migrant, year-round residents. In some winters, some males apparently initiated a migration, moving toward and near the floodplain but remained 0-3 mi away rather than utilize the floodplain. I suspect these individuals utilized early successional habitats available on "disclimax sites" (see section). The data suggest that in contrast to females origin of male moose that winter on the floodplain is more equally distributed between the 0-3, 5-15 and 15+ mi zones distant from the floodplain. The data imply that both males and females initiate emigration from floodplain winter range in March. However, males did not appear to start immigrating to wintering areas until after Decemeber, two months later than females. Males may remain on early winter ranges (post-rut) longer than females to replenish condition lost during rutting activities. Males may be physically unable to migrate at the same time as females.

I am uncertain why data for both sexes imply that few emigrant moose originated between 3 and 5 mi from the floodplain. Other noteable wintering areas, Kroto and Moose Creeks, are not located in that range but are farther west of the Susitna River in the 5-10 mi range. It may be that moose from the 3 to 5 mi range utilize wintering areas to the west rather than the Susitna River floodplain or that habitat in the 3 to 5 mi range is low quality spring-summer-early fall moose habitat and supports few moose.

Male and female moose radio-marked on the floodplain upstream from Talkeetna emigrated considerably less distance to winter on the Susitna River floodplain than did their counterparts downstream from Talkeetna (Fig. 31). Less than 25 percent (vs. 50-60 percent) of the moose marked in this area migrated from distances greater than 3 mi. Only infrequently, did moose from this area utilize habitats farther than 5 mi from the floodplain. These data also suggest that for moose north of Talkeetna major migratory movements to the Susitna River floodplain did not occur until January and were reversed by April. This was a much shorter time period of use than for marked moose downstream from Talkeetna.

The most contrasting behavior between moose south and north of Talkeetna was the apparent "reverse" movement of latter female moose (see Modafferi 1984:59, Table 17) back to the floodplain during May and June. The timing of this movement correlates with parturition in females. Female moose from this subpopulation apparently seek and utilize floodplain areas during calving. Specific factors causing this movement have not yet been identified but they may be related to availability of early growing nurtitious forage plants (Leresche and Davis 1973) and/or the scarcity of predators (Stringham 1974, Ballard et al. 1980 and Edwards 1983) in the relatively moist and inaccessible floodplain habitats, respectively (also see Section).

Mortality of Unmarked and Radio-marked Moose

Mortality of radio-marked moose in the lower Susitna River valley was attributed to the following sources: winter "kill", collisions wiht trains, drowning, injury, hunting, defense of life and property, capture activities and poaching (Table).

Moose mortality rates from some sources will likely increase with hydroelectric development of the Susitna River.

Accidents From Collisions with Trains and Vehicles:

Access plans for hydroelectric development of the Susitna River call for extension of railroad and vehicular roads to Devil Canyon as well as increased traffic on existing track and road systems. Traffic on access routes will be greatest during the construction phase when equipment, materials and personnel will be transported to and from areas near the prospective dam sites. Presently large numbers of moose are killed by collisions with trains and vehicles (ADF&G files). Moose mortality rates vary between year, season, location, and time of day. Mortality is greatest in winters when deep snowpacks in adjacent and upland areas cause moose to concentrate on lowland winter range near railroad and highway rights-of-way. Shallower snow, availablity of browse and plowed paths through snow in and near rights-of-way encourage moose to remain in these areas while deep snowpacks persist in adjacent areas. Mortality is accentuated at locations where large subpopulations and/or several different subpopulations congregate and feed during winter. Mortality is probably greatest at all locations at night following additional local snow accumulation. The fomer further restricts and impedes moose movements and the latter is when moose are most active and visibility by engineers and motorists is minimized.

Moose collisions with trains and highway vehicles result in property damage and are a hazard to human safety. Hazards to humans and mortality of moose from collisions with trains and vehilces is not limited to Alaska. In years of heavy snowfall, over 1000 moose are reported to have been killed by collisions with trains in the Omineca

Region of British Columbia, Canada (Child 1983). In Ontario, Canada, road accidents involving moose, in spring, are hazardous to motorists and result in unwanted mortality of moose (Fraser 1979).

Alaska Railroad Right-Of-Way:

Mortality of moose from collisions with trains in the Alaska Railroad right-of-way can be a major source of mortality to specific subpopulations. From May 1984 through April 1985, over 380 moose were reported killed by collisions with trains in the Alaska Railroad right-of-way (Table 10). These data illustrate that mortality rates in summer were relatively insignificant and that outstandingly high mortality rates occurred in the 1970-71, 1978-79, 1982-83, and 1984-85 winters. All these winters were characterized by above average snowpacks.

A more refined analysis of data among those four years and within each winter period indicates that mortality rates were greatest from December through March. A mean of 87 percent of the reported mortality occurred during this seasonal period (Table 11). These data further indicate that over 50 percent of the mortality in each winter occurred during February and March.

An analysis of the 1978-79, 1982-83 and 1984-85 data by location (railroad milepost), indicated that moose mortality was not distributed evenly throughout the right-of-way (Table 12). Data for 1970-71 were not included in this analysis because moose, in part, utilize these areas because of available winter browse. As early seral vegetation matures its desirability as moose browse declines. Therefore, unless subpopulation traditional use is an overriding factor, one would expect that moose use of specific winter range areas would change over time in relation to availability of early seral browse. Data for all three winters, indicate that the highest percent of mortality occurred between milepost 195 and 199. This interval of right-of-way accounted for a mean of 12 percent of all railroad based mortality. In winter 1984-85, 46 moose were killed in this section of right-of-way. A mean of 50 percent of all mortality occurred in the milepost section 185-225. Two hundred and six moose were killed in the latter section in 1984-85.

Fig. 32 graphically illustrates number of moose killed within milespost sections for the three years with the highest kill in the last ten years. These sections of right-of way roughly correspond to winter range areas utilized by different moose subpopulations identified in this study (see Fig . p. and Table p.). The kill data indicate that relatively high rates of mortality (4-5 moose per mile of right-of-way) were sustained by moose in sections south of Talkeetna and that relatively low mortality rates (0.2 to 1.5 moose per mile of right-of-way) occurred in the 236-278 milepost sections north of Talkeetna.

However, to realistically assess impacts from this source of mortality, mortality rates and numbers of moose killed must be related to the size of the respective moose subpopulations which sustain that mortality. Though higher kill rates occurred for right-of-way sections farther south, the impact of that mortality on those subpopulations is considerably less due to the relatively large size of those moose subpopulations.

Data on winter weather, mortality by month, and moose kill rates in specific milepost sections may be integreted with information on moose subpopulation size and movement patterns to formulate a list of precautionary measures to follow to minimize negative impacts of increased railway traffic on moose subpopulations.

Increasing the length of traveled right-of-way or frequency of train traffic between Anchorage and Devil Canyon will increase moose mortality. Before measures are taken to decrease moose mortality in railroad rights-of-way, it should be determined whether the goal of these measures is to decrease overall moose mortality or whether it is to decrease the impact on subpopulations whose longterm integrity may be threathened because of their relatively small size.

Precautionary measures to consider for decreasing moose mortality from collisions with trains include: scheduling trains during the day, decreasing the number of trains by combining several together and/or hauling the maximum numbers of cars per trip, slowing the speed of trains so engineers have time to react to moose and/or moose have time to avoid oncoming traffic, wing-plowing snow in right-of-way and adjacent to tracks to decrease snowdepths and increase the likelihood of moose running off track area to avoid oncoming traffic, providing bright lights on trains so engineers may see moose in time to slow down, and providing winter range type browse in strategic locations, removed from right-of-way to "intercept" and hold moose subpopulations migrating toward winter ranges near rights-of-way. Some measures could be employed in milepost sections where moose are partilcularly vulnerable and other measures may be undertaken in areas where small-sized subpopulations are particularly vulnerable.

Seven radio-marked moose were killed by collisions with trains in the Alaska Railroad right-of-way. Six of the moose killed (four females and one male) ranged in areas north of Talkeetna where 21 moose were radio-marked. Four of the moose were killed during the relatively severe 1984-85 winter. These data suggest that train kills may be a significant cause of mortality in the subpopulation of moose which winter on the Susitna River floodplain north of Talkeetna. These data also indicate that rates of mortality by collisions with trains are much higher during a winter when snowpack depth is extreme.

<u>Highway System Right-of-Ways</u>: Mortality of moose from collisions with vehicles along the railroad corridor appear to be of lower magnitude than for collisions with trains but the potential hazard for humans is considerably greater.

Moose-highway vehicle accident problems in Canada occur during spring and early summer and are related to the appetite of moose for dissolved sodium, originating from highway deicing salt and available in roadside pools (Fraser and Thomas 1982).

In Alaska, moose mortality in highway rights-of-way occurs primarily in winter when moose concentrate in lowland wintering areas located near major highway systems (ADF&G files). Occurrence of early successional vegetation in rights-of-way adjacent to roadways attracts moose and increases the likelihood of collisions with vehicles. Numbers of collisions are reported to be greatest at night when moose are more active and visiblity by motorists is minimized.

Use of deicing salt is becoming more common on roadways between Anchorage and Fairbanks. This road maintenance practice may increase moose mortality. In recent years, travelers using those highways frequently report observing moose licking the paved surface (frequently from a "kneeling" position) or eating snow in the roadside plow berms. I presume these moose are obtaining sodium from the deicing salt. Continued use of deice salt may encourage moose to remain along roadways during spring and early summer as in Canada.

The magnitude of moose mortality in winter is affected by snowpack depth in surrounding uplands and along highway rights-of-way. Relatively large numbers of moose were reported killed by collisions with vehicles in winters (1971-72 and 1978-79, 1982-83, 1983-84 and 1984-85, Table 13) when heavy snowfall and deep snowpacks caused large numbers of moose to migrate to lowland winter ranges near the Susitna River floodplain (see Table 6) and along the adjacent highway system.

Additional development of the highway system and increases in highway traffic projected to occur during development and maintenance of the proposed hydroelectric project will increase the number of moose killed by collisions with vehicles on roadways.

Moose mortality will increase significantly if new roadways are constructed in or across moose migratory corridors or in lowland wintering areas.

To minimize moose mortality on roadways, highway construction in the former areas should be avoided, use of deicing salt should be minimized, traffic patterns should be shifted toward daylight hours and away from periods of heavy snowfall.

No radio-marked moose were known to be killed by collisions with highway vehicles. One moose relocated in the highway right-of-way was relocated one week later in the Talkeetna dump. I suspect that this moose was either killed illegally (poached) or hit and killed by a highway vehicle. Though large numbers of moose may be killed in highway right-of-ways in some winters, data from radio-marked moose suggest that very few moose which winter on the Susitna River floodplain are killed by collisions with highway vehicles.

The fact that no radio-marked moose were killed by vehicles appears to contradict data which indicate large numbers of moose from GMS 16A migrate easterly to winter on the Susitna River floodplain and near highway and railroad rights-of-way. However, I believe these data may merely emphasize the fact that moose are exceptionally traditional in use of specific wintering sites. In this case, moose that winter on the Susitna River floodplain, where marked individuals were captured, do not frequently venture to rights-of-way only another mile to the east. Likewise, moose that traditionally winter near the rights-of-way probably spend little time on the floodplain (where moose were marked) while in transit to their wintering areas near right-of-ways one mile eastward.

I suspect more moose were killed on roadways in GMS 14A than on roadways in GMS 14B (Table 13) because moose densities and highway traffic are greater in the former Subunit.

Additional development of the highway system and increases in highway traffic that are projected to occur during development and maintenance of the proposed hydroelectric project will increase the number of moose killed by collisions with highway vehicles.

Other Accidents:

Mortality of some radio-marked moose was attributed to slipping on glare ice; falling through open water leads or thin ice while crossing frozen rivers; drowning while attempting to cross sections of open water, log jams or ice jams; attempting to swim across sections of open water in winter; injuries sustained from fighting during the rut or from wounds received during the open hunting season.

Two radio-marked moose died from injuries sustained from slipping and falling on a glare ice cover of the Susitna River. Another moose died from similar injuries sustained during capture procedures while under effects of tranquilizing substances. Field observations indicated that mortality of other nonmarked moose resulted from similar causes. This source of mortality is probably most frequent on the Susinta River downstream from the Yentna River where strong northeasterly winds commonly blow snow off the frozen floodplain. Similar conditions may occassionally occur on sections of the Susina River floodplain north of Talkeetna.

Death of one radio-marked moose north of Talkeetna was attributed to drowning after falling through an open lead or thin ice on the ice covered Susitna River. Observations near the site, indicated the presence of a small open lead that may not have been visible to the moose. In any event, it was not large enough for the moose to have anticipated having to swim to the other side. I make this distinction because death of several moose north of Talkeetna apparently resulted from moose attempting to swim across a section of open water. Field evidence suggested that these moose probably succumbed to hypothermia because they were unable to climb back out onto firm shore fast ice after traversing open water or slush ice.

Hunting:

Roughly, 900-1400 moose have been killed annually by hunters in the portion of the lower Susitna River valley watershed utilized by moose which may also utilize the Susitna River floodplain. The estimated number of moose killed varies greatly with current management strategy (ie.timing and length of the open hunting seasons and occurrence of either sex and special permit late season permit hunts).

Hunting seasons have always been open to the harvest of males in September. Therefore, I will direct my comments on impacts of hydroelectric development to the harvest of male moose during that time period. Male moose radio-marked on the Susitna River floodplain were distributed throughout a relatively large area during the September open hunting season (see Fig. 18).

Eleven moose radio-marked on the Susitna River floodplain were subsequently killed by hunters during open hunting seasons. One male (out of 3 radio-marked, 33%) was killed north of Talkeetna and 3 females (out of 35 radio-marked, 9%) and 7 males (out of 14 radio-marked, 50%) were killed south of Talkeetna. Data from the small sample of moose north of Talkeetna indicate that a high proportion of that subpopulation which winter on the Susitna River floodplain are killed by hunters. Data from radio-marked male moose south of Talkeetna indicate that about half the moose which winter on the Susitna River floodplain south of Talkeetna are subsequently killed by hunters. Together data suggest that decreases (or increases) to carrying capacity of moose winter range downstream from Talkeetna would have a significant affect on moose available to hunters.

Predation:

Only one adult radio-marked moose was suspected to have been killed by a predator. This moose may have been killed by a hunter and the brown bear observed at the kill site may have been feeding on carion. Because a hunting camp was located near to the kill site, I suspect that the latter scenario may be the most likely cause of death.

Because neonate and calf moose were not radio-marked, parallel information on predation rates for those age categories is lacking. However, evidence from others studies in nearby areas Ballard et at. (1982), and other areas in Alaska Schwartz and Franzmann (1981), indicates that brown and black bears, respectively, can be significant predators on neonate moose. Brown and black bears are common in many portions of the lower Susitna River valley and probably are a significant mortality factor for neonate moose. With-project actions that increase the numbers of bears or displace additional bears into other areas could secondarily impact moose subpopulations by increasing rates of predation. Actions that decrease numbers or densities of bears would have opposite affects on moose mortality rates.

Predators and rates of predation for various moose subpopulations within the study area are discussed more thoroughly in a subsequent section of this report (Moose Subpopulation Naratives p. 104).

In some localities wolves are significant predators on moose (Ballard 1980). Predation by wolves may limit expansion of moose subpopulations Gasaway et al. (1983). Wolves are uncommon in most portions of the study area. Wolves occur in areas north of Talkeetna and probably account for a small percentage of moose mortality in that area.

Winter Kill:

Moose carcasses were observed during aerial surveys in all winters, 1981-1985. Numbers of carcasses observed in each winter (Figs. 33-36) roughly correlated with amount of snowfall and the accumulative snowpack. The 1981-82 and 1984-85 winters were judged to be mild and severe, respectively. The 1982-83 and 1983-84 winters were intermediate to the former winters but estimated to be more near severe than mild. Five, 31, 8 and 50 moose carcasses were observed on the Susitna River floodplain in winters 1981-85, respectively. The occurrence of moose carcasses in wintering areas as a winter progresses indicates that the resident subpopulation has exceeded carrying capacity of that winter range (primarily density dependent mortality) and/or that the energy costs of obtaining forage exceeds energy extracted from forage (primarily density independent mortality). In either case, availability of winter browse was inadequate to support and maintain moose under the given environmental conditions.

Data collected in Susitna River and adjacent floodplain areas provided evidence that moose died in those habitats in winter 1984-85. Within the latter area, magnitude of mortality was found to vary between 2 areas differing in geographic location and gross habitat type.

Percent calf moose and number of dead moose observed during aerial surveys conducted on Moose, Kroto and Alexander Creeks and riparian areas adjacent to the Susitna River floodplain were found to decrease and increase, respectively, between late November and mid-April (Tables 13 and 14). Percent calves in the those herds decreased from 19 or 28 percent, in November, depending on area, to about 6 to 10 percent by mid April.

Numbers of dead moose observed varied between 9 and 18 depending on location. Nine dead moose and 8 percent calves were observed on a similar moose survey conducted 10 April on the Yentna River floodplain (see Table 5 Modafferi 1988 in prep.). Data collected in the 3 previous milder winters indicated that moose herds always contained more than 16 percent calves (Modafferi 1983:36, Table 14). Appearance of moose carcasses and decreases in calf composition through winter indicate that winter conditions were severe and suggest that winter range was inadequate for that level of moose standing crop.

Likewise, data collected from Susitna River riparian areas indicated that herd calf composition decreased from 20 or 40 percent, in November-December when adequate size samples were obtained, to 11 or 2-3 percent, depending on area, by mid-April. During the latter time period, moose carcasses were also observed in the 2 northern floodplain areas, but nc carcasses were observed in the more southern islanded areas near Cook Inlet. As for floodplains adjacent to the Susitna River, appearance of moose carcasses and decreases in herd calf composition, indicate relatively inclement winter conditions and suggest inadequate winter forage for moose herds on the Susitna River floodplain. Differences in herd calf composition recorded between the two areas on the Susinta River floodplain suggest that environmental conditions were not as harsh near Cook Inlet and/or moose subpopulation levels there were closer to range carrying capacity. The areas nearer Cook Inlet characteristically have a shallower snowpack than inland areas farther north. Strong northeast winds typically displace fallen snow from the latter areas when facilitate travel by moose and expose low growing browse and non-browse forage plants.

Seventy-nine percent of a sample of 24 moose carcasses examined on Alexander Creek, Kroto Creek and the Susitna River in winter 1984-85 were found to be calves. Age composition of this sample indicates a very low the potential annual recruitment to the subpopulations involved. Expasion of moose subpoopulations involved is probably precluded because of the low potential for recruitment. Expansion of these moose subpopulations in 1985 was apparently limited by affects of inclement winter conditions on forage and foraging behavior.

Studies by Franzmann and Arneson (1976) demonstrated that moose femur marrow fat content may be used as an indicator of nutritive condition. They provided evidence indicating that dead calf and adult moose with levels of femur marrow fat near 7.3 and 9.7 percent, respectively, died from inadequate nutrition. They found percent marrow fat for moose dying from accidental causes was determined to be 30.4 and 69.3 for calves and adults, respectively. They indicated that dead moose with marrow fat values below 10 percent dry weight probably were winter-killed (died from malnutrition).

Femur marrow fat content from a sample of moose found dead on the Susitna River and adjacent floodplains in late winter 1984-85 suggest that they died from undernourishment (Table 15). Inadequate winter forage conditions probably resulted in moose dying of malnutrition in the lower Susinta River valley during the 1984-85 winter. Apparently, some moose subpopulations in the lower Susitna River valley were temporally above range carrying capacity.

Defense of Life and Property:

Alaska state law allows humans to kill game animals in defense of life and property. Normally, defense of life and property killings involve aggressive confrontations with bears. However, female moose protecting calves and moose stressed by inadequate forage and difficult foraging conditions (a deep snowpack) in late winter can, and will, become very aggressive when confronting humans.

Because dense human populations are sympatric with moose winter range in the lower Susitna River valley, when inlcement winter weather conditions occur human/moose interactions are common. Under these circumstances, moose and females with calves, particularly, become defensive and aggressive towards humans. In winter 1984-85, over 40 moose were killed in defense of life and property along the "railbelt" in the lower Susitna River valley (ADF&G files). An extremely deep snowpack occurred in the area and moose were reluctant to leave snowpacked trails and plowed roadways. One radio-marked moose was killed in defense of life and property in winter 1984-85. Apparently this radio-marked moose acted aggressive towards children and would not permit a property owner access to several "out" buildings. I am certain many more moose were killed under similar circumstances, but were not reported.

Other moose were known killed by sled-dog owners when aggressive moose were confronted on remote training trails.

If hydroelectric development of the Susitna River results in increased development and human population in the lower Susitna River valley there will undoubtedly be an increase in the number of moose killed in defense of life and property in severe winters.

Illegal Kill:

Illegal killing (poaching) of moose occurs in the lower Susitna River valley. Moose are killed illegally in urban and rural areas. One moose radio-marked near Anchorage was later killed illegally (ADF&G files). Recent disposal of remote parcels of land by the State of Alaska, has encouraged many people to settle in rurals areas. Moose meat commonly provides sustenance for humans settling on remote land parcels. Moose poaching is probably not an uncommon occurrence in remote settlements.

One radio-marked moose was relocated in the highway right-of-way near Talkeetna. Two weeks later the radio-collar from this moose was relocated in the Talkeetna land fill. I suspect this moose was killed illegally and its remains and the radio-collar were subsequently deposited in the land fill.

If hydroelectic development increases human settlement in remote areas, I believe that the number of moose killed illegally can be expected to increase.

MITIGATION

Because habitat for moose and other wildlife will be altered and/or lost with hydroelectric development of the Susitna River, a mitigation to compensate for these losses is necessary. Mitigation for loss of wildlife and habitat will, in part, be achieved by measures that compensate for losses through enahancement and/or protection of moose winter range habitat on designated ("compensation") lands. Habitat enhancement will involve utilizing various land management techniques to increase moose carrying capacity by altering existing plant communites to favor of regrowth of early successional communities that produce large quantities of high quality winter moose browse. Habitat protection will involve preventing habitats that naturally have high carrying capacity from being disturbed or altered.

For habitat enhancement to be successful, target moose subpopulations should be limited by carrying capacity of the winter range. Therefore, before considering habitat enhancement, it should be demonstrated that moose subpopulations will respond to quantitative or qualitative improvements in winter browse. Deficiencies winter range quality and/or quantity may be evidenced by moose mortality on wintering areas.

Data gathered on number of moose carcasses observed on routine surveys, age composition of dead and live moose, and femur marrow fat content of dead moose suggest that moose from some subpopulations in the lower Susitna River valley were in poor nutritive condition in winter and died on winter range.

In either case, when mitigating for with-project losses, compensation should be directed at affected moose subpopulation (for the benefit of moose) and/or near the location of loss (for the benefit of resources users) . If integrity of a moose subpopulation is threatened by hydroelectrical development, compensation should be directed at that specific subpopulation or the next proximal subpopulation.

<u>Identificating of Potential Compensation Lands</u>

<u>Moose Distribution and Abundance</u>:

Moose distribution and abundance were criteria utilized to identify location of moose winter range lands. The relative importance of different winter range lands was evaluated by moose use. Moose use was estimated from densities of moose observed in delineated areas by aerial survey sampling techniques (Appendix A-D). Data from aerial surveys were used to identify and rate relative importance of different moose winter range lands in the lower Susitna River valley (Appendix D and Table 12).

Fifty-eight percent of the moose observed on distribution surveys occurred on 13 percent of the survey area. Ninety-one percent of the moose observed occurred on 36 percent of the land surveyed. No moose were observed on 29 percent of the area surveyed. Over 60 percent of the area surveyed had less than 1 moose per 4.5 mi^2 and was considered poor quality winter moose range.

Twenty-eight delineated areas, 6.8 percent of the area surveyed, contained 41 percent of the moose observed. Calculated densities of moose for these areas ranged from 3.1 to 13.6 moose per mi^2. These areas were considered to be good moose winter range and to have potential as compensation lands.

The 27 survey areas identified as compensation lands were dispersed through the lower Susitna River valley (Fig. 37). Most identified areas were associated with riparian or floodplain habitats. The fact that 8 areas were located on the Susitna River floodplain reemphasizes its importance as moose winter range in the lower Susitna River valley. Nonfloodplain areas identified as compensation lands were located in alpine habitat near the timberline ecotone on Willow Mountain (sample uint Nos. 19 and 24) and on glacial morraine of the Kahiltna Glacier (sample unit No.343).

Another nonfloodplain moose wintering area not specifically identified as a potential compensation land, but worthy of special mention, is an alpine area (sample unit No. 329) located on the south-western slopes of Little Peters Hills. This survey area contained 2.4 moose per mi^2. The area had burned by fire previously and has been recolonized by birch vegetation.

Snowpack Depth:

Because large numbers of moose were consistently observed wintering in specific areas of the lower Susitna River valley, it does not necessarily follow that these areas are good winter range. These areas may be adequate winter range during an average winter but they may become undesirable in severe winter conditions. Heavy snowfall and a deep snowpack affect availability of browse and movement of moose and decrease the desirability of areas for moose in winter (Coady 1974). It would be futile to enhance habitat for moose in areas where excessive snowfall would preclude a positive response in moose carrying capacity. Areas where the snowpack characteristically remains shallow through winter are ideal for moose winter range.

Survey results indicated that snowpack depth varied from 25 to 225 cm within the lower Susitna River valley in March 1985 (Fig. 38). Snow depth measurements between 110 and 150 cm were most common (Fig. 39). Eighty percent of the survey area was estimated to have a snowpack exceeding 100 cm and was considered undesireable for moose (Fig.40). After grouping locations with like snowpack depth measurements (Fig. 41), a geographical pattern between snowpack depth and moose distribution and mortality became apparent.

These data helped to explain moose distribution and mortality patterns observed in the lower Susitna River watershed. Areas that had shallow snowpacks were used by large numbers of moose (Fig. 37) and exhibited little winter mortality (Big Island-Bell Island, Figs. 33-36 and Table 14, and the Wasilla area). Other areas with less shallow snowpacks (Talkeetna Mountains foothills, Little Peters Hills and Kahiltna Glacier morraine) also had large numbers of moose and exhibited little moose mortality occurred there. Some areas with intermediate snowpack depths (Susitna River corridor (Table 14) and Chunilna Hills) contained substantial numbers of wintering moose and exhibited moose mortality. Geographical areas with deep snowpacks (Alexander Creek, Moose Creek, Kroto Creek, the Yentna River and most other locations in the survey area) either had very low densities of moose or exhibited substantial moose mortality (Table 13).

Data on snowpack depth and moose distribution, abundance, and mortality in the lower Susitna River valley provided a basis for evaluating locations for conducting mitigation.

Procedures for Conducting Mitigation on Compensation Lands

Replacement Lands:

Areas that sustain large numbers of healthy moose through inclement winter conditions have a high innate carrying capacity and are important in maintaining high subpopulation levels. Protecting important moose habitat (lands with high carrying capacity) from alterative land management practices can be considered a form of mitigation. Areas identified to have a high winter carrying capacity are important to moose subpopulations and should be considered in mitigation as replacement (lands) for lands altered during hydroelectric development.

Data on moose distribution, abundance and mortality, and snowpack depth suggest that floodplain areas including and downstream from Bell Island, nonriparian areas between Wasilla and the Little Susitna River, timberline ecotone areas of Willow and Bald Mountains and western slopes of the Little Peters Hills should specifically be considered as replacement lands (land areas with A and B snowpack designations, Fig. 41). These areas exhibited relatively densities of moose in winter, shallow snowpacks and low winter kill levels.

Quantifying the gain in carrying capacity as a result of habitat protection (ie., over and above that which would have occurred in the absence of habitat protection) on replacement lands is considerably more difficult than for assessing compensation in carrying capacity on enhancement lands and is beyond the scope of this study.

Enhancement Lands:

Lands that supported relatively high densities of wintering moose, exhibited moose winter kill and had snowpack depths less than 120 cm (land areas with C snowpack designations, Fig. 41) should be considered for compensation in mitigation through habitat enhancement.

Lands with E designation should not be considered for enhancement. Effects of the deep snowpacks on these lands would far outweigh any benefits to moose gained from increasing winter browse.

Most lands with D designations are probably also unsuitable for successful habitat enhancement programs. Some of these lands with snowpack depths near 120 cm (Moose Creek downstream from Petersville Road and Kroto Creek downstream from its confluence with Moose Creek) may be acceptable for enhancement. However, the fact that substantial moose winter kill occurred in the latter areas during consecutive winters indicates that the carrying capacity was exceeded even in relatively mild winters. Enhancement procedures would have a higher probability of greater success (ie. larger positive gains in carrying capacity) in C designated snowpack depth areas.

Most radio-marked moose consistently repeated annual movement patterns to use traditional winter ranges. These data suggest that areas selected for habitat enhancement should be located in traditional migratory routes and near traditional moose winter ranges to assure a high probability of success. Locating enhanced areas near traditional winter ranges or in traditional migratory routes will assure that migrating moose will be exposed to improved winter habitats and minimize divergence from traditional behavior patterns.

Enhanced habitats could be located away from traditional use areas where snowpack depth is desireable. However, if newly enhanced habitats were remote from traditional use areas I would expect that moose would be slow to learn of and utilize them. I doubt if many moose would greatly alter traditional behavior patterns to utilize newly-created habitats. Most probably, moose that would colonize enhanced areas that are removed from traditional wintering areas would be moosethat were resident to the area or yearling moose that are actively establishing traditional behavior patterns. Moose use of newly-created winter habitats remote from traditional winter ranges would increase at a slower rate than for enhanced habitats located near traditional ranges (Gasaway 1980). If other factors were equal and after carrying capacity was attained, total numbers of moose using enhanced habitats in both locations may be the same, but over a given time period significantly more moose would have utilized the area near traditional winter ranges.

Though benefits exist from enhancing habitats in close proximity to traditional winter use areas, in those instances, newly emerging second growth vegetation may be exposed to excessive browsing before it becomes established. Overbrowsing may even prevent new second growth vegetation from becoming established. I suspect that this may particularly be a problem in areas where the snowpack is shallow. A relatively deep snowpack may act to obscure newly growing plants from moose browsing for several years. Several years of protection from browsing pressure will enable plants to become more firmly established before being subjected to moose browsing.

Other factors significant to selection of areas for enhancement and implementation of enhancement procedures have been presented in detail elsewhere (Harza Ebasco, A Joint Venture 1986).

Quantifying Mitigation Potential for Compensation Lands

With-project losses to wildlife and habitat will, in part, be offset with increases in moose carrying capacity on compensation lands. Improved moose carrying capacity will eventually result in net increases in moose numbers and subpopulation sizes. Mitigation will be considered successful when with-project losses in wildlife carrying capacity are offset by gains in moose carrying capacity and increases in moose numbers. Follow-up field studies will be necessary to determine if mitigation is successful.

Replacement Lands:

Moose use (carrying capacity) was assessed for several areas representative of potential replacement lands. Areas selected represented alpine habitats (Table 17, also see Fig. 7 and Appendix E), riparian habitats adjacent to the Susitna River floodplain (Table 18, also see Fig. 4 and Table 13), and a Susitna River riparian habitat (Table 19, also see Fig. 5). All areas selected were used by relatively large numbers of moose for winter range.

Data from alpine habitats, Bald Mtn Ridge and Willow Mtn, indicate that these areas provided about 45,000 and 40,000 moose days use, respectively, during 196 days in winter 1985-86. These areas supported about eight and seven moose, respectively, per mi^2 of habitat for a 196-day period. Numbers of moose using these alpine areas peaked between November and January.

Data from riparian areas adjacent to the Susitna River floodplain, Alexander, Kroto and Moose Creeks, indicate that these areas provided roughly 23,000, 17,000 and 16,000 moose days use during winter 1984-85. These areas supported about six, two, and four moose per mi^2 of habitat for a 140-day period. Numbers of moose using these riparian areas peaked during January, December and February, respectively. Moose use of these areas was relatively low in November.

Data from Bell Island, a Susitna River riparian area studied 4 years, indicate that moose use varied greatly between years (see Table 8) and correlated with snowpack depth and winter weather conditions. In winter 1984-85, this area provided about 11,000 moose days use; four times the use which occurred in winter 1981-82 and 1983-84. In winter 1984-85, the area provided winter range for about 15 moose during a 139-day period.

Bell Island supported the greatest amount of moose winter use per mi^2 of habitat of any area studied. My calculations indicate that Bell Island provided about 2,000 moose days use during a 139-day period in winter 1984-85. These data suggest that each mi^2 of habitat on Bell Island provided winter range for about 14 moose.

For mitigation purposes, it may be said that protecting Bald Mountain Ridge from alternative land uses could offset a with-project loss in moose carrying capacity equivalent to 45,000 moose days use. Each square mile of habitat protected on Bald Mountain could theoretically offset with-project losses of about eight moose. Of course, these calculations assume that alternative land uses would eliminate all moose carrying capacity on Bald Mountain Ridge, if the area were not protected. However, in reality this assumption would most likely be incorrect.

Perhaps from an economic standpoint, moose use per mi^2 of habitat protected should be considered when selecting replacement lands. Bell Island supported the largest amount of moose use per mi^2 of habitat. During a 139-day period in winter 1984-85, Bell Island provided about 2,000 moose days use per mi^2 of habitat. Each square mile of habitat on Bell Island had the capacity to support 15 moose through a 139-day winter period. Considering data obtained during winter 1984-85, protection of habitat on Bell Island (15 moose per mi^2) would offset twice as much loss in moose winter range carrying capacity as could be offset by protecting an equal quantity of habitat on Bald Mountain Ridge.

Enhancement Lands:

To assess the mitigation potential of habitat enhancement, moose use (carrying capacity) was studied on 14 disclimax habitat sites located adjacent to the Susitna River floodplain (Table 19, also see Appendix F and Fig 6). Carrying capacity estimates averaged 4,500 and 4,300 moose days use, respectively, for the Montana West and the Montana Middle disclimax sites over three winter periods, 1982-85 (Table 19). Maximum values of 6,200 and 3,900 moose days use, respectively, were calculated for those respective sites in winter

1982-83. These higher values may be attributed to the fact that significant snowfall occurred at least a month earlier in winter 1982-83 than in the latter two winters. This early snowfall prompted large numbers of moose to use these sites earlier.

Data from the former disclimax sites suggest that habitat enhancement on about a square mile of similar land, similarly located could be expected to provide 4,300-4,500 moose days use in an average winter. These data indicate that application of appropriate habitat management procedures (habitat enhancement activity) to 1 mi^2 of mature forest habitat in the same area could provide winter range with carrying capacity for 30-34 moose.

These data indicate that disclimax sites (Montana West and Montana Middle) and application of appropriate habitat management techniques may provide winter range with carrying capacity for three times as many moose as the best natural (natural) site (Bell Island) studied. These data indicate that habitat management (rather than habitat protection) may be the most economical method for accomplishing compensation of with-project losses in wildlife carrying capacity with carrying capacity of moose winter range.

Bald Eagle Nest Sites. Nests of bald eagles were commonly observed incidental to conducting moose surveys in the lower Susitna River valley. Federal law prohibits activities that might cause eagles to desert traditional nest sites. Eagles commonly nest in cottonwood trees in mature forest habitats located on floodplains. Because habitat enhancement activities involves altering and/or disturbing mature forests to encourage regrowth of early successional plant communities conflicts with eagle nest trees or nesting activites may occur. Eagle nests were commonly observed throughout the lower Susitna River valley (Fig. 42). Areas containing eagle nest sites should not be considered for habitat enhancement unless more specific field studies are conducted to more precisely delineate location of nests and to determine if enhancement activities would follow federal law.

Potential Impacts From With-Project Alteration in River Hyrology

The following is an annotated list of with-project hydrological mechanisms that I believe could impact moose subpopulations downstream from Devil Canyon. Relative impacts of these mechanisms will likely vary greatly between river sections from the Devil Canyon dam site to Talkeetna, from Talkeetna to Sunshine Bridge, from Sunshine Bridge to the Yentna River and from the Yentna River to Cook Inlet.

Some hydrological mechnisms may have relatively small impacts on moose subpopulations but "insignificant" losses to a subpopulation from a number of different sources may in total result in a "significant" impact.

Assessments of the significance of any should be related to the percent of the moose subpopulation affected. Impacts to small numbers of moose may have profound affects on a small moose subpopulations. Impacts to small numbers of moose in a large subpopulation may in reality be insignificant.

I believe that the following with-project hydrological mechanisms could impact moose populations downstream from Devil Canyon:

Flow Regimes:

Moose use of floodplain habitats is greatest in winter (October to April) for foraging and in spring (May to June) for calving, foraging and/or escape from predators. Altered flow regimes (timing, depth or flow rates) may impact moose by directly or indirectly affecting species composition of vegetation, availability of browse plants, access to food sources and refuge from predators.

Proposed with-project (vs. pre-project) increases in winter water levels and/or decreases in spring water levels will impact moose subpopulations downstream from Devil Canyon. Extent of impacts will probably vary between the following river sections: Zone I (Devil Canyon to Talkeetna), Zone II (Talkeetna to Sunshine), Zone III (Sunshine to the Yentna River and Zone IV (Yentna River to Cook Inlet). Alterations in timing of peak flows and maximum and minimum flow levels and are probably more important values to consider when evaluating potential impacts of flow regimes than monthly averages for those values. The current or rate or speed of water flows during these time periods will also affect dymnamics of the floodplain.

Innudation. Ground water tables, water levels and soil oxygen content can affect survival of plant species differently and result in plant communities with different species composition (Strahan 1981) and/or differences in seasonal timing of plant growth and maturation processes (Harris et al. 1975). Timing and duration of there hydrologic variables will influence their level of impact. Water acts as a medium for plant seed dispersal and affects where viable seeds are distributed and the viability of seeds (Peltzman 1973). Together, these hydrological factors along with floodplain innudation will affect quantity (browse availability) and quality (timing of plant growth and maturation) of moose browse and species composition of floodplain plant communities.

Water levels can also influence moose movements and foraging along and across the floodplain.

Open Water. In winter, moose commonly use ice covered waterways as travel routes. Wind action and periodic ice "glaciering" on waterways act to decrease snowpack depth over river ice and facilitate moose travel across and along floodplain areas. This relatively unrestricted travel enables moose to utilize available browse and does not discoruage moose from "wandering" and "locating" other local, new and preferred food sources.

The extent of "open water" downstream from the Devil Canyon dam site in winter will have a profound affect on moose movements in that area. Theoretically, with-project, in winter, open water will at least extend from the Devil Canyon dam site to Talkeetna. Circumstantial evidence obtained from studies in Canada suggests that open water in winter may be a barrier to moose movements (Bonar 1985). Evidence obtained in this study, indicates that open water in combination with shore ice and/or ice shelving along the margins can be detrimental to moose attempting to traverse open water.

Moose from subpopulations east and west of the Susitna River frequently cross the waterway to forage on opposing bankside vegetation. The existence of open water in winter will discourage or inhibit this behavior. Occurrence of ice shelving or shore ice along the river margin will likely result in mortality.

In spring, open water in waterways surrounding islands may inhibit predators from frequenting those habitats and locating and preying on neonatal moose. Low water levels in the Susitna River during this season may make island habitats more accessible to predators and increase predation on moose calves.

The impacts of open water separating island habitats from the mainland shoreline in winter and decreased water levels bridging island habitats ot mainland shoreline, in spring will in part, be influenced by the location and amount of island habitat involved. Affects of these phenomena will vary between moose subpopulations.

Ice Formation. Ice jams which occur during spring breakup on the Susitna River result in flooding; scouring; diversion of main channel water; bank erosion; and transportation of soil, debris, and browse plants. All of these factors can act to create, eliminate and/or maintain early successional riparian plant communities preferred by moose.

Since ice will not form in a stretch of the Susitna River downstream from the Devil Canyon damsite ice processes now associated with fall freeze-up and spring breakup will not occur with-project.

The ability and desire of moose to negotiate open water in winter may be affected by timing, occurrence and extent of river ice and mainland and island shore ice shelving. Additional shoreline and island habitat may be innundated if shore ice forms, dislodges daily, and subsequently, accumulates downstream in ice jams which, in turn, restrict flow rates and act to rise water levels upstream and flood adjacent habitats.

Some riparian habitats are impacted and changed annually by ice processes associated with spring breakup. Scouring, flooding and other processes associated with ice dynamics affect occurrence and availability of moose winter browse and phenology and composition of vegetation on islands and streambanks. Absence of ice processes will tend to stabilize riparian habitats utilized by moose and not perpetuate there maintenacne.

Downstream from the Devil Canyon dam site where formation of cover ice is initiated, ice jams may occur from ice forming instream or shore ice dislodging daily. Ice jams will cause water levels to rise and result in backup flooding in upstream areas. Backup flooding and residue ice formed after flood waters release could be detrimental to moose directly or indirectly through impacts to vegetation.

Backup flooding caused by ice jams in winter may leave a coating of glare ice over the floodplain after jams release and water levels subside. Glare ice may remain in these areas until the next backup flood or until spring. Periodic backup flooding could result in a thick layered build up of ice on the floodplain. Ice cover on the floodplain can result in mortality of moose. I documented moose mortality attributable to glare ice cover on the floodplain.

Daily fluctuations in water levels in winter will leave a glare ice cover over periodically innudated floodplain areas. Ice cover on the floodplain will result in moose mortality, may affect moose use of these floodplain areas and may have long term affects floodplain plant communities. Ice cover formed in this mannner may become layered and increase in thickness each time the water subsides after a daily flooding.

Water Temperature. Water temperature can affect all of the ice processes discussed above. Water temperature can affect temperature of subsurface water and alter seasonal timing of plant growth. Altered water temperature regimes may eventually affect species composition of floodplain plant communities because of variation in physiological tolerances between different plant species. Phenology of moose spring forage plants and species composition of floodplain communities preferred by moose may be affected by altered water temperature regimes. If parturition in moose is is correlated with plant phenology (diet quality) changes in timing of plant development may affect productivity of moose subpoplations that feed and calve on the floodplain.

Silt. Accumulation of silt in sections of the river forms bars that may eventually become more stabilized and lead to the formation of islands. Silt originates from melting headwater glaciers and from erosion in non-glacial tributary streams. Erosion and secondary deposition of silt already in the mainstem system also contribute to island formation. Bars and islands form the substrate for establishment of early successional plant species. Presence or absence of silt in the substrate and size of surface sediments may also determine which plant species are able to colonize a particular site.

McBribe and Strahan (1984) demonstrated that willows, the preferred moose browse species, preferentially colonized sites where surface sediment was small-sized (less than 0.2 cm), and poplars more readily became established on sites with a larger-sized surface sediments (0.2-1.0 cm). Birch, less preferred as moose browse, succeed the former species as the sites become more stable and drier.

Plant species as willows are adapted to periodic silting and may out compete other plant species in areas where silting is common. Siltation may stimulate willows to root or shoot side-sprout. Prolific side-sprouting greatly increases willow biomass and production.

Impoundments associated with hydroelectric development of the susitna River will greatly restrict or essentially eliminate silt from the Susitna River system between Devil Canyon and Talkeetna. This will further decrease the silt load in the Susitna River south of Talkeetna. Silt will be reintroduced into the Susitna River mainstem by the Chulitna River at Talkeetna. Farther downstream, other tributary streams will contribute to the silt load.

Lack of silt in the mid-river section of the Susitna River will affect ecology of riparian vegetation (particularly willows), and may affect competition between preferred moose browse plants and less desireable species (alder).

In the absence of a silt source, existing islands formed of silt and substrates permeated with silt may gradually erode and be translocated to areas farther downstream. Silt islands may fail to be reformed in the mainstem Susitna River immediately downstream from the Devil Canyon impoundment. A decrease of silt in the Susitna River system immediately downstream from the Devil Canyon dam site with-project will probably cause willows to be a less common component of the floodplain plant communities in that area.

The projected with-project decrease in peak spring and summer mainstem flows (vs. increased winter flows) will affect present patterns of silt erosion, translocation and deposition.

<u>Tree</u> <u>Debris</u>. During peak spring flows, many floodplain trees are uprooted and carried downstream. Uprooted trees eventually become stranded in relatively shallow water on gravel or silt bars, entangled in perennial log jams or are deposited as peak flows decrease. In many cases, deposited vegetation initiate additional silt deposition and lead to the formation of more stable silt bars or islands. Logs, trees and other debris, etc. frequently occur at the leading edge of silt bars/islands on which willows and populars subsequently become established. Lack of peak flows will decrease occurrence and transportation of debris and slow or preclude processes which lead to formation of mainstem islands.

Newly formed log jams and islands divert mainstream currents. When mainstream currents are diverted, erosion is redirected to other substrates on the floodplain. Erosion then occurs in different areas releasing additional tree debris and silt for formation of new islands which inturn initiates erosion of other substrates that may also contribute to formation of additional islands farther downstream.

Uprooted or dislodged vegetation, particularly willows and poplars which moose prefer for browse, may subsequently become established where they are deposited. Willows and poplars are particularly adept at rerooting and growing when deposited on suitable substrates. These plant species are important source plants for colonizing and stablizing new silt bars or islands as well as important moose forage plants.

Tree debris appears to be important component for initiating formation of silt bars or islands. Tree debris also appears to be important for stabilizing and protecting the uptream side of newly-formed silt bars or islands.

Altered flow regimes and decreased peak spring and summer flows will probably affect creation and transportation of tree debris or uprooting and transportation of browse plants.

Fog. In winter and summer, fog frequently forms above the Knik River downstream from where effluent enters from a hydroelectric project facility (Eklutna Hydroelectric Project). Persistant winter fog can affect microclimates and phenology of riparian vegetation and heat balance of moose.

Because of warmer water temperatures and relatively cold air temperatures (-40 degrees below zero C), fog will probably form in winter over open water sections of the Susitna River downstream from the Devil Canyon dam site. To my knowledge many questions regarding the formation of fog (ice fog, icing of vegetation, etc.) have yet to be addressed: how far from the river will fog occur? how far downstream from Devil Canyon will fog form? how frequently will form? how many days in an average, cold and warm winter will fog form? how many consecutive days will fog occur at any one time?

Presence of fog will affect solar radiation of moose and vegetation on the floodplain. This may affect winter energy budgets of moose and phenology of floodplain plants. The occurrence of fog over the floodplain may ultimately affect species composition of floodplain plant communities.

Dissolved Nutrients. Glacial streams as the Susitna Rivier are generally considered sterile. Waters in these streams are generally very low in organic nutrients and minerals. When flood waters innudate substrates adjacent to the floodplain which are rich in organics and minerals, the latter chemicals can become dissolved and/or suspended in floodwaters. Moist conditions resulting from floodwaters can further hasten on site decomposition of organic materials and release additional nutrients and minerals from (and to) underlying substrates. It appears likely that flood waters can increase fertility of underlying local floodplain substrates and/or transport nutrients to other floodplain substrates areas downstream.

Altered flow regimes and decreased frequency and extent of flood conditions may affect fertility, nutrient turnover rates and overall productivity of floodpalin habitats along the Susitna River downstream from Devil Canyon. Number and extent of spring and summer floods will be decreased with-project.

Salt Water Encroachment. With-project flow rates and reduced water levels in the Susitna River will enable salt water to encroach farther upstream from Cook Inlet than presently occurs. Species composition of plant communities will likely be altered in areas where salt water infiltrates substrates or innundates the floodplain.

Floodplain and island habitats near Cook Inlet support very dense winter concentrations of moose. Increased encroachment of salt water into the mouth of the Susitna River may negatively affect survival of moose browse plants (willows and populars) in this region and decrease the value of these habitats to moose.

If increased substrate salt concentration precludes plant growth existing islands may lose stability and eventually erode away.

DRAFT

Moose Subpopulation Naratives

Fourteen moose subpopulations were identified to utilize the Susitna River floodplain between Devil Canyon and Cook Inlet. Annual range for each identified moose subpopulation was delineated (Fig. 43). Moose "subpopulations" were primarily differentiated on the basis of movement patterns, range use, and behavior or life history patterns that appeared common for moose in a given geographic area.

The following narratives summarize knowledge about life history, biology, environment and management of moose subpopulations accumulated during this study. Data provided may be important to consider when assessing impacts or prescribing mitigation for hydroelectric development of the Susitna River.

Some information provided is circumstancial, some information contained in these accounts was not substantiated by scientific methodology and other information presented is my best assessement and interpretation of the present situation.

Devil Canyon-Talkeetna:

The Area. This 360 mi^2 area encompasses the watershed of the Susitna River from Talkeetna to Devil Canyon. It is not accessible by the hignway system or by highway vehicle. Access is afforded by boat on the Susitna River, the Alaska Railroad and by aircraft on an unimproved mail airstrip adjacent to the River and railroad at Gold Creek. Several lakes and flat ground topography in other locations are seasonally accessible by float-, ski- or wheel-equipped light aircraft. The area provides opportunites for fishing, hunting, trapping and limited hiking and camping in the Curry Ridge Lookout area. Some recreational activities are undertaken with professional guides and commercial boat or air taxi operators. About a quarter of the land area utilized by this moose subpopulation occurs within the Denali State Park. Human settlement in the area is limited to a scattering of recreational and year-round remote homesites. Year-round residents probably rely heavily on available wildlife resouces for sustenance.

The entire area is bisected longitudinally by the Susitna River. The Alaska Railroad right-of-way parallels the Susitna River for 35 miles from Talkeetna to Gold Creek where the railroad diverges westerly away from the river valley. The river and the railroad rights-of-way may, at times, affect movements and negatively impact moose that utilize habitats on both sides of the valley.

In general, temperatures and snowfall in this "interior" climatic area tend to be more extreme than for more southern areas where climate is milder and more maritime. However, "winter" and "spring" come sooner to the former area. At times, the snowpack is deeper on side slopes and valley bottoms, where windblown snow is deposited, than on the alpine ridges where windblown snow orginated. In spring, ground vegetation may become prevalent sooner on higher south-facing ridges than at lower elevations in the valley bottoms.

The Subpopulation. I estimate that 375 moose presently winter in the Susitna River watershed between Devil Canyon and Talkeetna. Short and long-term subpopulation size can be influenced by contemporary land and wildlife management practices and annual weather conditions. This subpopulation could be larger or smaller under different management programs or winter weather conditions and may not presently be at carrying capacity of the habitat.

Data obtained from a radio-marked sample of moose indicate that individuals from this subpopulation seldom range out of the Susitna River watershed. Moose use of the Susitna River floodplain and southeast facing mid-slope habitats located northwest of the Susitna River were considerably greater than use of ridge tops and northwest facing habitats on the south side of the Susitna River.

Significant Movement Patterns. Evidence obtained from radio-marked moose and aerial surveys of unmarked moose substantiated several basic subpopulation movement patterns.

Females in this subpopulation moved to and remained in floodplain and island habitats of the Susitna River during May and June (Modafferi 1984). Timing of this movement, late May to early June, correlated with parturition. Other studies indicate that female moose may move to riparian and islanded habitats during calving to avoid contact with predators (Peterson 1955). Moose are known to seek water as a defensive behavior when pursued by predators. It is also probable that dams move to island and floodplain areas in spring to obtain early growing, nutritious, riparian forage for themselves and their neonates. If the former contention is correct, predation must be (or was once) a significant mortality factor to this subpopulation.

Moose of both sexes moved to and utilized Susitna River floodplain and island habitats during the winter period. Timing, magnitude and duration of this movement was correlated with winter severity (occurrence, depth and persitence of the snow pack). Moose apparently seek refuge on the Sustina River floodplain from deeper snowpacks and associated poor forage conditions on adjacent, predominantly alder covered upland slopes. The windblown and frozen riverbed and floodplain provide moose with preferred early successional, low growing, browse species. Movements to and from different food patches are less restricted by the shallower, wind compacted snowpack conditions on the floodplain. Shallow snow conditions probably also decrease the vulnerability of moose to predation by wolves. Though a shallow snowpack also occurred on exposed upper alpine slopes and ridge tops, the scarcity of forage or excessive wind chill may preclude moose use of those habitats.

Six, 10, 7 and 11 surveys conducted to quantify moose use of the Susitna River floodplain in winter 1981-82, 1982-83, 1983-84 and 1984-85 revealed an average of 26, 78, 54 and 116 moose, respectively, for the highest three survey counts within each winter. The greatest number of moose observed on the floodplain in those winters was 36, 84, 88, and 132, respectively. These data demonstrate that moose use of floodplain wintering areas is highly variable and closely related to winter weather conditions. Snowfall in 1984-85 was reported to be the greatest in the last ten years (SCS, March 1985).

Moose which are attracted to and utilize the Susitna River floodplain in winter are vulnerable to mortality from drowning by falling through thin ice and/or into open water and from collisions with trains in the adjacent Alaska Railroad right-of-way.

Moose collisions with trains increase dramatically with depth and persistence of the snowpack in areas adjacent to the railroad right-of-way. Inclement winter conditions cause large numbers of moose, that are stressed physiologically, to utilize the railroad rights-of-way and adjacent lowland habitats for a longer period of time. An above average snowpack in winter 1984-85 resulted in substantial moose mortality from collisions with trains.

A 13-15 March 1985 moose survey revealed gatherings of 60+ moose southeast of Lane Creek above timberline on south facing slopes (1,000-2,000 ft elevation) in the Chunilna Creek watershed and 40+ moose above timberline on south facing slopes (1,700-2,300 ft elevation) between the Chulitna and Susitna Rivers north of Blair. Lake. These concentrations probably included moose from this and the respective adjacent Chunilna Creek and Chulitna River (not included in this report) subpopulations that moved to these alpine areas for winter range.

Movements of radio-marked moose outside this general area were recorded infrequently during the rut (September-November) and calving (June-July) periods.

<u>Noteworthy</u> <u>Behavior</u> <u>Patterns.</u> On winter surveys moose were commonly observed lying singly or in small groups, in the open, on the exposed, frozen riverbed or floodplain. In most instances, moose appeared to be exposing themselves to solar radiation, probably for warmth. Resting, in the open, probably also lessened the opportunity for wolves to approach unnoticed.

Tracks in the snow indicated that moose commonly walked along the margin of the floodplain seeking and utilizing browse offered by trees overhung from undercut river banks.

It was apparent that the windblown and hard-packed snow on the floodplain provided considerably less resistence to moose movements than the deeper, soft snowpack on adjacent upland slopes where additional windblown snow secondarily accumulated.

On several occasions, moose were observed on sparsely-timbered upland slopes bedded in the relatively snowfree area under a spruce tree. These individuals were apparently seeking the snowfree bedding area, avoiding wind and intense solar radiation and/or seeking visual concealment from potential predators.

On the west bank of the Susitna River, uptream about 10 mi from Talkeetna, moose were commonly observed in open paper birch (Betula papyiphera)/white spruce (Picea glauca) forest habitats digging ("cratering") through snow. Subsequent field trips to that area during the snowfree period revealed that overwintering basal stems and rhizomes of ferns had been heavily grazed by moose. Ferns are utilized as winter forage by large numbers of moose in post rut and wintering areas farther south in the western foothills of the Talkeetna Mountains. Chemical analyses indicated that fern fiddleheads, basal stems and rhizomes appear to be a relatively high quality winter food source (Modafferi 1984, p.100.).

Mortality. Predators and predation. Very dense black bear and moderately dense brown bear populations occur in this area (Miller 1985). Black bears primarily utilize south-facing slopes north and west of the Susitna River. Black bears usually frequent timber habitats, except in fall when they seek ripening berries above timberline (Miller 1982). Brown bears primarily occur above timberline. In winter, wolf sign was frequently observed in this area. This is the only area downstream from Devil Canyon where I observed wolves. Packs of five wolves each were observed near the Chulitna-Susitna Rivers confluence (January 1985) and in upper Portage Creek (March 1985). Wolf tracks were observed in snow along the floodplain on two separate occassions in the Sherman area, at the mouth of Portage Creek and near Gold Creek. In two of the above instances, moose carcasses were obsevered near the wolf tracks. I presume the moose had been killed by wolves.

Though no radio-marked moose in this area were known to be killed by predators, I presume brown and black bears prey on neonatal calf moose in spring, and wolves and brown bears prey on moose of all ages throughout the year. Though brown and black bears may prey heavily on moose calves (Ballard 1981 and Franzmann et al. 1980, respectively), I suspect that black bear predation may predominate in this area because of their greater abundance and more common use of riparian and south facing, side-slope habitats frequented by moose. Attempts to avoid vulnerable confrontations with predators may, in part, account for moose use of island and floodplain habitats in both spring and winter. Other studies have documented influence of predators on moose movements (Ballard, Gardner and Miller 1980) and habitat use (Edwards 1983).

Other sources of mortality. Eight moose radio-marked in this area were observed or reported dead during the study. Four moose were killed during winter by collisions with freight or passenger trains. One was killed in winter 1983 (March) and three were killed in winter 1985 (one in January and two in March).

Death of one moose in April 1984 was classified as a "winter kill". Winter kill is a "catch-all" category including many winter-related mortality factors associated with inclement winter weather conditions. The most prominent, proximate mortality factor included in the winter-kill category is starvation from inadequate nutrition. The moose found dead was estimated to be 19 years old when captured in March 1982.

One male moose was killed by a local resident hunter during the 1982 open hunting season.

Death of three moose was associated with the Susitna River itself. Presumably these individuals died from drowning while trying to traverse the river. Circumstances at the site of one death in March 1985, suggested that the moose fell through an open lead in the ice on the snow-covered river. The moose apparently never resurfaced and was located later that spring in a sideslough farther downstream. Another "river-related" mortality occurred sometime prior to June in 1981. Circumstances suggested that this individual moose got caught between breakup iceflows while crossing open water or fell through thin ice or an ice jam while crossing "apparently" solid river ice. Its carcass was discovered "silted in" on a river bar in an area where "breakup" ice jams commonly form. The third "river-related" moose mortality was discovered in June 1982, floating near a log jam in a Susitna River side-channel, shortly after spring peak flow levels. This individual had previously been relocated on the adjacent bank several weeks before. Perhaps the moose tried to cross the river when flow rates were extreme and was swept into the log jam where it subsequently drowned.

On 3 January 1985, while capturing moose on the Susitna River floodplain about 10 mi upstream from Talkeetna, I observed 2 dead moose, about 400 m apart, frozen into "rough" river ice. Evidence at the site suggested that these moose attempted to cross the river but fell through the soft ice cover and could not get back out before succumbing to hypothermia or drowning. At that time, there was about 1 m of snow cover over existing river ice. This deep snowpack probably insulated preformed river ice from cold ambient temperatures and resulted in the ice gradually melting/eroding away from beneath by warm flowing water. In places, the ice was very thin or non-existent at all and the river was essentially covered by a floating, 1+ m soft mat of snow and slush-ice. Toward the river banks where water was shallower and current less, river ice was still firm and supported humans. Evidence in the snow/slush-ice indicated that after breaking through the surface both moose had moved/swam around for about 400-500 m making unsuccessful attempts at several locations to climb out onto firmer shorebound ice. Both carcasses were located at the interface of snow/slush river ice and firm shorebound ice. Similar conditions probably reoccur whenever a deep snow pack blankets and insulates preformed river ice over fast moving, deep channel water. These conditions are probably prevalent in winters when large amounts of snowfall occur before rivers become adequately frozen.

Between 1 January and 27 March 1985, 65 moose were reported killed by collisions with trains in the 45 mi stretch of railroad right-of-way between Talkeetna and Chulitna Pass. Inclement winter conditions persisted in this area through mid-April 1985, and more moose undoubtedly were killed after the 27 March period for which mortality data were available. Moose kills per mile of track decreased from south to north; 23 moose were reported killed in the 9 mi stretch immediately north of Talkeetna, whereas only eight were killed in the 14 mi stretch between Sherman and Chulitna Pass. The rate of moose killed by trains probably decreases northward of Talkeetna because of lower moose densities and because the railroad right-of-way diverges from the river bottom, spatially and altitudinally, in its course from Gold Creek to Chulitna Pass. Both factors probably contributed to decrease the probability of moose-train collisions.

In winter, periodic surveys were conducted on the Susitna River floodplain to assess moose distribution and abundance during 1981-85. Incidental to primary objectives of these surveys 0, 11, 2 and 5 moose carcasses were observed in winter 1981-82, 1982-83, 1983-84 and 1984-85, respectively. Death of these moose was attributed "winter kill" and probably related to winter severity. Because frequency and timing of surveys, field and weather conditions, and moose population levels varied between years, caution must be exercised in making annual comparisons with these data.

Concerns and Potential With-Project Conflicts. In winter, the frozen Susitna River and floodplain provides moose with high quality forage, a place to be exposed to solar radiation and to rest relatively protected from secretive approaches by wolves, and a relatively snow-free corridor for movement to and from dispersed and patchy food sources and habitats on both sides of the valley bottom. If hydroelectric development of the Susitna River prevents the river from freezing over in winter, these values to moose will be altered or lost altogether.

Moose forage on early successional plant species. In most cases, availablity of these food sources is both unpredicatable and temporary. However, periodic perturbations on the Susitna River floodplain caused by large variations in flow regimes add periodicity and relative stability to early successional plant communities preferred by moose in winter. Specific locations of these plant communities may vary over time but the quantity of surface area involved may be relatively stable during that same time period. Eliminating or decreasing these hydraulic perturbations will reduce the amount of habitat that is peridocially altered and thereby renewed and/or maintained in the early successional state. Altering the variation and intensity of the perturbations will decrease the quantity of high quality habitats and winter browse for moose.

Because specifics on changes in ice and flow regimes, calculations of amount and location of habitats affected (or not affected), and data for calculating and balancing amounts and locations of browse lost and/or gained were produced by other disciplines, proportional alterations in moose carrying capacity cannot presently be estimated.

Hydroelectric development of the Susitna River may affect this moose subpopulation by altering characteristics or seasonal timing of river ice or flow regimes. These alterations could result in mortality to moose directly or indirectly through decreased carrying capacity of the habitat.

Any increase in access, human settlement or the human population in the area may affect this moose subpopulation negatively by increasing numbers of moose killed legally during open hunting season, illegally during closed hunting season and in defense of life and property; by decreasing or altering habitats preferred by moose, or by increasing the level of human disturbance.

Chunilna Creek:

The Area. This 400 mi^2 area encompasses the Chunilna Creek ("Clear Creek") watershed. The area is not accessible by the highway or railroad systems. Seasonal access into the area is provided by snowmachine; river boat from Talkeetna via the Talkeetna River; all terrain vehicle from Curry via an overland unimproved trail to a placer gold mining camp located in the upper watershed ; and ski-, float- or wheel-equipped light aricraft. The area provides opportunities for fishing, hunting and trapping. Some activities are undertaken with professional guides and commercial boat or air taxi operators. Chunilna Creek is a popular salmon fishing stream. Placer gold mining camps, which are active during the ice-free season, occur in the upper watershed.

Recreational homesites occur along the Talkeetna River downstream from its confluence with Chunilna Creek. State landholdings in the area were recently opened to entry for agricultural development and recreational homesites.

The Alaska Department of Natural Resources has recently classified portions of this area as having a high potential for livestock grazing. This particular area is located on the south-facing alpine slopes north of Chunilna Creek. This same area is utilized by substantial numbers of moose from the post-rut period through winter.

Temperatures and snowfall in this "interior" area tend to be more extreme than for more southern areas which are under greater maritime influence. The snowpack on sideslopes and in valley bottoms of this watershed is frequently deeper than in alpine areas as windblown snow from exposed ridge tops is deposited and accumulates in the latter lee areas.

The Subpopulation. I estimate that about 350 moose presently utilize the Chunilna Creek watershed as winter range. This estimate is subjective and extrapolated from data obtained on a distribution type survey conducted 13-15 March 1985. Approximately, 150 moose were actually observed in the Chunilna Creek drainage on that survey and roughly 50 percent of the moose present may be overlooked on this type of survey. An additional 50 moose are estimated to have moved downstream out of the watershed to winter on the more extensive Talkeetna and Susitna River floodplains.

Previous winter surveys on the Susitna River floodplain revealed concentrations of moose near the confluence of the Chulitna, Susitna and Talkeetna Rivers. I suspect that this conglomeration of moose also included migrants from smaller upstream tributary watersheds. A small sample of moose was captured and radio-marked on the Susitna River floodplain near Talkeetna, in February 1985. One moose from that small sample was relocated in early spring several miles up Chunilna Creek. I estimate that about 50 or so other moose from the Chunilna Creek subpopulation, probably also utilize Susitna River floodplain habitats during severe winters.

The 13-15 March 1985 distribution survey revealed more than 60 moose southeast of Lane Creek above timberline on south facing slopes (1,000-2,000 ft elevation) of the Chunilna Creek watershed. Moose from this and/or the Devil Canyon-Talkeetna subpopulation apparently utilize these alpine habitats as winter range.

During the distribution survey, more than 70 moose were observed on the Chunilna Creek floodplain. Though this riverbed is considerably smaller than that of the adjacent Susitna River, it appeared to support more wintering moose in 1984-85 than the latter river bed. In this particular area, the Chunilna Creek riverbed appears to have a higher proportion of actively changing floodplain, where preferred moose winter forage grows, than the adjacent Susitna River. This could, in part, account for the relatively high densities of wintering moose observed on the narrower Chunilna Creek floodplain.

Moose from this subpopulation which travel to and utilize winter range on the Susitna River floodplain must traverse the railroad right-of-way which parallels the east bank of the Susitna River. While migrating and/or remaining in this area moose are particularly vulnerable to collisions with trains.

Significant Movement Patterns. Data on movements of this subpopulation are largely based on circumstantial evidence. However, it seems probable that behavior patterns of moose in this watershed mimic those of the Talkeetna-Devil Canyon subpopulation in the adjacent Susitna River watershed. Most moose which winter in the Chunilna Creek watershed are probably resident to the area during other seasonal periods. In winter, some moose from the Talkeetna-Devil Canyon subpopulation may move from northwest-facing slopes in the Susitna River valley to occupy southeast-facing slopes in the Chunilna Creek watershed. South-facing slopes are more exposed to solar radiation and probably contain a shallower snowpack and more desireable plant communities.

A portion of the Chunilna Creek moose subpopulation moves downstream with inclement winter weather and increasing snowpack depth. It is probable that some moose which make this downstream movement eventually end up on the Talkeetna and Susitna River floodplains in late winter when the snowpack is typically deepest. Timing, duration and magnitude of this movement is correlated with winter severity (depth and persistence of snow cover). Some individuals from this subpopulation probably utilize the Susitna floodplain every winter, regardless of weather conditions, whereas movements into this area by other segements of the subpopulation are probably more closely governed by prevailing winter weather. Duration and magnitude of moose use of the Susitna River floodplain, by moose from this subpopulation, would be greatest during a winter characterized by large amounts of early snowfall that forms a deep snowpack which persists well into spring. I suspect that the 30 percent increase in moose observed on the Susitna River floodplain between Sunshine Bridge and Devil Canyon in late winter 1984-85 (Table 6) was, in large part, attributable to moose "funneling" into the drainage from smaller, peripheral, tributary drainages as Chunilna Creek.

Mortality. Predators and predation. Dense black and brown bear populations exist in the Chunilna Creek watershed. Density of black bears is greatest in the timbered lower reaches of the drainage and density of brown bears is greater near the alpine portions of the watershed. Brown and smaller numbers of black bears concentrate in this drainage in late summer to feed on spawning salmon. Densities of wolves in this drainage may be greater than those along the Susitna River because this watershed is more remote (off the "beaten path") than the latter. I presume that black and brown bears prey on moose calves in spring and early summer and brown bears and wolves prey on adult moose throughout the year. I do not know if moose in this watershed utilize floodplain habitats during the calving period as was documented for moose in the Susitna River watershed. Islands on the Chunilna Creek floodplain may not be attractive to parturitent female moose because of their relatively small size. However, if availability of high quality forage and not the lack of predators is the salient factor responsible for this behavior pattern, parturient female moose in this subpopulation may utilize riparian habitats along Chunilna Creek in late-May and early-June to obtain phenologically early and nutritious plant species that are present in the floodplain plant communitities.

Other Sources of Mortality. One radio-marked moose that moved from the Susitna River to the Chunilna Creek watershed in late winter, was found dead, in early spring, 3 miles upstream from the Talkeetna River. Death of this individual was attributed to the category "winter kill". Two other unmarked "winter killed" moose were also observed near the mouth of Chunilna Creek in early March 1985.

I presume that some moose killed by collisions with trains immediately north of Talkeetna were emmigrants from the Chulitna Creek subpopulation utilizing or in route to or from winter range on the Susitna River floodplain.

Concerns and Potential With-Project Conflicts. Because moose from this subpopulation move to and utilize the Susitna River floodplain near Talkeetna in winter, alterations in river ice or flow regimes or floodplain habitats of Chunilna Creek or Susitna River in that area, that result from hydroelectric development of the Susitna River, will affect moose from this subpopulation.

Any increase in access, human settlement or the human population in the area may affect this moose subpopulation negatively by increasing numbers of moose killed legally during open hunting season, illegally during closed hunting season and in defense of life and property; by decreasing or altering preferred habitats, or by increasing the level of human disturbance of moose.

Increases in train traffic on the railroad will result in additional moose mortality from collisions with trains. Construction of vehicle rights-of-way between this area and the Susitna River will increase moose mortality from collisions with vehicles. Moose from this subpopulation will primarily be exposed to these sources of mortality in winter when they utilizing or migrating to or from wintering areas along the Susitna River floodplain.

Lower Talkeetna River-Iron Creek-Sheep River:

The Area. This 880 mi^2 area is bounded on the west by the Susitna River and includes watersheds of the Iron Creek, Sheep River, and the Talkeetna River downstream from Praire Creek. The area is seasonally accessible primarily by float-, ski- and wheel-equipped light aircraft. The lower 10 mi of the Talkeetna and Sheep River are accessible by boat. The western part of the area contains the town of Talkeetna and its satelite communities, the Alaska Railroad right-of-way and a major highway spur road right-of-way into Talkeetna. The spur road and railroad rights-of-way run parallel to each other and the Susitna River. Substantial human settlement radiates easterly from Talkeetna and the Susitna River over about 40 mi^2. Recent state-sponsored land disposals in the area have provided lands to the public for remote recreational homesites and agricultural development. The area provides opportunities for recreational fishing, hunting and trapping. Limited snowmachining and cross-country skiing occur in the Larsen Lake and Bald Mountain areas. Some recreational activities are undertaken with professional guides and commercial boat or air taxi operators.

About 360 mi^2 of land area in this area rises above 3500 ft in elevation. Since moose seldom utilize habitats above that elevation, only about 520 mi^2 in the area should be considered as useable moose habitat.

Human settlement in the area includes scattered homesites, fledgling agricultural developments and rural town and residential developments in Talkeetna and its satelite communities along the highway system. Year-round residents in the area desire a "rural" lifestyle and "expect" that the opportunity to live off available wildlife resources is a necessary part of that lifestyle.

The railroad, highway spur road, agricultural developments and human settlements and associated activities may at times affect movements of moose, preclude traditional use of wintering areas and negatively impact moose using the area. These conflicts become particularly evident during winter when large numbers of moose immigrate to lowland areas near and on the Susitna River floodplain.

In general, temperatures and snowfall in this "interior" area tend to be more extreme than areas farther south which are more under maritime influence.

The Talkeetna River watershed, upstream from its confluence with Praire Creek, was not considered within the range of this moose subpopulation for several reasons: 1) moose from there would have to travel over 40 mi to utilize Susitna River floodplain winter range and no radio-marked individuals were known to travel that far to winter on the Susitna River floodplain; 2) because more than 140 moose were observed in that upstream portion of the Talkeetna River during a 13-15 March 1985 distribution survey, it appeared that numerous moose remained in or immigrated to that area for winter range rather than travel to lower elevations and the Susitna River floodplain; and 3) snow depth, an important factor influencing moose use and selection of wintering areas, appeared to be considerably less there than farther downstream. For these reasons, it appeared that this upstream area provided adequate winter range for moose.

<u>The Subpopulation.</u> One hundred sixty-six moose were observed in this area on the distribution survey. Substantially more moose were probubly present in this area than were evidenced by the survey because: 1) a large proportion of the habitat is forested and the probability of observing moose on this type survey is lower in forested habitat, and 2) search effort was greatly reduced in settled areas along the railroad and highway rights-of-way where substantial numbers of moose are known to winter. Assuming, that 50 percent of the moose present were not observed on the distribution survey, that 100 moose are added to compensate for those not observed in forested habitat, and that another 75 moose are added to account for moose in settled areas not surveyed, it was estimated that about 500 moose occurred in the area that winter.

Most moose observed on the 13-15 March distribution survey were scattered in floodplain habitats along major watersheds or their tributary streams. Few moose were observed on the Talkeetna River near Praire Creek and on the Sheep River upstream from Rainbow Lake. Noteworthy numbers of moose were observed near the headwaters of Iron Creek and on the Talkeetna River upstream from Praire Creek.

The only nonfloodplain area where concentrations of moose were observed was a southwest-facing slope (1,500-2,500 ft elevation) about two mi west of Diana Lakes and immediately north of Sheep River.

<u>Significant Movement Patterns.</u> Since, only one individual from a small sample (12) of moose radio-marked near Talkeetna in February 1985, was later relocated near the Sheep River floodplain five miles upstream from the Talkeetna River and 15 mi from its capture site. I suspect that a very small number of moose from these watersheds migrate downstream to winter at lower elevations and on the Susitna River floodplain.

Because large concentrations of moose were not observed near the mouth of the Talkeetna River and fair numbers were observed spread evenly along its downstream floodplain and in the headwaters of it and Iron Creek, there was probably not a major moose movement out of these watersheds to the Susitna River floodplain. However, large numbers of moose could have emigrated from those watersheds but: 1) wintered on disclimax vegetative sites (distrubed sites) which are readily available near human settlements and along the railroad and highway rights-of-way in and near Talkeetna or 2) bypassed the Sustina River floodplain to winter on the Chulitna River floodplain, which in that area is more braided and probably has greater carrying capacity than the adjacent Susitna River floodplain.

Perhaps, there once was a traditional movement from these upland drainages to the Susitna River floodplain but moose may have secondarily altered that behavior pattern to take advantage of winter browse recently available in disclimax seral plant communities associated with human settlement and development along the railroad and highway rights-of-way. If this scenario is correct, and those disclimax plant communities become unavailable or undesireable in the future, displaced moose would probably again seek traditional winter range on the Susitna River floodplain.

Mortality. Predators and predation. Though specific information on bear population levels is lacking for this area, I suspect the area supports dense black bear and moderately dense brown bear populations. Black bears are probably closely associated with forested habitats and brown bears probably occur more commonly in the alpine and short shrub habitats. Bear population levels and distribution suggest that predation by bears on adult and calf moose may be substantial. Traditionally low calf:cow moose ratios observed in this area on fall moose herd composition surveys lend support to this contention (ADF&G files).

Wolves are reported to occur in the area. Upper watersheds in this area are somewhat "remote" and local wolf populations probably remain relatively unexploited by trappers or hunters. For this reason, I suspect that moose in this area are subject to higher levels of wolf predation than are other moose subpopulations in the lower Sustina River valley.

Other sources of mortality. When moose migrate from these watersheds to winter in lowland areas near human settlements along the highway and railroad rights-of-way and the Susitna River floodplain, they are exposed to mortality from the following sources: collisions with trains and highway vehilces, defense of human life and property situations, drowning by falling through thin ice and/or open water and injuries sustained by slipping and falling on glare ice on major rivers. Though moose migrate to lowland areas to find ameliorated winter conditions, severe winters may still result in considerable mortality from inadequate nutrition. Moose undertaking these weather related movements, are very dependent on obtaining adequate winter food sources in the lowland areas for survival.

Mortality from hunting is realtively low in this area due to limited access.

Noteworthy Behavior Patterns. Moose that move from this area to lowland areas during inclement winters likely share available winter ranges with moose from several other subpopulations. This may be particularly true for the area where the Talkeetna, Susitna and Chulitna Rivers converge near Talkeetna. Moose originating from subpopulations in each of those drainages probably gather in this area and share a common winter range.

One radio-marked female moose captured on the Susitna River floodplain near Talkeetna in early February was soon after relocated about 15 miles up the Talkeetna River watershed on Sheep River. Evidence available suggests that this individual migrates from the lowland area near Talkeetna in mid-winter and travels up the Talkeetna River watershed to spend the critical, late-winter period near alpine habitats. This individual followed a similar movement pattern for two consecutive years. Snowfall in these upper drainages does not appear to be any less than in lowland areas but wind action in alpine areas may displace snow and result in a shallower snowpack and more favorable foraging conditions. I do not know if this movement pattern is common for large numbers of moose.

Concerns and Potential With Project Conflicts. Because moose from this subpopulation must contend with trains and vehicles in railroad and highway rights-of-way when moving to and from wintering areas, any increase in train or vehicle traffic will likely result in increased moose mortality.

Alterations in the carrying capacity of the Susitna River floodplain near Talkeetna will affect numbers of moose the area can sustain during winter.

Alterations in characteristics or seasonal timing of river ice formation or flow regimes could result in moose mortality directly or indirectly through decreased carrying capacity of floodplain areas. This impact could be accentuated if distrubed sites near human settlements and developments become unavailable or altered in the future.

Moose mortality is likely to increase if access into and/or the human population within the area increases. Additional mortality could result from moose killed legally during open hunting season or illegally for sustenance during closed hunting season, moose displaced from areas by human disturbances, and from alterations in habitats and decreased carrying capacity caused by increased human activities.

Montana Creek-Sheep Creek-Kashwitna River

The Area. This 880 mi^2 area is bounded on the west by the Susitna River, on the east by the Talkeetna Mountains and includes the watersheds of Montana Creek, Sheep Creek and the Kashwitna River. The interior of the area is seasonally accessible by all terrain vehicle, snow machine and to a lesser extent wheel- and ski- equipped light aircraft. Limited access is also provided by float-equipped light aircraft. One unimproved "four wheel drive" road extends from the Parks highway easterly about seven miles along the banks of the South Fork of Montana Creek. The Alaska Railroad and the Parks Highway rights-of-way essentially parallel each other and the Sustina River along the western boundary of the area. Small human settlements and numerous parcels of land that had previously been cleared for homesteads are scattered thoughout a three-mile-wide band adjacent to those rights-of-way. In many cases, homestead activities have been abandoned and land previously cleared in that process has reverted to second growth plant communities which are preferred by moose for winter range. Similar, disclimax, seral vegetative associations occur in rights-of-way maintained for the railroad and highway and around human habitations where man has disturbed natural plant communities.

Recent state sponsored land disposal programs have resulted in numerous fledgling agricultural developments and recreational homesites in the northwest portion of the area.

The area provides opportunities for fishing, hunting and trapping. Limited cross-country skiing occurs near Bald Mountain and the North Fork of Montana Creek. In the last two years, recreational snowmachining has become increasingly popular in alpine habitats of the area. After a fresh snowfall, it is not uncommon to see evidence of snowmaching in watersheds of Sheep Creek, North Fork of Kashwitna River and all Montana Creek tributaries. If uncontrolled in the the future, disturbances from winter recreational activities may displace, undoly stress and/or otherwise conflict with moose use of the area.

Increased summer/fall use of all-terrain-vehicles throughout the area has resulted in rutted trails and limited habitat destruction in wetland areas. If vehicle use in alpine areas increased greatly during late-summer when moose begin to concentrate in those habitats conflicts with moose may be of concern. Presently, these activities do not appear to impact moose directly.

Prevailing winds in some alpine areas of the Talkeetna Mountains commonly displace fallen snow, lessen snowpack depth and often expose ground vegetation. Moose prefer to forage in areas with shallow snow and are known to concentrate in these habitats in fall and early winter.

The Subpopulation. Thirty-three, 74, 13 and 93 moose were observed in Montana Creek, Sheep Creek, North Fork Kashwitna and Kashwitna River watersheds, respectively, on 15 March on a distribution survey in the inclement 1984-85 winter. Significantly more moose probably occurred in these areas but large tracts of forest habitat in the survey area decreased observability of moose and survey intensity was greatly reduced near human settlements to decrease disturbance of humans.

Surveys, in December 1985, in alpine habitats only, near Sheep Creek and North Fork of the Kashwitna River in December 1985 revealed 126 and 129 moose, respectively.

Annual late fall/early winter moose population composition surveys conducted by the Alaska Departmert of Fish and Game indicate that 600-800 moose occurred in this area between 1968 and 1971 (ADF&G files). About 400 moose were observed on similar surveys conducted between 1978 and 1982. These data may, in part, reflect variations in carrying capacity of the habitat, but they also indicate what the habitat could support under different environmental conditions or land managment practicies. I estimate that 500-600 moose inhabited this area in winter 1984-85.

Five moose captured and radio-marked on the Susitna River floodplain were periodically relocated in this area. Four of the moose were captured in a 17 April 1980 sample and one female was captured in a 10 March 1982 sample. One marked male commonly ranged in middle to upper Sheep Creek from spring through early fall. During late fall he moved down to the North Fork of the Kashwitna River. In late winter, this individual typically moved downstream to an alpine area between the Kashwitna River North Fork and Sheep Creek. If mild winter weather conditions prevailed, he remained in this area until spring, when he would return to higher elevations in the Sheep Creek drainage to complete an annual circuit. However, if the winter snowpack became deep, this individual would depart the alpine habitat and move to disclimax, disturbed sites in lowland areas near human settlements along the Susitna River floodplain where he remained through winter, before returning to upper Sheep Creek in April completing a different annual circuit pattern.

One female moose, which spent each winter above timberline near middle Sheep Creek and Montana Creek South Fork, departed those areas in mid-April and traveled about 30 miles southwest across the Susitna River to a location near Lockwood Lake for parturition. After calving she traveled north to Trapper Lake for several weeks in June before returning to the parturition area where she remained until late September when she again traversed the Susitna River and returned to the alpine area near middle Sheep Creek. This individual apparently "wintered" in alpine habitats near middle Sheep Creek and was probably initially captured in a mid-April sample near the Susitna River while in transit to her parturition area.

The other three radio-marked females wintered on or near the Susitna River floodplain, went through parturition west of the Susitna River and spent the remainder of the year in the low to middle elevations of Sheep Creek-south fork Montana Creek.

Although accurate data are lacking there appear to be three behaviorally different movement patterns within this moose subpopulation: 1)a large portion of moose resident in early winter, remain near timberline through the winter, 2)an equal portion of moose migrate from alpine habitats to winter on the Susitna River floodplain and/or in disclimax habitats among human settlements and near the railroad and highway rights-of-way and 3)an unknown sized portion of female moose which migrate to lowland marshy habitats near or across the Susitna River for parturition and do not return to alpine habitats until early fall. Some moose from subpopulation that typically winter near timberline seek refuge and forage in lowland areas among human settlements and along the Susitna River floodplain when the snowpack becomes deep in alpine areas.

Significant Movement Patterns. Because large numbers of moose have been observed on the Susitna River floodplain near the mouth of Montana Creek, Sheep Creek and Kashwitna River, moose migrating from higher elevations must "funnel down" through and from those drainages in route to winter range on the Susitna River floodplain.

Movements of radio-marked moose indicate that timing, duration and maginitude of migrations from higher elevations to the Susitna River floodplain are closely related to snowpack depth. If the snowpack becomes deep early in winter moose migrate early. Moose remain in lowland areas as long as deep snows persist. Magnitude of the migratory movement is positively correlated with persistance and spatial extent of the deep snowpack. However, there is a small segment of this subpopulaiton that remains near timberline throughout winter, regardless of snow conditions. Of moose observed near timberline in early winter, some may eventually migrate to lowland areas in response to deepening snowpacks while others may remain resident in alpine habitats regardless of snowpack conditions.

Evidence obtained in November-December 1985, indicated that moose congregate in alpine areas during late fall and early winter (late October-December). Few moose were observed in these areas in early October. Either nonrutting moose moved to these areas after the rut or rutting groups terminated activities in these areas, because by November, large numbers of moose were present. Incidental observations obtained in 1984 and 1985 indicated that considerably fewer moose were in these alpine areas in mid-February of those years than were observed in February 1986. Parallel observations indicated that large numbers of moose had immigrated to lowland areas near human settlements and the railroad and highway rights-of-way by early February. This movement pattern may account for the apparent inconsistancies in results of standard composition surveys conducted in alpine areas in different seasonal periods (ADF&G files). However, other evidence from radio-marked individuals is contradictory, in that, it indicates that not all moose which occur in these lowland wintering areas originate from the Talkeetna Mountains. The latter data indicate that many moose in these lowland winter ranges have emmigrated from areas west of the Susitna River floodplain.

Sex segregated groups of moose were observed in these alpine areas in December. Groups solely or predominantly of males were frequently observed at higher elevations in the headwaters of major drainages above timberline in primarily riparian shrub willow plant communities. This habitat was noticeably different than that utilized by other moose. A group of 25+ males was observed annually in the upper North Fork of Kashwitna River. Smaller sized male groups were also observed annually in upper South Fork of Montana Creek. Even when mixed agmonst females, males still seemed to maintain loosely knit groups. As winter progressed (and spring approached) these male groups seemed to drift to lower slightly elevations (nearer to timberline), become less distinct, and became more diluted by females.

The railroad, highway, agricultural developments, human settlements and associated human activities may at times affect moose movements or preclude moose traditional use of wintering areas and negatively impact moose subpopulations involved. These conflicts become particularly evident when moose seek lowland areas and the Susitna River floodplain for winter range.

Mortality. Predator and predation. Wolves, brown bears and black bears occur in this area. There are reports of wolf sightings in the area but their occurence must be rare as I have yet to observe wolves or their sign. Impact of wolves on moose is probably negligible. Brown bears are primarily distributed in areas near and above timberline. A brown bear was observed on the carcass of a radio-marked moose. I am uncertain whether the moose was carrion from a hunter kill or killed by the bear. Black bears are distributed throughout the area, but probably primarily occur in forested areas near and below timberline. I presume that brown and black bears prey on upon neonatal moose calves as many radio-marked moose utilized habitats immediately below timberline during parturition. I suspect black bears also frequent these habitats during the same time period to forage and/or prey on moose calves. Coyotes are common throughout the area and may harass moose calves and may prey on them if the situation arises.

Other sources of mortality. Moose from this subpopulation that move to lowland areas near human settlements, the railroad and highway rights-of-way and the Susitna River floodplain for winter range are exposed mortality from humans in defense of life and property, from collisions with trains and vehicles, respectively; from drowning by falling through thin ice and/or into open water and from injuries sustained from slipping and falling on glare ice. Moose that traverse the Susitna River during ice free periods are also exposed to drowning when crossing open water.

Though access into this area is difficult, numbers of hunters and hunting effort is great and large numbers of moose are killed by hunters during the open hunting season.

Because substantial numbers of humans live in remote areas and desire a subsistence-type life style, I believe that some moose are killed illegally (during closed hunting season) for human sustenance.

Points of Concern and Potential With-Project Conflicts. Hydroelectric development of the Susitna River may affect this moose subpopulation by altering characteristics or seasonal timing of river ice or flow regimes which could result in mortality directly or indirectly through decreased carrying capacity of the habitat.

Any increase in access, human settlement or the human population in the area will negatively impact affect this moose subpopulation by increasing numbers of moose killed legally during open hunting season, illegally during closed hunting season and in defense of life and property; by decreasing or altering preferred habitats, or by increasing the level of human disturbance to moose.

Willow Mountain-Bald Mountain Ridge:

The Area. This 400 mi^2 area is bounded on the west by the Susitna River and encompasses watersheds of Little Willow Creek, Iron Creek, Peters Creek, Purches Creek, Willow Creek, Deception Creek and northern tributary drainages of the Little Susitna River upstream from the Parks Highway. Rural towns of Kaswitna and Willow occur in the area. Rural communities of Houston, Wasilla and Palmer are within 15 miles and the metropolitan areas of Eagle River and Anchorage which contain over a quarter million people are less than 60 miles away. This area is the "outdoor playground" for inhabitants of those rural communities and metropolitan areas.

The area is seasonally accessible by ski-, wheel-, and float-equipped light aircraft; all terrain vehicle (ATV); highway vehicle and snow machine. Several commonly used ATV trails originate from the Parks Highway and Willow-Hatcher Pass Road and provide terrestrial access into alpine habitats. The Willow-Hatcher Pass Road bisects the lower one third of the area in an east-west direction. The western portion of the area contains the Alaska Railroad and Parks Highway rights-of-way which essentially parallel each other about one mile east of the Susitna River. Numerous small settlements, and the towns of Willow and Houston, occur in a five-mile-wide band along those rights-of-way. Within this band of land are numerous parcels that had been cleared for homesteads. In many cases, homesteading and land clearing activities were subsequently abandoned and land cleared in that process reverted to second growth plant communities preferred by moose for winter range. Similar disclimax plant communities occur in rights-of-way maintained for the railroad and the highway and throughout settled areas where man has disturbed natural plant communities.

Active gold mining operations occur in the area along the Willow Creek drainage.

Several areas adjacent to Bald Mtn Ridge are presently leased from the State of Alaska for grazing livestock.

A land use management plan is being formulated for the Hatcher Pass Area by the Alaska Department of Natural Resources. This plan addresses an array of land uses including mining, livestock grazing, snowmachining, skiing, wildlife viewing, habitat preservation, forestry, and important alpine habitat moose winter concentration areas.

The railroad and highway rights-of-way and settlements and associated human activities, may negatively impact moose using the area by affecting movements or precluding use of of traditional areas. Conflicts are evident when moose utilize lowland areas and the Susitna River floodplain for winter range. Impacts become of particular concern, when above-average snowpacks occur at higher elevations and large numbers of moose move to lowland areas.

The area provides opportunites for fishing, hunting and trapping. In the past several years, seasonal use of all terrain vehicles and snowmachines has increased tremendously in alpine areas of Bald Mountain Ridge and Willow Mountain. Limited cross-country skiing also occurs in alpine areas. If uncontrolled in the future, disturbances from these human activities may conflict with moose use of alpine areas when moose concentrate there during the post-rut and winter periods. Extensive use of all terrain vehicles throughout the area during snow-free seasons has resulted in rutted trails and limited habitat destruction in alpine and wetland habitats.

Prevailing winds in the western foothills of the Talkeetna Mountains commonly displace fallen snow from exposed alpine slopes, lessen the snowpack and low-growing vegetation. Solar radiation on south-facing slopes also helps to melt snow and frequently exposes low-growing vegetation at unseasonal times. Since, moose prefer to forage in areas with shallow snow, high densities of moose occur in these habitats in winter.

Ferns (Dryopteris) are a common component of alpine habitat plant communities in this area. Moose are commonly observed digging ("cratering") through the snowpack to feed on fern rhizomes. Ferns have been identified as a relatively high quality forage plant for moose wintering in the area.

It has been said that this area contains some very high quality moose wintering areas and at one time the area may have supported the densest winter concentrations of moose in the state (Chatelain 1954).

The Subpopulation.Moose frequenting Willow Mountain and Bald Mountain Ridge in winter probably do not commonly intermix between those respective mountains and may actually represent two distinct subpopulations. However, because moose from both geographical areas appear to exhibit parallel behavior patterns, they will be treated as a common subpopulation in this report.

Late fall herd composition surveys conducted in the mid-1960's and early 1970's indicated that over 1,000 moose occurred in the area at that time (ADF&G files).

A distribution and abundance survey in November of 1985, in alpine habitats alone, revealed over 275 and 300 moose, respectively, on Willow Mountain and Bald Mountain Ridge, during the relatively mild 1985-86.

Relatively low subpopulation levels that presently exist in the area perhaps reflect affects of several harsh winters and/or present land management practicies and policies rather than potential carrying capacity of the habitat. Different land managment practicies and several mild winters could perhaps result in significantly higher subpopulation levels.

I would estimate that about 600-700 moose presently winter in this area. These moose are concentrated on Willow Mountain, Bald Mountain Ridge and in disclimax habitats near human settlements and along railroad and highway rights-of-way.

Significant Movement Patterns.Though no moose captured and radio-marked on the Susitna River floodplain were later relocated in alpine habitats of this area, I believe small numbers of moose from this subpopulation commonly utilize and/or traverse Susitna River floodplain habitats in winter or during other seasonal periods. I believe that timing of sampling and weather conditions prior to sampling may have prevented the latter moose subpopulations from entering samples obtained on the Sustina River floodplain in winter. There is little reason to suspect that subpopulation behavior in this area differs from that of adjacent, northern subpopulations where moose captured on the Susitna River floodplain were subsequently relocated in alpine areas of the Talkeetna Mountains. Some moose from lowland areas probably move to alpine winter range on Willow Mountain and Bald Mountain Ridge. Timing, extent and magnitude of this seasonal movement may be affected by winter weather conditions. I suspect that some females from this subpopulation utilize lowland and riparian areas in spring when they seek particular habitat types during parturition. Some of the lat female moose mlay also winter in the alpine areas. Annual range of other moose in these subpopulations is probably limited to higher elevations encompassed entirely within the described boundaries.

Sex-segregated groups of moose were observed in this area in December. Groups solely or predominantly of males (up to 30) were frequently observed in alpine habitats at slightly higher elevations than most other moose.

Mortality. Predators and predation. Black bears, brown bears and wolves are reported to occur in the area but I believe that densities of predators in this area are considerably less than in more northern areas. Basically, I believe that predation on moose subpopulations in the western foothills of the Talkeetna becomes increasingly more important as a population regulating factor as one moves from south to north. It is believed that this is the result of decreased exploitation rates by trappers and hunters but I also believe that subtle habitat factors, human disturbance and habitation and availability of alternate prey are influential factors.

However, approximately 12 brown bears were reportedly observed in Peters and Purches Creek watersheds in spring of 1985. The very late phenology in spring 1985 may, in part, account for this "apparently" atypical occurrence.

In the spring of 1986, I frequently observed black bears while relocating radio-marked moose on the southeast slope of Bald Mountain Ridge. Since numerous moose were also in this area and these observations were made about the time of parturition, I suspect black bears had the opportunity to prey on neonatal moose calves.

In spite of these two observations, I believe that predators are not a major factor influencing the level of this subpopulation.

Other sources of mortality. In winter 1984-85, 80 moose from this subpopulation were reported killed by collisions with trains in the railroad right-of-way between Houston and the Kashwitna River.

In winter 1982-83 and 1983-84, 182 and 77 moose were reported killed by collisions with vehicles in highway rights-of-way in Game Management Subunits (GMS) 14A and 14B, respectivley. Because subpopulation delineations and GMS boundaries differ, direct quantitative allocations of moose mortality to this particular subpopulation are not possible.

In the winter of 1984-85, it was estimated that 40 moose in GMS 14B were killed by humans in defense of life and property (ADF&G files). When a deep snowpack persists for long period, moose are stressed and become aggressive when confronted by humans. Stressed and aggressive moose interfer with activities of humans and are eventually killed to resolve local conflicts.

Mortality of moose from collisions with trains and vehicles and defense of life and property is correlated with winter weather conditions. Moose mortality from these causes increases tremendously in relation to depth and persistence of the snowpack locally and in the surrounding uplands.

Mortality from these sources can have a significant impact on this subpopulation in a severe winter when over 300 moose may be affected.

Since, moose from this subpopulation traverse the Susitna River when moving to and from winter and calving ranges, I suspect that some mortality results from drowning by falling through thin ice and/or into open water and from injuries sustained by slipping and falling on glare ice.

Proximity to large human populations and good access through the area contribute to a relativley high hunter kill of moose during the open hunting season.

Because of the large number of human inhabitants in relatively remote areas, I believe that some moose are killed illegally, out of season, by humans for food.

Concerns and Potential With-Project Conflicts. Since moose from this subpopulation must contend with trains and vehicles in those respective rights-of-way when moving to and from wintering and calving areas any increase in traffic in those rights-of-way will result in increased mortality to that subpopulation. Levels of moose mortality will be elevated greatly if peak traffic flows correlate with moose migratory and behavior patterns.

With-project alterations in composition and/or distribution of plant species on the Susitna River floodplain may affect the carrying capacity of the area for wintering moose.

With-project alterations in timing, levels and characteristics of river hydraulics (flow rates, peak stages, ice regimes, etc.) of the Susitna River may affect mortality rates for moose that traverse the river bed to utilize ranges on both sides.

Hunting effort and mortality from hunting to this moose subpopulation will likely increase, if hydroelectric development of the Susitna River, increases the local human populations or access into the area.

Little Susitna River:

The Area. This 500 mi^2 area is bounded on the west by the Susitna River and encompasses watersheds of the lower Little Susitna River (excluding Bald Mtn Ridge tributaries), Fish Creek and Rolly Creek.

The area contains relatively large rural/suburban human settlements at Wasilla, Big Lake, Houston and along the Parks Highway and includes their associated infrastructure of roads, residential dwellings and commercial developments. A substantial rural human population occurs in outlying and more remote areas. Large parcels of land in the south, which were once black spruce and muskeg and mixed mature paper birch and white spruce forests have recently been cleared as part of a fledgling, state sponsored, agricultural industry. The Alaska Railroad, Parks Highway, and a network of paved and unpaved vehicular roads occur throughout the central portion of the area. The area lacks alpine habitats and is dominated by lowland habitat types with elevational extremes varying from sea level to about 400 m. Numerous lakes, muskegs and black spruce bogs occur in the west where human habitation is negligible.

Along the railroad and highway rights-of-way and near most human settlements, previously disturbed natural vegetation has reverted to second growth plant communities that are preferred by moose for winter browse. Overall, the area appears as a mosaic of lowland habitat types interspersed with rural developments and disclimax second growth plant communites on sites where human disturbances altered natural plant communites. Large numbers of moose presently utilize browse available on these disclimax disturbed sites in winter.

Much of the eastern and central portion of the area is accessible by a network paved or unpaved roads. Access to the western portion is seasonally limited to snowmachine, all terrain vehicle, river boat and ski-, float-, or wheel-equipped light aircraft.

The trains, vehicles, human settlements and associated human activities, may negatively impact moose by affecting their migratory movements or precluding traditional use of particular areas. Conflicts between humans and moose are evident in winter when moose seek second growth browse in lowland areas near railroad and highway rights-of-way and human settlements. Magnitude of conflicts are of particular concern when an above average snowpack occurs in adjacent areas and very large numbers of moose seek refuge from the deep snowpack in lowland areas where the snowpacks are shallow and forage is plentiful on disclimax, second growth distrubed sites.

The area provides opportunities for cross-country skiing, hiking, boating, camping, fishing, hunting and trapping. Human participation in these activities decreases westerly away from access routes and population centers.

In all winters, prevailing north and northeasterly winds from the Matanuska and Knik River valleys commonly displace fallen snow, lessen the snowpack and expose low-growing vegetation in most of these lowland areas. Since moose prefer areas with shallow snow cover, these lowland habitats remain attractive to moose even in winters when most other areas have very deep snowpacks. Because of consistantly shallow snowpacks and readily available high quality winter forage, this area supports a very large and productive moose subpopulation and provides an attractive winter range for moose from adjactent areas and subpopulations. For these reasons, winter survival rates for moose, particularly calves, which utilize this wintering area, are probably significantly higher than for most subpopulations elsewhere in the state. The coincident abundance and availability of high quality winter browse and lack of deep persistent snowcover enable the area to support extremely large numbers of moose through the winter period.

A major portion of moose winter browse available in this area resulted from past and present disturbances to natural (sometimes climax) plant communities by human activities. I believe that the availability of these food sources have caused an increase in the resident moose subpopulation and secondarily attracted (or encouraged the establishment of different movement patterns) moose from neighboring subpopulations which previously wintered in other, adjacent areas as the Susitna River floodplain.

In this area, ice on Susitna River is frequently blown free of snowcover and polished to a glare surface. Moose are known to have died as a result of injuries sustained from slipping and falling while negotiating glare ice conditions in this area.

<u>The Subpopulation</u>.The typically light and shallow windblown snow cover in this area frequently precludes accurate surveys and information on moose subpopulation distribution and abundance in this area is piecemeal. Though available data suggest that small numbers of moose are resident in this lowland area, very large numbers of moose are observed in portions of the area in winter. Whether these local concentrations of moose result from a redistribution of the resident subpopulation or an immigration from adjacent subpopulations is presently unknown. I suspect the latter possibility is the predominant factor.

Density for the resident moose subpopulation probably averages slightly less than 1 per mi^2.

<u>Significant Movement Patterns.</u> Data presently available from several moose radio-marked on the Susitna River in winter, indicate that some moose from this subpopulation make seasonal movements from that area to near Pittman and Wasilla, the Little Susitna River or the Big Lake area in early winter, late winter and during parturition, respectively.

Because this area provides a winter range with shallow snow cover and readily available high quality winter browse, many resident moose probably redistribute within the area rather than move to the Susitna River floodplain for winter range. It is very likely that moose from neighboring subpopulations immigrate to this area in winter.

Data gathered in the 1960's, from a sample of visual-marked moose, suggested that about 15% of the moose captured in winter near Willow, Pittman, Wasilla, or Palmer utilized areas east of the Matanuska River and that another 15% later utilized areas west of the Susitna River (ADF&G files). Most moose making the shorter movement (generally less than 15 mi) across the Matanuska River were females, whereas, mostly male moose were found to make the longer movement (over 50 mi) across the Susitna River.

Apparently, moose movements into and within this area occur during different seasons, result from a combination reasons, and involve several different subpopulations.

In winter, moose prefer early successional stages of vegetation for browse. Because these many of these plant communities are seral in nature, one must be cautious when using "historical" data to characterize contemporary patterns of movement and habitat use. As early seral habitats are replaced by more climax vegetative communities, carrying capacity and numbers of moose using them will typically decrease. Moose displaced by a gradual decrease in carrying capacity or an abrupt and complete loss in carrying capacity will only gradually alter movement patterns to utilize newly available and/or more productive seral communities available at different locations. Movement patterns for subpopulations of moose documented in the 1970's may not be appropriate for subpopulations inhabiting the same area in the 1980's.

Mortality.Predators and predation. Brown bears frequent the Little Susitna River when spawning salmon are available. But becuase of the relatively high density of human habitation in the area numbers of wolves and brown bears are low. Predation from brown bears and wolves on this moose subpopulation is probably very low. Black bears occur commonly in the east and west portions of the area. Numbers of black bears in the central portion are probably considerably lower because of denser human habitation. Black bear predation may be a significant mortality factor for neonatal moose calves in the western portion of the area where wet marshy habitats probably attract parturient females for calving and black bears for foraging on early spring herbaceous vegetation.

Other sources. Collisions of moose with trains and vehicles in the railroad and highway rights-of-way, respectively, are a significant source of mortality to this subpopulation in the winter.

Moose from this subpopulation that move to the Susitna River floodplain for winter range or calving, are exposed to seasonal mortality from drowning by falling through thin ice and/or into open water and from injuries sustained by falling on glare ice.

Due to relatively easy access and the proximity to large human populations, a substantial hunting effort occurs in the area and results in a large moose kill.

Concerns and Potential With-Project Conflicts.Hydroelectric development of the Susitna River may affect moose utilizing these areas by altering characteristics or seasonal timing or river ice or flow regimes or by increasing the human related activities in the area.

With-project alteration in timing, levels and characteristics of hydraulics (flow rates, peak stages, ice regimes, etc.) of the Susitna River may affect mortality rates for moose that utilize and/or traverse these floodplain areas en route to seasonal ranges on opposite sides.

With-project alterations in phenology, composition and/or distribution of plant species on the Susitna River floodplain may affect the carrying capacity of the area to support wintering moose.

Moose from this subpopulation which must cross the railroad or highway rights-of-way to access seasonal ranges will be exposed to mortality from collisions with trains or vehicles, respectively. Any increase in traffic in those rights-of-way will increase moose mortality. Seasonal increases in traffic that correlate with moose movements or behaviors will increase mortality above that level.

Hunting effort and moose mortality from hunting will likely increase if the local human population or access into the area increases as a result of hydroelectric development.

Decreases in predation rates and increases in moose net productivity levels may be expected with-project if increases in human populations and access in the area resulted in increased hunting, trapping and human disturbances of predators which negatively affected local predator population levels.

Little Susitna Flats-Susitna River:

The Area. This 100 mi^2 area is located along the north shore of Cook Inlet, extends from the mouth of the Susitna River to east of the mouth of the Little Susitna River and includes the tidal salt flats of Cook Inlet.

Except for several streamside seasonal commercial fishing set-net site out buildings and scattered duck hunting shacks, the area contains little human development. Seasonal access to the area is provided by ski-, float- and wheel-equipped light aircraft; snowmachine; all terrain vehicle; and boat via Cook Inlet and the Susitna and Little Susitna Rivers. The area is dominated by lowland bog habitat types interspersed with "islands" of sparse black spruce and mature paper birch/white spruce forest. Some habitat types present in the area are commonly used by female moose during parturition. Elevations in the area seldom rise above 100 m. The area provides opportunities for fishing, hunting, trapping and snowmachining.

Prevailing north and northeasterly winds from the Matanuska and Kink River Valleys commonly displace fallen snow, lessen the snowpack and expose low-growing vegetation in most of this lowland area. Tidal action in Cook Inlet melts and erodes the snowpack from the tidal flats and exposes low-growing vegetation. Since moose prefer areas with shallow snowcover, these lowland and tidal areas are utilized by moose in winter and become particularly attractive to moose when deep snowpacks ocurr in adjacent areas.

In winter, moose from the Little Susitna River subpopulation may travel through this area when moving to winter range on the tidal flats winter range along Cook Inlet.

The Subpopulation. Because the typically light snow cover precludes accurate surveys, information on distribution and abundance of this moose subpopulation is piecemeal. Probably only very small numbers of moose are resident to this area.

One female moose radio-marked near the Susitna River floodplain subsequently ranged annually over only 6 mi^2 within this area. On occasions, up to 25 moose have been observed in winter, shortly after daybreak, feeding on the salt flat areas adjacent to the north shore of Cook Inlet. In the spring, up to 15 moose have been observed feeding in wet, marshy habitats and ponds located near the Susitna River. In winter, up to 15 moose have also been observed feeding in this same area and along adjacent minor drainages into the Susitna River. It is unknown whether moose involved in these local concentrations are resident within the area or are from neighboring subpopulations. A large proportion of the resident moose subpopulation probably utilize winter range on the Susitna River floodplain. Densities of moose within this area probably do not exceed 0.5 moose per mi^2.

Significant Movement Patterns. I suspect that this moose subpopulation is largely sedentary. Major, short distance, seasonal movements occur, in winter, to the Susitna River floodplain or to the tidal flats along Cook Inlet and in spring, to wet, marshy habitats between the Susitna River and Figure Eight Lake.

Mortality. Predators and predation. Wolves are rare in the area and brown bears may occassionally travel through it. Black bears occur at low densities throughout the area. Black and brown bears likely prey on neonatal moose calves as habitats frequented by parturient female moose (marshy habitats, interspersed with islands of sparse black spruce) occur throughout the area.

Other Sources. Moose which winter on the Susitna River floodplain would be exposed would be exposed to mortality from drowning by falling through thin ice and/or into open water and from injuries sustained by slipping and falling on glare ice.

Though near a large human population, restricted access into the area probably results in only a small amount of hunting effort and hunting related moose mortality.

Concerns and Potential With-Project Conflicts. Hydroelectric development of the Susitna River may affect this moose subpopulation by altering characteristics or seasonal timing of river ice or flow regimes. These impacts could result in mortality directly, or indirectly through decreased carrying capacity of the habitat or by increasing access or the human population in the area which could, in turn, increase the number of moose killed by hunters.

Increased human settlement and access into the area could depressed predator levels by increasing the numbers killed by trappers and hunters or degrading habitat quality by increasing the level of human disturbance. If this occurred, there would be a corresponding decrease in mortality from predators and an increase in net productivity of the subpopulation.

Susitna-Beluga River. This 50 mi^2 area occurs along the north coast of Cook Inlet, extends from the mouth of the Susitna River to the mouth of the Beluga River and includes the lower sections of Ivan, Lewis and Theodore Rivers and the adjacent tidal salt flats of Cook Inlet.

Other than riverside seasonal commercial fishing site out buildings and scattered duck hunting shacks, the area contains little human development. Seasonal access to the area is provided by ski-, float-, and wheel-equipped light aircraft; snowmachine; all-terrain vehicle; and boat via the Susitna Rvier or Cook Inlet. The area mainly contains lowland marshy, muskeg type habitats interspersed with "island forests" of sparse black spruce and mature paper birch/white spruce. The sparse black spruce forest present in this area are commonly used by female moose during parturition. Elevations within the area rarely exceed 100 m. The area provides opportunities for hunting, fishing and trapping.

Prevailing northeasterly winds from the Matanuska and Knik River valleys and northerly winds from the Susitna valley commonly displace fallen snow, lessen snowpack depth and expose low-growing vegetation throughout most of this lowland area. High waters from tidal action of Cook Inlet frequently erode and melt the snowpack from the tidal flats and expose low-growing vegetation. Since moose prefer to winter where snowpacks are shallow, these lowland areas are commonly utilized by moose for winter range. These habitats become particularly attractive to moose in winters when deep snowpacks occur in adjacent areas.

The Subpopulation. Because the typically light and patchy snow cover precludes accurate surveys, information on moose subpopulation distribution and abundance in this area is piecemeal. Probably only very small numbers of moose are resident to this area. A high proportion of the resident moose subpopulation probably travel to and utilize winter range on the Susitna River floodplain. In winter, moose from other subpopulations probably travel through this area when moving to winter range on the Susitna River floodplain. In spring, female moose from adjacent subpopulations probably move into the area to utilize muskeg habitat during parturition. Density of the resident subpopulation is probably less than 0.5 moose per sq mi.

Significant Movement Patterns. Though no radio-marked moose remained entirely within this area, I believe that contains a small number of resident moose. Seasonal movements of this subpopulation would likely be to the Susitna River floodplain or the tidal flats along Cook Inlet for winter range and to the open marshy muskeg habitats in spring for parturition.

Mortality. Predators and predation. Wolves rarely occur in the area. Brown bears probably occasionally pass through the area. Black bears probably frequent the small bands of forest that occur in the area. Use of the area by black bears is probably greatest during spring when the area is also utilized by parturient female moose. Occurrence of moose and black bears in the same habitat probably results in limited black bear predation on neonatal moose calves.

Other Sources. Moose from this subpopulation that move to the Susitna River floodplain for winter range are exposed to seasonal mortality from drowning by falling through thin ice and/or into open water or from injuries sustained by slipping and falling on glare ice.

Though the area is near a large human population, low densities of resident moose and poor access probably discourage efforts by hunters and lead to a low hunter moose kill.

Concern and Potential With-project Conflicts. Hydroelectric development of the Susitna River may affect this moose subpopulation by altering characteristics or seasonal timing of river ice or flow regimes. These impacts could result in mortality directly or indirectly through decreased carrying capacity in the habitat or by increasing access or human population in the area which could inturn increase human disturbance or the number of moose killed by hunters.

Increased human settlement and access in the area could negatively impact predator populations by increasing numbers killed by trappers and/or hunters and by increasing the level of human disturbance. If this occurred, there would be a decrease in moose mortality from predators and a corresponding increase in net moose productivity.

Mount Susitna-Little Mt. Susitna:

The Area. This 650 mi^2 area emcompasses the upper watersheds of Beluga, Theodore, Lewis, and Ivan Rivers; watersheds on Little Mt. Susitna, Mount Susitna and Trail Ridge and lower Alexander Creek. Topography and habitats in the area range from flat wet marshy habitats only slightly above sea level, to lowland floodplain habitats along the lower Yentna River and Alexander Creek, to alpine habitats at elevations above 3,000 and 4,000 ft on Little Mt. Susitna and Mount Susitna, respectively, and to wet, marshy habitats above 800 ft elevation near Drill Creek and upper Theodore River.

The area is seasonally accessible by wheel-, float- and ski- equipped light aircraft; snowmachine and all-terrain vehicle.

A major strip coal mining operation is centered in the upper Lone Creek watershed.

Some activities in the area are undertaken with professional guides and commercial air taxi operators. Hunting and fishing field camps are sparsely scattered throughout the area.

Very heavy snowfall and deep snowpacks are not uncommon in the upper elevations of this area.

The Subpopulation. Behavior of this moose subpopulation is strongly influenced by snowpack depth and winter weather conditions. When a snowpacks are deep in upper elevations of the area, large numbers of resident moose emmigrate to winter ranges at lower elevations on Alexander Creek, the Yentna River and the Susitna River floodplains.

Six moose radio-marked on the Susitna River floodplain in late winter, later redistributed off the floodplain within portions of this area. Nonwinter ranges for these individuals centered near Beluga River, Drill Creek, Theodore River, Talchulitna River, Mount Susitna and Trail Ridge. Timing, magnitude and duration of moose use of Susitna River floodplain winter range in this area is closely associated with occurrence and extent of snowfall and snowpack depth. This moose subpopulation probably contributes greatly to the dramatic fluctuations in numbers of moose wintering on the Susitna River floodplain downstream from the Yentna River.

Information obtained in winter 1982-83, indicated that moose subpopulations in this area promptly, responded to a decrease in the snowpack, as well as increasing snowpack depths. Following a heavy snowfall in late October, early November and through December a major immigration of moose onto the Susitna River floodplain occurred from Bell Island to Cook Inlet. During that time period, numbers of moose observed in that section of the Susitna River floodplain increased from about 100 to 260. By early-December over 120 moose were observed on Bell Island alone and 412 were present on the Susitna River floodplain downstream from the Yentna River. Ameliorating weather conditions, redistribtuion and settling of the deep snowpack was followed by a significant decrease in numbers of moose observed on the floodplain. By early-February, when the snowpack is normally deepest and moose use of the floodplain typically greatest, numbers of moose observed in that same area had decreased to 206. I presume the decrease in numbers of moose was due to an emmigration of moose back to alternate winter ranges off the floodplain. These data suggest that more than 300 moose from this subpopulation may migrate to the Susitna River during inclement winter conditions.

In addition to the Susitna River floodplain, some moose from this subpopulation probably winter on the floodplains of Sucker and Alexander Creeks and the Yentna River. Large numbers of moose have been observed on these drainages in previous winters. Though, these later floodplains may provide some refuge from an excessive snowpack, I believe that in all winters, they normally have a deeper snowpack than the Susitna River floodplain. The Susitna River floodplain also differs from the former areas in that it is more open and exposed to prevailing northerly and northeasterly winds which typically redistribute and compact fallen snow so affectively that the snowpack seldom completely covers low-grwoing vegetation for periods longer than a week. Very few "winter killed" moose were observed in this section Susitna River floodplain in 1984-85, when about 30 dead moose were observed on Alexander Creek.

Since relatively "favorable" winter conditions prevail in this area even in harsh winters, winter mortality of moose, particularly calves, in this area is exceptionally low even when compared to other low elevation winter ranges in the Susitna River basin.

Information obtained from several radio-marked female moose suggested that female moose in the area may utilized wet, marshy, lowland muskeg habitats during parturition.

Concentrations of moose were observed on the southern slopes of Mount Susitna in October, a time period when rutting activity normally occurs. Apparently, moose from this subpopulation utilize this portion of the area for rutting behavior.

<u>Significant Movement Patterns</u>. In winter, a portion of this moose subpopulation moves to lowland ranges. Timing, duration and magnitude

of this movement is correlated with snowpack depth and severity of winter weather conditions. In winters when snowpacks become deep, a large proportion of this moose subpopulation immigrates to wintering areas at lower elevations along the Yentna River, Alexander Creek and the Susitna River floodplain downstream from the Yentna River. This movement pattern results in extremely high densities of moose on the Susitna River floodplain.

One radio-marked female moose in this subpopulation was found to travel over 25 miles to winter on the Susitna River floodplain. One radio-marked male moose which also winter on the Susitna River floodplain traveled about 25 mi to the Denslow Lake area, during the rut period. These individuals made similar movements in several consecutive years.

Some female moose from this subpopulation move to wet marshy muskeg habitats at lower elevations along the Susitna River floodplain during parturition. Similar type habitats occur west of the Susitna Mountains at higher elevations near the upper Talchulitna River. I presume some females from this subpopulation move to and utilize calving habitats at these higher elevations in years when snowpacks are shallow.

Mortality.Predators and predation. Wolves, brown bears and black bears occur in the area. Observations of wolves or wolf sign are frequently reported for the upper Sucker Creek and Wolf Lake areas west of the Susitna Mountains. Because of human activities in lowland areas along the Susitna River, I suspect that wolves normally remain at higher eleveations and seldom visit the Susitna River floodplain. Brown bears occur scattered throughout the area but are probably more common at higher elevations away from human disturbances. Black bears are common at all elevations throughout the area. Because of their tolerance for humans, black bears occur commonly in lowland areas and along the Susitna River floodplain. I presume that black and brown bears frequent muskeg habitats in spring to prey on neonatal moose calves. I suspect brown bears prey on adult moose in spring and through summer when deep snowpacks and relations with calves increase their vulnerability.

Other Sources of Mortality. Moose from this subpopulation that utilize the Susitina River floodplain are seasonally exposed to mortality from drowning by falling through thin ice and/or into open water and from injuries sustained from slipping and falling on glare ice. In winter 1982-83, several marked moose in this area died of injuries sustained from slipping on glare ice. Circumstantial evidence indicated that several unmarked moose also died from similar causes. This source of mortality is probably most common in this section of the floodplain because of very wide ice-covered river channels and strong winds which remove snow cover and expose and polish extensive areas of glare ice.

This subpopulation is exposed to moderate levels of mortality from hunters. I suspect that additional moose mortality results from illegal hunting for sustenance by year-round residents after the open hunting season closes.

Concerns and Potential With-Project Conflicts. Hydroelectric development of the Susitna River may affect this moose subpopulation by altering characteristics or seasonal timing of river ice or flow regimes. These impacts could result in mortality directly or indirectly through decreased carrying capacity of the habitat and/or by increasing human access or the human population in the area which could inturn increase the level of human disturbance or the number of moose killed by hunters.

Increased human settlement and access into the area could negatively impact predator populations by increasing the level of human disturbance and by increasing numbers killed by trappers and/or hunters. If this occurred, there would be a corresponding decrease in mortality from predators and an increase in net moose productivity.

Big Island-Bell Island:

The Area. This 75 mi^2 area encompasses 12 miles of the Susitna River floodplain and adjacent habitat immediately upstream from Cook Inlet. The area is composed mainly of five large, low relief islands on the Susitna River floodplain. The islands range in size from about 1 to 6 mi^2. The area includes about 1 mi^2 of land which parallels this section of the floodplain.

The area is bisected by a buried natural gas pipeline and over head electrical transmission lines. A roughly-maintained, maintenance road paralleling these facitilies provides seasonal access to the area by snowmachine, all-terrain vehicle and four-wheel drive highway vehicle. The area is also accessible seasonably by boat from the Susitna River and Cook Inlet or by float-, ski- and wheel-equipped light aircraft.

Permanent human habitation, in the area, is limited to small rural settlements along lower Alexander Creek. Several duck hunting shacks and commercial fishing cabins occur in the area. The area provides opportunities for recreational snow machining, hunting, fishing, trapping, and boating.

Prevailing northerly winds and northeasterly winds from the Matanuska and Knik River valleys commonly displace fallen snow, lessen the snowpack and expose ground vegetation in most of this lowland area. In winter, high water and tidal action of Cook Inlet frequently melt and erode the snow pack from the tidal flats and island margins and expose low-growing vegetation. Because moose prefer areas with shallow or no snow cover, this floodplain area is particularly attractive to migratory moose subpopulations in winters when deep snowpacks occur in adjacent areas. In winters of heavy snowfall, this area provides the most favorable winter range available to moose subpopulations from the west and southwest. Numbers of moose utilizing the area may increase by 4-5 times in winters with deep and persistant snowpacks.

These islands are apparently varied and large enough to sustain small numbers of moose year-round. The island habitats are a mosaic of wet meadows, open shrub grasslands and mature mixed deciduous/conifer forests. Willow and poplar browse is abundant along island perimeters and on sandbars where river hydraulics and flood action maintain early successional plant communities.

The Subpopulation. Because the typically light snow cover precludes accurate surveys, information on moose subpopulation distribution and abundance in this area is piecemeal.

Small numbers of moose are resident within this large islanded area of the Susitna River floodplain. Density for the resident moose subpopulation is probably about 1 moose per mi^2. One female moose, radio-marked in an adjacent area near Figure Eight Lake seldom ranged more than 2 mi from its capture site. A radio-marked male, seldom left Bell Island, and over a three-year period ranged within a 30 mi^2 area. I believe the behavior patterns exhibited by these individuals are characteristic of the resident moose subopopulation.

In winter, the resident moose subpopulation shares these island and floodplain habitats with subpopulations from adjacent areas. In severe winters, densities of 10-20 moose per mi^2 are neither unrealistic nor uncommon for portions of the area.

Perhaps some of the moose observed in spring utilizing the wet, muskeg habitats adjacent to the Sustina River floodplain orginate from this subpopulation.

Significant Movement Patterns. The resident moose subpopulation is largely sedentery. The only major seasonal movements for this subpopulation are probably to wet, marshy muskeg areas adjacent to the floodplain in early spring and spring to forage and calve, respectively, or to particularly good foraging areas on the islands themselves in winter.

Mortality. Predators and predation. Wolves are probably absent from this area. Because of the proximity of the area to Mt. Susitna, brown bears are probably not uncommon. Black bears are common throughout the area. I suspect that brown and black bears both prey on neonatal moose calves. Brown bears probably also prey on adult moose in early spring and summer when deep snowpacks or presence of neonate calves, resjpectively, increase their vulnerability.

Coyotes are commonly observed in the area. I would not be surprised if coyotes did not harass and/or occassionally prey on neonatal moose calves.

Other Sources. Moose which winter on the Susitna River floodplain would be exposed to mortality from drowning by falling through thin river ice and/or into open water and from injuries sustained by slipping and falling on glare ice.

Good access to the area by river boat and float- or wheel-equipped light aircraft contribute to substaintial hunting effort and moderate hunting related mortality.

Concerns and Potential with-Project Conflicts. Hydroelectric development of the Susitna River may affect this moose subpopulation by altering characteristics or seasonal timing of river ice or flow regimes. These impacts could result in mortality directly or indirectly through decreased carrying capacity or by increasing access or the human population in the area which inturn could increase the level of human disturbance and/or number of moose killed by hunters.

Increased human settlement and access into the area could negatively impact predator populations by increasing numbers killed by trappers and/or hunters and by increasing the level of human distrubance. If this occurred, there would be a corresponding decrease in mortality from predators and an increase in net moose productivity.

Delta slands-Caswell Islands:

The Area. This area encompasses about 65 mi^2 of open river water, large islands, floodplain and paralleling adjacent uplands of the Susitna River between the mouth of Kroto Creek and Sheep Creek.

This area is seasonally accessible by all-terrain vehicle, river boat, snow machine, float-, ski- and wheel-equipped light aircraft. Human habitation is limited to recreatio al cabins along the banks of the Susitna River and major tributary streams.

Riparian poplar forests were commercially logged on some islands in the past. Grass, shrubs and second growth birch and poplar stands now dominate these disturbed sites. New logging operations have recently been initiated on other floodplain islands.

The area provides opportunities for recreational hunting, exceptional salmon fishing, trapping, boating, camping, sled-dog mushing, and cross-country skiing.

This area does not appear to be northerly or northeasterly winds from Susitna River valley or the Matanuska and Knik River valleys, respectively, as more southern floodplain areas. In the absence of strong winter winds, fallen snow in this area remains relatively undisturbed and snowpacks accumulate to considerably deeper levels compared to more southerly floodplain areas which are exposed to valley winds. This area generally seems to recieve larger amounts of snowfall than areas to the south and snowpacks within the area appear to decrease from south to north. In general, winter conditions in this area are more favorable for moose than conditions to the west but less favorable than winter conditions to the south.

River islands in this area apparently are large enough and contain habitats types essential for sustaining small numbers of resident moose year-round. River hydraulic action maintains early successional open shrub plant communites and higher relief islands provide stability for open and closed canopy forest communities.

Tnough some islands in the Delta Island complex are as large as those in the Big/Bell Island area, habitats in the former area are denser, more mature, closed canopy forests which lack many of the seral plant communities preferred by moose.

During particular seasonal periods, moose from other subpopulations travervse and/or share these floodplain habitats with the resident subpopulation. In winter, moose from subpopulations east and west migrate to and winter on this section of the Susitna River floodplain. Depending on severity of winter conditions, numbers of moose in the area may increase by five to tenfold. Field data gathered indicate that large numbers of moose from westerly subpopulations problably utilize the floodplain in most all winters. In severe winters, substantially larger numbers of moose from those westerly subpopulations and additional moose from easterly subpopulations migrate to and use habitats on this section of floodplain. Some moose from westerly subpopulations traverse the floodplain area to utilize disclimax (disturbed sites) habitats near human settlements and highway and railroad rights-of-way. Smaller numbers of moose from westerly subpopulations are known to migrate completely through this area en route to alpine wintering areas in the western foothills of the Talkeetna Mountains. Immediately prior to parturition, some female moose from subpopulations east of the Susitna River traverse the floodplain when migrating to lowland muskeg calving areas west of the Susitna River.

The Subpopulation. About 50 moose are probably resident to this area and range almost entirely on this section of the Susitna River floodplain. These resident moose may ocassionally make forrays, short in distance and time, to adjacent uplands which parallel the floodplain.

Field data obtained from early winter floodplain surveys and observations from several radio-marked moose which seldom moved far off the floodplain in this area during a five-year period, provide biological evidence in support the former contentions.

Size and existence of this moose subpopulation is largely determined by the presence and maintenance of the mosaic of habitat types on the floodplain. Size and/or behavior patterns of this moose subpopulation would likely be altered if the proportions of seral and climax plant communities were changed.

Two radio-marked female moose, relocated over a four-year period only rarely departed floodplain habitats. Another radio-marked female, observed over a similar time period, only infrequently utilized habitats immediately adjacent to the floodplain.

Significant Movement Patterns. Moose in this small resident subpopulation are quite sedentary. Subpopulations, from the east and west, travel distances up to 25 mi to winter on this section of the floodplain. Numbers of moose wintering in this area are correlated with winter severity. Moose from some subpopulations move through the area in spring and winter en route to other wintering and calving areas. Some moose from this subpopulation may move to disclimax habitats, east of the floodplain and near human settelements and highway and railroad rights-of-way for winter range.

Mortality. Predators and predation. Brown bears probably rarely occur in the area. Wolves may occasionaly occur in the area in winter.

Black bears and coyotes occur commonly throughout the area. Black bears probably prey on neonatal moose calves in wet muskeg habitats used by parturient females. Coyotes may harass and/or also prey on neonatal moose calves.

Other Sources. Moose utilizing this area are seasonally exposed to mortality from drowning by falling through thin ice and/or into open water and from injury by slipping and falling on glare ice. Moose that winter along highway and railroad rights-of-way and human settlements may be killed by collisions with vehicles and trains or by humans in defense of life and property.

Concerns and Potential With-Project Conflicts. Hydroelectric development of the Susitna River may affect this moose subpopulation by increasing train and vehicle traffic in the railroad and highway rights-of-way, by altering characteristics or seasonal timing of river ice or flow regimes which could result in mortality directly or indirectly by decreasing habitat carrying capacity, by increasing access or the human population in the area which could inturn increase the number of moose killed legally or illegally by humans.

Kroto Creek-Moose Creek:

The Area. This 750 mi^2 area is located west of the Susitna River and is bounded by the Yentna River, Peters Creek, Little Peters Hills and the Sunshine Bridge on the Susitna River.

The area is seasonally accessible by highway vehicle along its northern border, all-terrain vehicle, river boat, snow machine, float-, ski- and wheel-equipped light aircraft and off-road vehicles via the Oilwell and Moose Creek Roads. Human habitation ranges from solitary homesteads, recreational homesites and recreational cabins on many lakes scattered throughout the area, to clusters of rural homesites and recreational cabins along the unmaintained Oilwell and Moose Creek Roads which extend south 15 and 10 mi from the Petersville Road to the Amber Lake area and from the Moose Creek Road to Gate Creek, respectively.

Numerous state-sponsored land disposals have occurred and are proposed within this area. The most recent land dispoal was along the eastern banks of the lower Yentna River.

Matunuska-Susitna Borough state forest land occurs in the Chijuk Creek area. This land area is unique in that it encompasses the most extensive mature paper birch/white spruce forest in the lower Susitna River valley.

The area is generally characterized by marshy lowland meadows interspersed with "islands" of open black spruce and paper birch/white spruce forests.

The area provides opportunities for recreational fishing, trapping, hunting, boating, camping and sled-dog mushing.

The area is not exposed to strong winter winds and fallen snow remains undistrubed and accumulates to considerably deeper depths than in areas farther south that are exposed to strong northerly and northeasterly winds. Within the area, snowfall and the snowpack both generally increase westerly away from the Susitna River.

Riparian habitats along Kroto and Moose Creeks and the Susitna River floodplain and a previously burned area on the south-western slopes of Little Peters Hills provide winter range for substantial numbers of moose.

Wet, marshy habitats interspersed with "islands" sparse black spruce and mature paper birch/white spruce forests are commonly utilized by female moose from this and adjacent moose subpopulations during parturition. These "calving" habitats are essentially devoid of moose during winter.

The Subpopulation. About 2,500 moose are presently estimated to be in this subpopulation. Short and long term size of this subpopulation is strongly influenced by winter weather conditions. Fluctuations of plus or minus 60-70% about that population level are probably realistic.

Data obtained from radio-marked moose and winter aerial surveys indicate that a large portion of moose from this subpopulation move to floodplain habitats along the Susitna River, riparian habitats along Kroto and Moose Creeks, and disclimax sites along Parks Highway and Alaska Railroad rights-of-way for winter range. Some moose from this subpopulation utilize the Susitna River floodplain as winter range in all winters but timing, magnitude and duration of this migratory movement is closely associated with winter weather and snowpack depth. A large portion of the moose which winter on the Sustina River floodplain originate from this subpopulation. About 400-500 moose from this subpopulation wintered for varying periods of time in riparian habitats along Kroto and Moose Creeks in winter 1984-85.

Roughly, 40 to 65 moose wintered opposite Goose Creek on an abandoned homestead adjacent to the western bank of the Susitna River between October and March, 1982-85.

Since moose radio-marked on the Susitna River floodplain in winter were not found to range farther west than the Yentna River, I presume the Yentna River to be the western range boundary for this subpopulation. Because snow conditions normally worsen to the west, I assume that as the winter snowpacks deepen moose from this subpopulation normally move easterly to obtain relief from excessively deep snowpacks. This migratory movement brings moose to wintering areas along Kroto and Moose Creeks and the Susitna River floodplain.

Significant Movement Patterns. Because of deeper snowpacks and a scarcity of adequate wintering areas, moose from this subpopulation migrate in an easterly direction as winter progresses. Timing, magnitude and duration of this movement is closely correlated with snowpack depth. Moose appear to utilize wintering areas along Kroto Creek early in winter and move on toward Moose Creek and the Susitna River floodplain as winter progresses and/or snow conditions become worse.

Female moose were commonly observed in the wet, marshy habitats interspersed with "islands" of sparse black spruce and paper birch/white spruce forests during parturition. I suspect movement to these areas is for more favorable foraging habitat or away from habitats more commonly frequented by predators. Movements to these habitats involve moose from this subpopulation as well as moose from adjacent subpopulations.

Mortality. Predators and predation. Wolves, black bears and brown bears occur in the area. Wolves occur more commonly in the western and northern portions of the area. Wolf sign has been observed along the Moose and Kroto Creek drainages in winter. Brown and black bears are distributed throughout the area. Densities of black bears are considerably greater than for brown bears.

I presume that black bears prey on neonatal moose calves as habitat use overlaps between the two species in spring when parturient female moose seek stands of sparse black spruce in wet muskeg habitats. Because of relatively high black bear densities their predation on moose calves may be a significant mortality factor. Brown bears probably also prey on neonatal moose calves in spring, as well as adults during other seasonal periods. But, because of relatively low densities, the contribution of brown bear predation to moose mortality is probably not as significant as that of black bears.

Coyotes occur commonly throughout the area and may occassionally harass and/or prey on neonatal moose calves.

Other Sources of Mortality. Moose from this subpopulation that move to the Susitna River floodplain for winter range are exposed to seasonal mortality from drowning by falling through thin ice and/or into open water and from injuries sustained by slipping and falling on glare ice.

Because the area is near a large human population center and is relatively accessible during the open hunting season, hunting related mortality can be a significant mortality.

In winter, some moose from this subpopulation cross the Susitna River to utilize disclimax habitats near human settlements and railroad and highway rights-of-way. Mortality from collisions with trains and highway vehicles can be a significant mortality factor. Because this subpopulation winters among human settlements it is not uncommon for moose to be killed in defense of life and property. These mortality factors become of particular significance during in winters when deep snowpacks persist for long periods.

Large numbers of humans live in remote portions of this area. Many individuals living in remote areas depend heavily on wildlife resources for sustenance. Though there is a special "subsistance" open hunting season in the area to accomodate use of moose by rural inhabitants, I believe there is still a significant illegal kill of moose in the winter for use as human food.

Indirect loss of moose in this subpopulation may occur when land use patterns are altered and carrying capacity of the habitat for moose is decreased. This situation may occur when large state-sponsored land disposals result in moose habitat being changed into homesites or agricultural developments.

Concerns and Potential With-Project Conflicts. Hydroelectric development of the Susitna River may affect this moose subpopulation by altering characteristics or seasonal timing of river ice formation or flow regimes. These impacts could result in mortality directly or indirectly through decreased carrying capacity or by increasing access or the human population in the area which could in turn increase the number of moose killed by hunters.

Increases in the human population and access into the area could negatively affect predator populations by increasing numbers killed by trappers and/or hunters and by increasing the level of human disturbance. If this occurred, there would be a decrease in mortality from predators and a net increase in moose productivity.

Little Peters Hills- Petersville:

The Area. This 325 mi^2 area extends from the Susitna River westerly to Petersville and the Little Peters Hills. East, north and south boundaries of the area are the Mouth of Whiskers Creek on the Susitna River north of Talkeetna and the Sunshine Bridge, respectively. The area emcompasses the upper watersheds of Peters, Kroto and Trapper Creeks and the terminus of the Chulitna River.

The area is seasonally accessible by riverboat from the Susitna and Chulitna Rivers; by vehicle from the Parks Highway near the eastern boundary, the Petersville/Trapper Creek Road which bisects the area into north/south halfs and the Oilwell Road which extends south from the Petersville Road and by float-, ski- and wheel-equipped light aircraft, snowmachine, and all-terrain vehicles at other locations.

The area provides opportunity for fishing, hunting, trapping, camping and sled-dog mushing. The area is served by commercial air taxi operators and professional guides.

Human habitation ranges from roadside developments, residences and homesteads along the Parks Highway and the Petersville/Trapper Creek Road and clusters of rural settlements and recreational cabins and homesites along the unmaintained Oilwell and Moose Creek Roads. Many small seasonal placer mining operations occur along streams near the Dutch/Peters Hills.

Numerous state sponsored land disposals have occurred and are planned within the area along the Oilwell and Petersville Roads.

The area is characterized by marshy lowland meadows interspersed with "islands" sparse balck spruce and mature paper birch/white spruce forests. These lowland areas grade up elevationally to alpine habitats in the northwest.

The area receives very large amounts of snowfall in the Dutch/Peters Hills. Generally, winter snowpack depths increase westerly from the Susitna River.

Riparian habitats along Moose Creek and floodplain habitats on the Susitna and Chulitna Rivers provide winter range for large numbers of moose.

The Subpopulation. About 500 moose are presently estimated to be in this subpopulation. Short and long term size of this subpopulation is strongly influenced by snowpack depth and winter weather conditions. Fluctuations plus or minus 60-70% about that population level are probably not unrealistic.

Data obtained from radio-marked moose and winter aerial moose surveys indicate that a large portion of moose from this subpopulation move to riparian and floodplain habitats along Moose Creek and the Sustina and Chulitna Rivers, respectively. An unknown portion of this subpopulation may winter on the western slopes of Little Peters Hills or on the Kahiltna Glacier forelands where large numbers of moose have been observed in winter. A small number of moose from this subpopulation may travel across the Susitna River to winter on disclmax habitats along the railroad and highway rights-of-way and near human settlements in the Talkeetna area.

Significant Movement Patterns. In winter, moose from this subpopulation gather along Peters Creek near the Little Peters Hills, on the south- and west-facing slopes of Little Peters Hills, along Moose Creek south of the Petersville Road, on disclimax sites near the town of Trapper Creek, and on the floodplains of the Susitna and Chulitna Rivers. The latter five locations are the most heavily used winter ranges in the area.

Large portions in the interior of this area are essentially devoid of moose in winter. Data collected during winter 1984-85, suggested that as the snowpack depth increases moose may move from the interior of the area (Kroto and Moose Creeks) easterly to winter on disclimax sites near the town of Trapper Creek and on floodplains of the Susitna and Chulitna Rivers.

In winter, a small number of moose may traverse the Chulitna and Susitna River floodplain to utilize disclimax habitats along highway and railroad rights-of-way and around human settlements near Talkeetna.

I suspect that in spring female moose depart winter ranges and move to wet, marshy muskeg areas during parturition.

Mortality. Predators and predation. Wolves, brown bears and black bears occur in the area. A pack of 5 wolves were observed near Talkeetna in winter 1983-84 and wolf sign was frequently observed in the western portions of the area. I suspect that wolf predation could be a significant mortality factor in this area. Moose may be particularly vulnerable to wolf predation in relatively severe winters when large numbers of moose concentrate on open floodplains.

Density of brown bears probably increases in westerly portions of the area. Brown bears probably prey on adult moose in early spring when snowpacks are deep, neonate shortly after parturition and adult moose during summer when they are protective of neonate calves. Black bears are distributed throughout the area and probably are a significant predator on neonatal moose calves shortly after parturition..

Coyotes occur commonly along open floodplains in eastern portions of the area. Though not documented, I believe that coyotes may harass neonatal moose calves and occassionally prey on them if the opportunity arised.

Other Sources of Mortality. Moose which winter on the Susitna and Chulitna River floodplains would be exposed to seasonal mortality from drowning by falling through thin ice and/or into open water and from injuries sustained by slipping and falling on glare ice.

Because interior portions of this area may receive large amounts of snowfall, winter kill can be a significant mortality factor. Winter kill mortality is particularly significant in winters when deep snowpacks persist into early spring. Winter kill typically affects a disproportinate number of calf and yearling moose.

Moose which travel across the Susitna and Chulitna River floodplains to winter in disclimax sites near human settlements and along highway and railroad rights-of-way are exposed to mortality from collisions with trains and vehicles and from humans defending life and property. These sources of mortality are particularly important during severe winters when large numbers of moose utilize these areas.

Good access into the interior of this area contributes to a relatively high jkill of moose during the open hunting season.

Because of the large number of seasonal and year-round human inhabitants in remote portions of the area, I believe that substantial numbers of moose are killed illegally in winter for human consumption. As human populations in remote areas increases the illegal kill of moose can be expected to increase.

Increased human habitation in remote portions of the area can have positive affects on local moose populations, if predator populations are decreased by trapping and/or hunting or human disturbances.

Concerns and Potential With-Project Conflicts. Hydroelectric development of the Susitna River may affect this moose subpopulation by altering characteristics or seasonal timing of river ice or flow regimes or by increasing human activities or habitation in the area. These impacts could result in moose mortality directly or indirectly by decreasing habitat carrying capacity or by increasing access or the human population in the area which could inturn could increase levels of mortality related to human activities (hunter kill, illegal kill, defense of life and property kill, kill by collisions with trains or vehicles).

Increased human settlement and access into the area could negatively impact predator populations by increasing numbers by trappers and/or hunters and by increasing the level of human disturbance. If this occurred, there would be a decrease in mortality from predators and an increase net moose productivity.

Susitna River Floodplain:

The Area. This area includes all remaining portions of the Susitna River floodplain that: 1)have not been identified as being utilized by any particular moose subpopulations and 2)are communally utilized in winter by several subpopulations from adjacent areas. More specifically, this area includes a 60 mi^2 portion of the Susitna River floodplain between Bell Island and the Delta Islands and a 100 mi^2 portion of the floodplain between the Caswell Islands and Whiskers Creek.

These floodplain areas are seasonally accessible by all-terrain vehicle, river boat, sled-dog, snowmachine, float-, ski- and wheel-equipped light aircraft. Human habitation in the area is primarily limited to seasonal recreational cabins along the banks of the Susitna River.

The areas provide opportunities for recreational hunting, fishing, trapping, boating, camping, sled-dog mushing and cross-country skiing.

The areas encompasses a variety of floodplain plant communities, which include: river bars colonized by sedges and equisetum, alder and willow shrub communities, open early seral poplar and adler forests, open and closed canopy mixed deciduous/conifer forests, and closed canopy cottonwood forests. Though these plant communities may be similar to those in other sections of the floodplain, I suspect that the habitats and islands are not extensive enough to support resident moose subpopulations.

Islands, habitats and plant communities formed on the floodplain are largely the result of seasonal river flow and ice dynamics that initiate flooding; ice and debris scouring; erosion and deposition of soil; uprooting, translocation and deposition of debris and vegetation; disolving and translocation of minerals and organic compounds which, inturn, act to 1) preclude development of climax plant communities and 2) maintain portions of the floodplain in early seral shrub communities preferred by moose for winter range. These seral habitats attract and provide winter range for large numbers of moose from adjacent migratory subpopulations.

Since the floodplain is relatively open and exposed to sunlight and wind, its snowpack tends to settle, become crusted and/or be redistributed in a manner more favorable to moose for obtaining forage and for moving from one food source to another than snowpacks in surrounding forested or non-floodplain areas. At times, moose appear to prefer to rest in open areas on the floodplain exposed to the sun and incident solar radiation.

Timing, duration and magnitude of moose use of floodplain winter range are correlated with snowpack depth in surrounding areas. Moose use of floodplain winter range increases greatly when deep snowpacks occur in adjacent areas.

The Subpopulation. Moose utilizing these floodplain areas originate from numerous different migratory subpopulations resident to adjacent non-floodplain areas. Data obtained from radio-marked individuals indicate that some moose migrate over 25 miles to utilize these floodplain winter ranges.

Data obtained from radio-marked moose indicate that indivduals which utilize floodplain areas are also known to frequent nearby disclimax habitats located among human settlements and along railroad and highway rights-of-way. If these disclimax sites became unavailable, moose from many subpopulations would become more dependent on floodplain areas for winter forage. Similarly, as food sources on the floodplain become exausted, some moose probably opt to spend more time foraging off the floodplain in nearby disclimax habitats.

In several consecutive years, three radio-marked female moose moved to and utilized these floodplain areas during parturition.

Significant Movement Patterns. Large numbers of moose from subpopulations in adjacent non-floodplain areas immigrate from distances over 25 miles to winter on these floodplain areas. Timing, duration and magnitude of use of these areas are correlated with snowpack depth in adjacent areas.

A small number of female moose from subpopulations in adjacent areas migrated to utilize these floodplain areas during parturition.

Moose from adjacent subpopulations that utilize areas on opposite sides of the floodplain traverse this area en route to other seasonal ranges.

Mortality. Predators and predation. Wolves and brown bears probably occur infrequently in these areas. Black bears are commonly distributed throughout both areas. Black bears probably prey on neonatal moose calves. Because of the relatively high density of black bears in these floodplain areas, I suspect black bear predation on moose neonates may be a significant mortality factor for moose which use the area during parturition. Coyotes occur commonly in these floodplain areas and may harass and prey of neonatal moose calves if the situation arises.

Other Sources of Mortality. Moose which utilize these areas or travel through them are seasonally exposed to mortality from drowning by falling through thin ice and/or into open water and from injury by slipping and falling on glare ice. Moose that move through or off the floodplain area to forage on disclimax distrubed sites among human settlements or along railroad or highway rights-of-way may be killed by collisions with trains or vehicles or by humans in defense of life and property.

Concerns and Potential With-Project Conflicts. Hydroelectric development of the Susitna River may affect moose utilizing these floodplain areas by altering characteristics or seasonal timing of river ice or flow regimes or by increasing the human related activities in the area.

With-project alteration in timing, levels and characteristics of hydraulics (flow rates, peak stages, ice regimes, etc.) of the Susitna River may affect mortality rates for moose that utilize and/or traverse these floodplain areas en route to seasonal ranges on opposing sides.

Moose from subpopulations east of the floodplain which utilize these areas are confronted with trains and vehicles, in those respective right-of-ways, when traveling to and from wintering and calving areas. Moose from subpopulations west of the floodplain which also frequent disclimax habitats east of the floodplain will likewise be exposed to mortality from collisions with trains and vehicles. Any corresponding increase in traffic in those rights-of-way will result in increased moose mortality. Mortality rates will increase significantly if increases in traffic correlates with moose diurnal and seasonal behavior patterns.

Alterations in phenology, composition and/or distribution of plant communities on the Susitna River floodplain may affect the carrying capacity of the area to support wintering moose.

Hunting effort and moose mortality from hunting will likely increase, if hydroelectric development of the Susitna River increases local human populations or access into the area.

Increased human settlement and access into the area could negatively impact predator populations by increasing numbers killed by trappers and/or hunters and by incresing the level of human disturbance. If this occurred, here would be a corresponding decrease in mortality from predators and a net increase in moose productivity.

DRAFT

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 (2)
I	Devil Canyon to Talkeetna	80	300 to 105	2.5	Susitna River, Indian River	20
II	Talkeetna to Montana Creek	30	105 to 76	1.0	Chulitna River, Talkeetna River	20
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

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

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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 [2] (elevation, m)	Vegetation 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 moutnain 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.

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

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)	Annual mean (cm)	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[2]
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, meterological 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

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Table 1. Inclusive calendar dates for significant life history events for moose subpopulations for populations of moose along the Susitna River from Devil Canyon to Cook Inlet, Alaska.

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

TABZONES

Table 6. Numbers of moose observed on periodic censuses of floodplain habitat along 4 zones on the Susitna River between Devil Canyon and Cook Inlet, Alaska 1981-85.

Winter period	Census date	River zone[1] I	II	III	IV	Total
1981-82	9 and 10 Dec	36	16	147	123	322
	28 Dec and 4 Jan	18	19	191	96	324
	2 and 6 Feb	8	5	134	92	239
	1 and 2 Mar	7	17	236	107	369
	23 and 24 Mar	25	25	166	41	257
	12 Apr	7	18	57	-	82
1982-83	29 Oct and 6 Nov	14	4	60	89	171
	10 and 18 Nov	57	28	232	159	476
	1, 2 and 6 Dec	76	46	292	412	826
	20-22 Dec	76	86	460	312	934
	5 and 6 Jan	84	94	345	-	523
	20 and 24 Jan	56	62	329	-	447
	7 and 9 Feb	26	44	251	206	527
	22 and 23 Feb	27	65	269	212	573
	7 and 8 Mar	32	62	260	190	544
	22 and 23 Mar	17	55	277	-	349
	7, 8 and 13 Apr	4	30	130	112	276
1983-84	17 and 18 Nov	21	15	96	-	132
	9, 14 and 16 Dec	34	14	103	127	278
	29, 30 Dec and 5 Jan	-	41	144	129	314
	13, 17 and 19 Jan	27	43	159	290	529
	3, 8 and 9 Feb	88	107	286	304	785
	21, 28 Feb and 1 Mar	41	50	325	403	819
	15 Mar	15	-	-	-	15
1984-85	27 Nov	7	1	--	--	8
	10 Dec	10	8	--	--	18
	24 Dec	36	13	--	--	49
	7 Jan	111	75	--	--	186
	18 Jan	132	96	--	--	228
	29 Jan	105	82	--	--	165
	13 Feb	42	60	--	--	85
	2 Mar	47	43	--	--	100
	21 Mar	47	53	--	--	97
	5 Apr	61	50	--	--	111
	17 Apr	32	37	--	--	69

[1] Zones I-IV = Devil Canyon to Talkeetna, Talkeetna to Montana Creek, (Talkeetna to Sunshine Bridge in 1984-85) Montana Creek to Yentna River and Yentna River to Cook Inlet, respectively. - = zone not censused because of inadequate snow cover or inclement flying conditions and -- = zone not censused that year.

Table 7. Winter density of moose in 4 zones along the Susitna River floodplain between Devil Canyon and Cook Inlet, 1981-85.

Zone[1]	Habitat area[2] (km)		No. moose[3]	Survey date	Density[4]
	Aquatic	Terrestrial			
I	28	31	132	6 Jan 1983	4
II	23	21	107	9 Feb 1984	5
III	65	104	460	21 Dec 1982	4
IV	65	29	412	1 Nov 1982	14

[1] Zone I-IV = Devil Canyon to Talkeetna, Talkeetna to Montana Creek, Montana Creek to Yentna River, Yentna River to Cook Inlet, respectively.

[2] Area of terrestrial and aquatic habitat estimated from 1:63360 scale USGS topographic maps.

[3] Maximum number of moose observed in zone during study.

[4] Density = No. moose/ area terrestrial habitat.

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TABFPDNS

Table 8 . Density of moose observed in floodplain and large island habitats on the Susitna River floodplain between Montana Creek and Cook Inlet, Alaska, 1981-85.

Habitat	Area[1]	Size[2]	Calculated density[3] 1981-82	1982-83	1983-84	1984-85
Floodplain						
	Kashwitna	14.5 (5.5)	1.9	2.7	0.8	2.4
	Caswell	15.5 (10.5)	2.7	3.9	2.2	3.9
Large Island						
	Beaver	9.0 (9.0)	2.4	3.0	3.6	3.6
	Alexander	10.5 (10.5)	2.8	7.6	5.1	4.9
	Bell	13.0 (13.0)	3.2	9.2	6.6	8.9
	Delta	21.0 (18.0)	0.8	1.3	1.0	1.4

[1] Locations of sample areas are illustrated in Fig. .

[2] Size expressed in Km2 represents surface area surveyed as estimated from 1/63360 scale USGS topographic maps. Number in parentheses represents terrestrial habitat included in area surveyed.

[3] Densities were calculated by dividing greatest number of moose observed in each area by its surface area.

Table 9. Fate for 55 female and 22 male moose captured and radio-marked along the Susitna River floodplain downstream from Devil Canyon, Alaska, 1980-86.

Sex	Fate	No. moose		
Female				
	Transmitter shed			4
	Alive			30
	Dead			21
	Winter kill		5	
	Accidents		10	
	Collision with train	5		
	Suspected drowning	3		
	Injury from slipping on ice	2		
	Hunting related		3	
	Defense of life and property		1	
	Capture related		2	
Male				
	Transmitter shed			3
	Transmitter failure			1
	Alive			1
	Dead			17
	Hunting related		10	
	Suspected bullet wound	1		
	Winter kill		2	
	Accidents		2	
	Collision with train	2		
	Capture related		2	
	Suspected poaching		1	

TABLEWORK

Table 10 . Numbers of moose killed by trains in the Alaska Railroad right-of-way between Seward and Fairbanks during winter (October through April) and summer (May through September) seasonal periods, 1963-86.

Year	Seasonal period		Total
	Summer	Winter	
1963-64	-	45	45
1964-65	7	37	44
1965-66	4	34	38
1966-67	5	49	54
1967-68	2	30	32
1968-69	2	9	11
1969-70	2	7	9
1970-71	3	149	152
1971-72	2	87	89
1972-73	5	23	28
1973-74	2	16	18
1974-75	1	69	70
1975-76	7	30	37
1976-77	4	23	27
1977-78	9	14	23
1978-79	2	162	164
1979-80	1	52	53
1980-81	4	16	20
1981-82	9	37	46
1982-83	18	130	148
1983-84	8	57	65
1984-85	7	375	382
1985-86	20	15	35

D10

Table 11 . Annual total, monthly percent, monthly totals for 4 annual periods and average period percent (average for percents of 4 annual periods) of moose killed by trains in the Alaska Railroad right-of-way between Seward and Fairbanks, 1963-86.

Month	Annual total (1587)	Monthly percent	Annual period 1970-71 (152)	1978-79 (164)	1982-83 (148)	1984-85 (382)	Average percent
May	30	2	0	0	4	1	1
Jun	24	2	0	1	3	1	1
Jul	18	1	0	0	5	0	1
Aug	25	2	0	1	3	3	1
Sep	32	2	3	0	3	2	1
Oct	22	1	2	0	3	0	1
Nov	54	3	0	1	22	1	4
Dec	174	11	14	59	22	4	15
Jan	296	19	59	37	34	40	24
Feb	416	26	55	42	32	104	28
Mar	411	26	19	14	14	201	21
Apr	85	5	0	9	3	25	4

D11

TABARRKL

Table 12. Location, number and average percent (mean of percents for each of 3 winter periods) of moose killed by trains in the Alaska Railroad right-of-way between Seward and Fairbanks during winter (October through April) 1978-79, 1982-83 and 1984-85.

Alaska RR			Winter period			Average percent
Milepost	Mi	Station	1978-79	1982-83	1984-85	
000-109	0	Seward	6	7	15	4
110-149	114	Anchorage	4	5	5	2
150-154	151	Matanuska	2	0	0	0
155-159	160	Wasilla	2	2	6	1
160-164			1	0	0	0
165-169	167	Pittman	4	6	5	3
170-174			2	4	7	2
175-179	175	Houston	4	4	5	2
180-184			2	1	10	2
185-189	186	Willow	13	2	16	5
190-194	194	Kashwitna	6	1	26	4
195-199			25	13	46	12
200-204	202	Caswell	19	6	24	8
205-209	209	Montana	11	4	23	5
210-214			12	3	26	5
215-219	215	Sunshine	20	4	24	7
220-224			8	4	19	4
225-229	227	Talkeetna	4	4	9	2
230-234			1	2	21	3
235-239	236	Chase	1	4	8	2
240-244			1	3	23	3
245-249	249	Curry	1	1	3	1
250-254			1	6	12	3
255-259	258	Sherman	4	6	2	3
260-264	263	Gold Creek	0	2	4	1
265-269	268	Canyon	1	2	7	2
270-274	273	Chulitna	0	10	0	3
275-279			0	0	4	0
280-284	281	Hurricane	0	0	0	0
285-289	289	Honolulu	0	1	0	0
290-294			1	0	0	0
295-314	297	Broad Pass	2	0	0	0
315-319			0	0	5	0
320-324	320	Cantwell	3	4	10	3
325-329	327	Windy	0	5	4	2
330-374	359	Healy	0	4	0	1
375-449	412	Nenana	1	8	10	3
450-470	470	Fairbanks	0	2	0	1
Total			162	130	375	99

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Table 13. Numbers of moose reported killed by collisions with vehicles on highway rights-of-way in Game Management Subunits 14 A and B, 1970-1986.

Year	Game Management Subunit	
	14A	14B
1970-71	99	10
1971-72	109	7
1972-73	36	3
1973-74	33	6
1974-75	40	5
1975-76	34	6
1976-77	80	7
1977-78	79	5
1978-79	108	41
1979-80	29	15
1980-81	13	10
1981-82	72	15
1982-83	182	22
1983-84	94	39
1984-85	51	77
1985-86	24	5

[a]Calendar dates for years are from 1 July to 30 June.
[b]Numbers jkof moose listed as killed are numbers actually reported to the Alaska Department of Public Safety. Many moose hit be vehicles and killed may not ber reported and others may be hit, injured and die later away from the roadway undetected.

D13

adjacent to the SRF

Table 14. *Live moose (M), dead moose (D) and percent calf moose (%C) observed in non-Susitna River floodplain riparian areas in winter 1984-85, Alaska.

Date	Moose Creek			Kroto Creek			Alexander Creek		
	M	%C	D	M	%C	D	M	%C	D
29 Nov 1984	32	28	0	142	18	0	53	26	0
12 Dec 1984	81	25	0	254	19	0	110	23	0
28 Dec 1984	105	30	0	177	18	0	119	12	0
11 Jan 1985	138	12	0	176	17	0	246	21	0
7 Feb 1985	147	16	0	144	12	1	201	14	2
20 Feb 1985	181	10	1	151	11	4	162	9	3
5 Mar 1985	169	8	0	90	9	4	212	12	0
9 Mar 1985	158	9	2	64	5	2	188	10	1
20 Mar 1985	117	9	3	37	3	1	156	8	3
28 Mar 1985	70	1	13	29	2	0	142	7	6
4 Apr 1985	67	7	10	19	5	9	160	6	9
16 Apr 1985	44	7	18	12	10	6	135	8	6

* A survey on the Yentna River floodplain from the Susitna River to Skwentna revealed 144 live moose, 9 dead moose and 8 percent calves.

Table 15. Live moose (LM), dead moose (DM) and percent calves (%C) observed in winter on large island and floodplain areas in the Susitna River, Alaska 1984-85.

Date	Location											
	Beaver Island			Alexander Island			Kashwitna floodplain			Caswell floodplain		
	LM	%C	DM[1]	LM	%C	DM	LM	%C	DM	LM	%C	DM
28 Nov	8	0	0	4	25	0	10	30	0	7	43	0
11 Dec	5	0	0	5	40	0	9	22	0	12	33	0
28 Dec	26	27	0	22	27	0	-	-	-	-	-	-
8 Jan	14	7	0	16	27	0	27	26	0	33	24	0
11 Feb	9	0	0	43	21	0	25	20	0	42	21	0
16 Mar	39	18	0	51	26	0	31	10	0	31	3	1
4-5 Apr	15	13	0	36	19	0	35	9	0	52	10	3
17 Apr	13	8	0	35	11	0	29	3	4	59	2	5

[1] DM = numbers of dead moose observed on each survey; it does not represent an accumulative total of dead moose. Snow cover may act to conceal or expose moose carcasses.

Table 16. Femur bone marrow fat content (% fat in marrow) for moose found dead in winter on the study area.

	Age	
Collection date	Calf	Adult
10 April 1983		5.5[a]
27 March 1985	11.0	10.5
		6.9
23 April 1985	11.0	60.0[b]
	12.5	10.1
	9.5	10.2
	7.3	8.2
	7.9	9.2
	7.8	
	9.8	
	8.9	
	7.6	
	7.4	

[a] Marrow fat determined by percentage loss of water on drying (Neiland 197).

[b] Marrow cavity of bone was 85-90% filled, marrow not solid, thick and pasty, pink in color.

Table 17. Numbers and densities for moose observed during late winter distribution survey conducted in the lower Susitna River Valley, Alaska, 25-28 March 1985.

Density class[a] (moose/mi²)	Sample unit No.	Sample unit Size (mi²)	No. moose	Percent total moose	Percent total area	Accumulative percent total moose	Accumulative percent total area
13.0 - 4.1	12	126	835	24	3	24	3
4.0 - 2.1	39	406	1,172	34	10	58	13
2.0 - 0.6	83	996	1,137	33	23	91	36
0.5 - 0.1	116	1,479	324	9	35	100	71
0.0	103	1,245	0	0	29	100	100
Total	353	4,252	3,440	100	100	100	100

[a] Density class = No. moose observed in sample unit divided by size (mi^2) of sample unit. Seven sample units (77 mi^2) in density class 0.0 were comprised of habitat above 3,500 ft. elevation; an elevation above which not considered moose habitat.

Table 8. Moose use (moose-days, monthly and accumulative) of two alpine areas in the western foothills of the Talkeetna Mountains calculated from 8 periodic aerial surveys conducted between 4 October and 17 April, 1985-86.

	Accum days	Bald Mtn Ridge[1]		Willow Mtn	
		Monthly	Accum	Monthly	Accum
Oct	28	3401	3401	3787	3787
Nov	58	8451	11852	8234	12021
Dec	89	8060	19912	9703	21724
Jan	120	8285	28197	7468	29192
Feb	148	7700	35897	4592	33784
Mar	179	7181	43078	4396	38180
Apr	196	2079	45157	1499	39679
Total	196		45157		39679

[1] Approximately 28 and 30 mi^2 of habitat were surveyed on Bald Mtn Ridge and Willow Mountain, respectively. To estimate numbers of moose using an area during intervals between consecutive surveys, the mid-point between surveys was determined and numbers observed on, respective, previous and subsequent surveys were assumed to occupy areas prior to and after that date.

Table 19. Moose use (monthly and accumulative monthly moose days) of non-Susitna River riparian areas calculated from periodic aerial surveys conducted between 29 November and 16 April, 1984-85.

Month	Accum days	Alexander Creek		Kroto Creek		Moose Creek	
		Monthly	Accum	Monthly	Accum	Monthly	Accum
Nov	3	106	106	284	284	64	64
Dec	34	3590	3696	6390	6674	2554	2618
Jan	65	6930	10626	4707	11381	4242	6860
Feb	93	5143	15769	4015	15396	4602	11462
Mar	124	5335	21104	1635	17031	3921	15383
Apr	140	2398	23502	259	17290	923	16306
Total	140		23502		17290		16306

1 Approximately, 20, 50 and 25 miles of river drainage were surveyed on Alexander, Kroto and Moose Creeks, respectively. To estimate numbers of moose using an area during intervals between consecutive surveys, the mid-point between surveys was determined and numbers of moose observed on, respective, previous and subsequent surveys were assumed to occupy areas prior to and after that date.

Table 20. Moose use (monthly and accumulative total moose days) of areas adjacent to the Susitna River floodplain calculated from periodic aerial surveys in winter, 1981-1985.

	Bell Island			Montana West			Montana Middle		
	Accum days	Moose use Month	Moose use Accum	Accum days	Moose use Month	Moose use Accum	Accum days	Moose use Month	Moose use Accum
1981-82									
Dec	20	1553	1553	30	704	704	-	-	-
Jan	51	1040	2593	61	772	1476	-	-	-
Feb	79	908	3501	89	672	2148	-	-	-
Mar	100	495	3996	120	402	2550	-	-	-
Apr	-	-	-	132	52	2602	-	-	-
1982-83									
Oct	3	27	27	3	39	39	-	-	-
Nov	33	1826	1853	33	1498	1537	25	275	275
Dec	64	3552	5405	64	1408	2945	56	1328	1603
Jan	95	2104	7509	95	1129	4074	87	965	2568
Feb	123	1120	8629	123	1259	5333	115	309	2377
Mar	130	245	8874	154	919	6252	146	1002	3879
Apr	-	-	-	162	16	6268	153	42	3921
1983-84									
Nov	-	-	-	14	305	305	14	60	60
Dec	18	277	277	45	1485	1790	45	133	193
Jan	51	1491	1768	56	1269	3059	76	556	749
Feb	72	1346	3114	85	1330	4389	105	897	1646
Mar	-	-	-	114	307	4696	134	1045	2691
1984-85									
Nov	3	42	42	3	200	200	4	0	0
Dec	34	1258	1300	34	1339	1539	35	95	95
Jan	65	2803	4103	65	1321	2860	66	732	827
Feb	91	3220	7323	93	911	3771	94	1105	1932
Mar	122	2560	9883	124	744	4515	125	1068	3000
Apr	139	859	10742	-	-	-	141	690	3690

1 Approximately 5, 1 and 0.8 mi^2 of habitat were surveyed surveyed on Bell Island, Montana West and Montana Middle areas, respectively. To estimate numbers of moose using an area during intervals between consecutive surveys, the mid-point between surveys was determined and numbers observed on, respective, previous and subsequent surveys were assumed to occupy areas prior to and after that date.

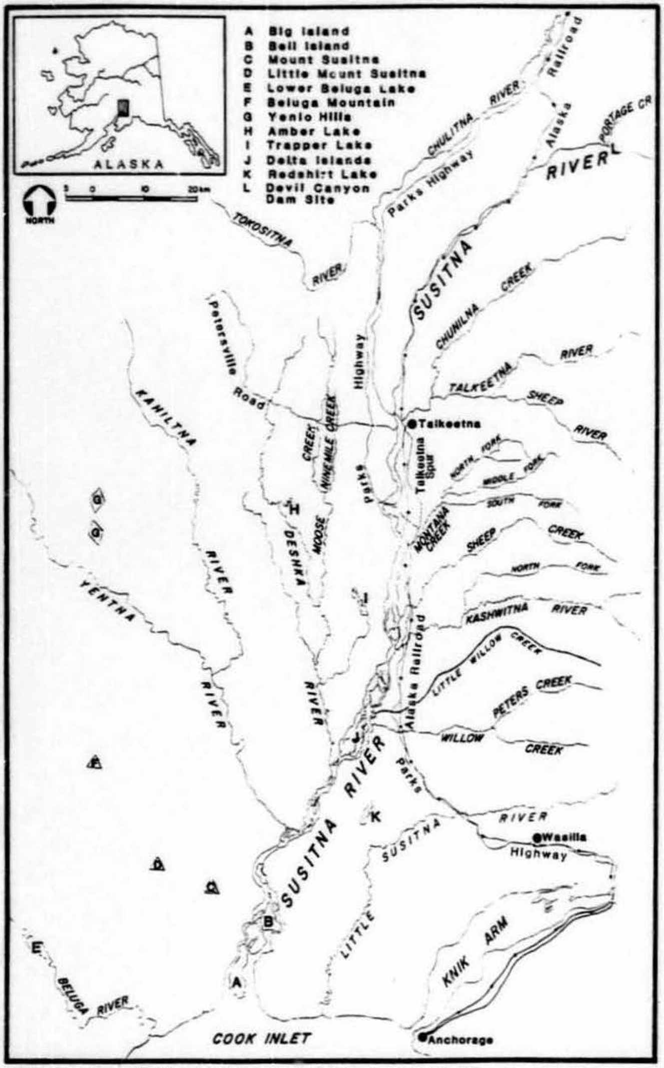


Figure 1. Map showing location of the study area in Alaska with names listed for rivers, lakes and other prominent landscape features.

D21

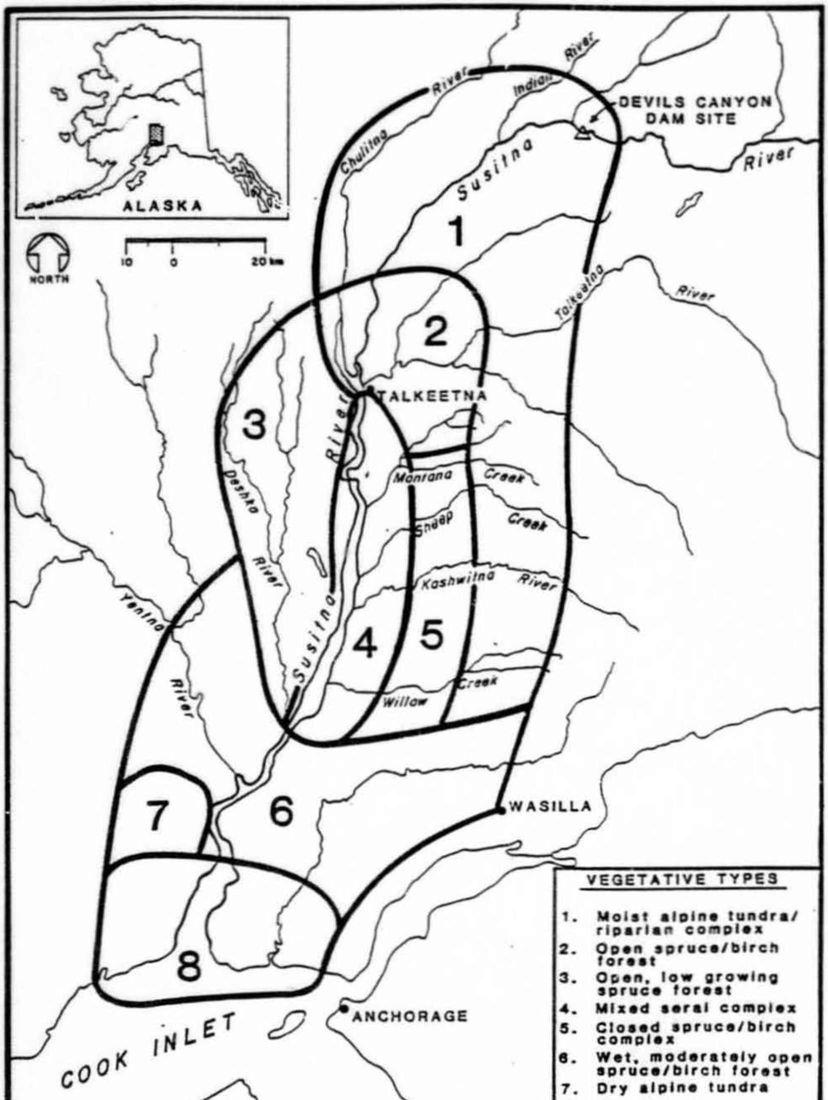


Fig. 2. Idealized habitat map showing the distribution of vegetative types which occur in the Susitna River watershed between Devils Canyon and Cook Inlet.

D22

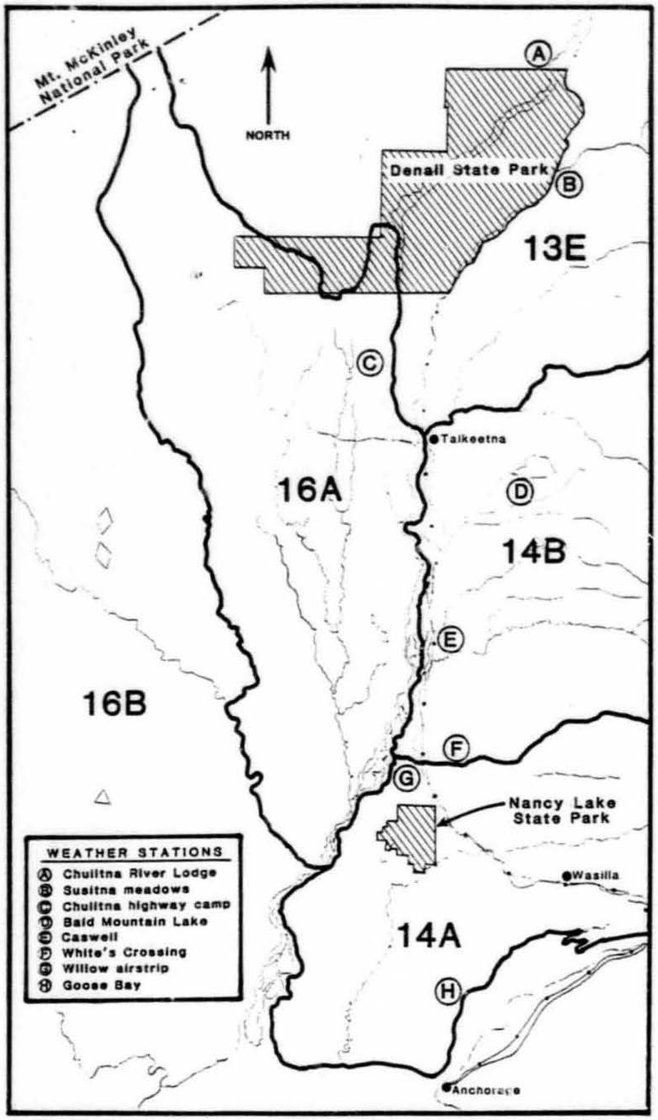


Fig. 3. Map of study area showing locations of Game Management Subunits (13E, 14A, 14B, 16A and 16B), state and national parks and weather stations (A–H).

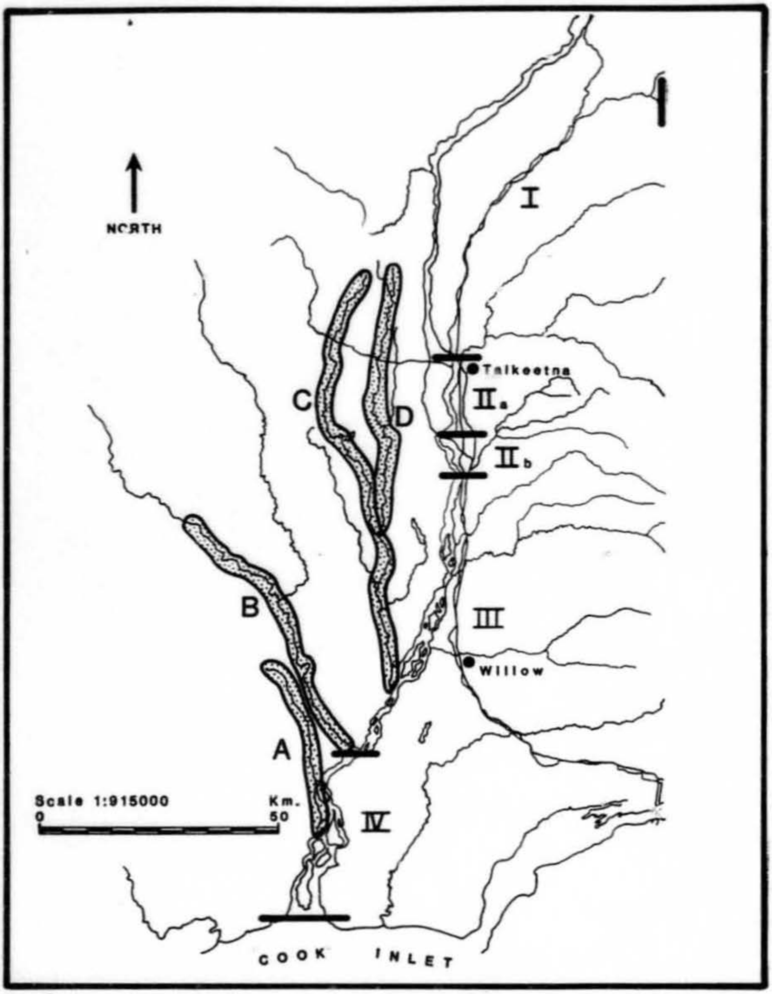


Fig. 4 . Location of riparian areas and subsections of the Susitna River floodplain (I-IV) where moose surveys were conducted (A=Alexander Creek, B=Yentna River, C=Kroto Creek and D=Moose Creek).

* Fig 5

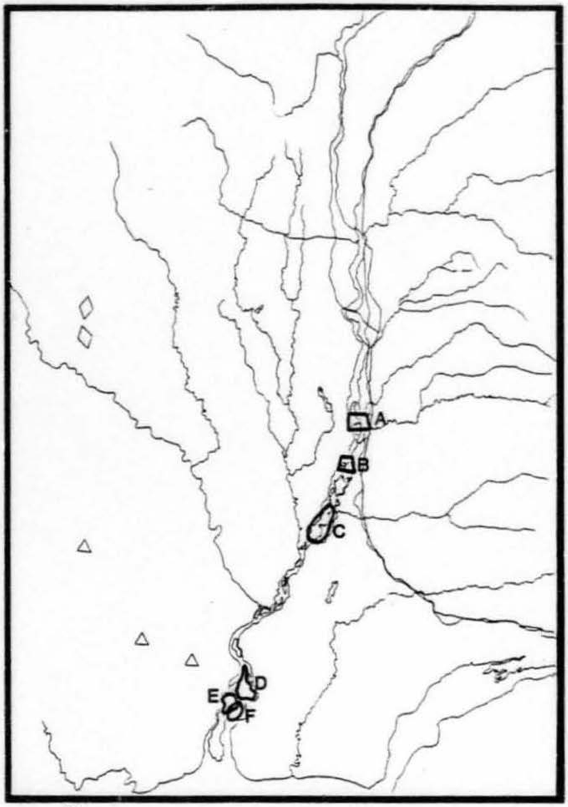


Figure 5. Location of floodplain and islanded areas along the Susitna River, Alaska, where densities and calf composition were determined for wintering moose, 1981-83.
(A = Caswell floodplain, B = Kashwitna floodplain, C = Delta Island, D = Bell Island, E = Alexander Island, F = Beaver Island)

Fig 6.

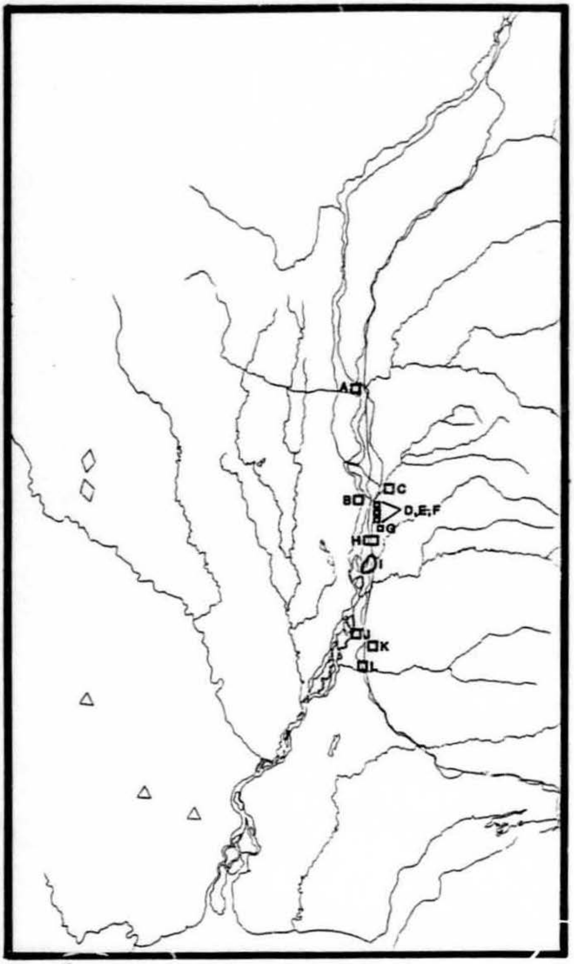


Figure 3.6 Location of sites adjacent to the Susitna River, Alaska, where climax vegetation has been altered by man and numbers of moose were counted periodically during the winter, 1981-84. (A = Talkeetna West, B = Montana West, C = Montana East, D = Montana North, E = Montana Middle, F = Montana South, G = Goose Creek, H = Chandalar East and West, I = Kashwitna Bluff, J = Kashwitna Lake, K = Kashwitna East and L = Willow Creek)

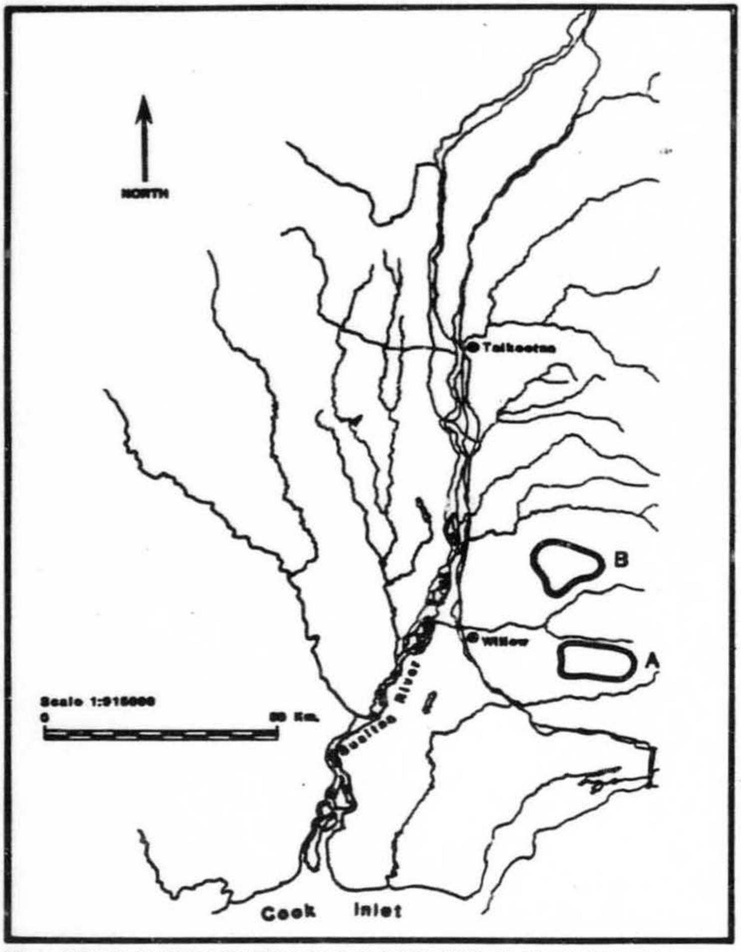


Fig. . Location of alpine areas where moose use (moose days) was calculated for winter 1985–86. (A = Bald Mountain Ridge and B = Willow Mountain)

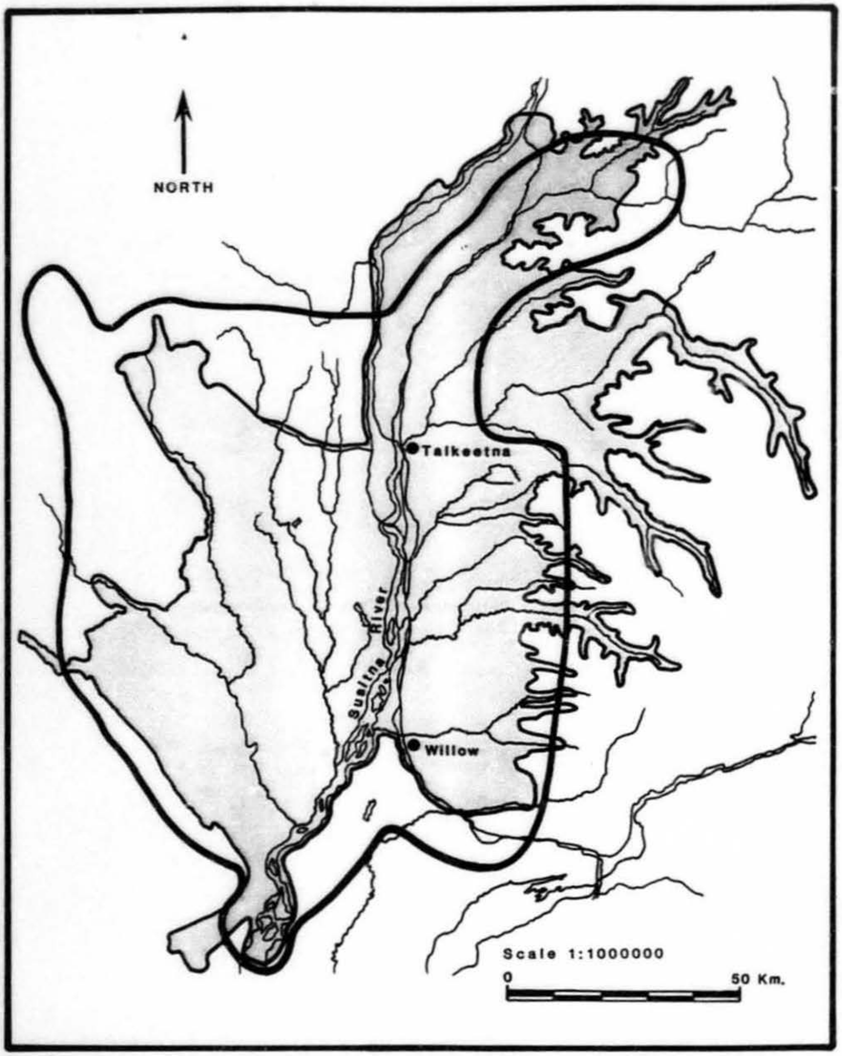


Fig. 8 . Areas surveyed for moose distribution and snowpack depth in the lower Susitna River valley, March 1985. (▬) Snowpack depth, (◯) Moose distribution.

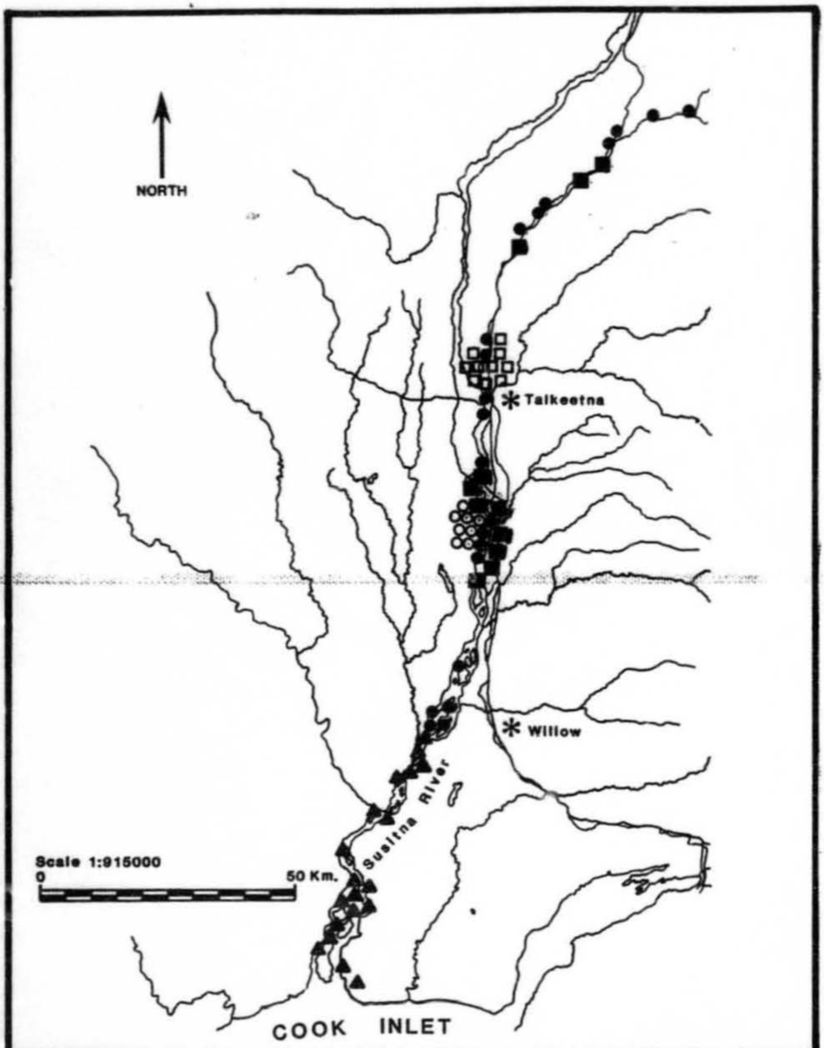


Fig. 9. Locations where moose were captured and radio-marked in 5 different annual samples. (■ = April 1980, ● = March 1981, ▲ = February 1982, ○ = February 1984, and □ = February 1985)

D29

D39

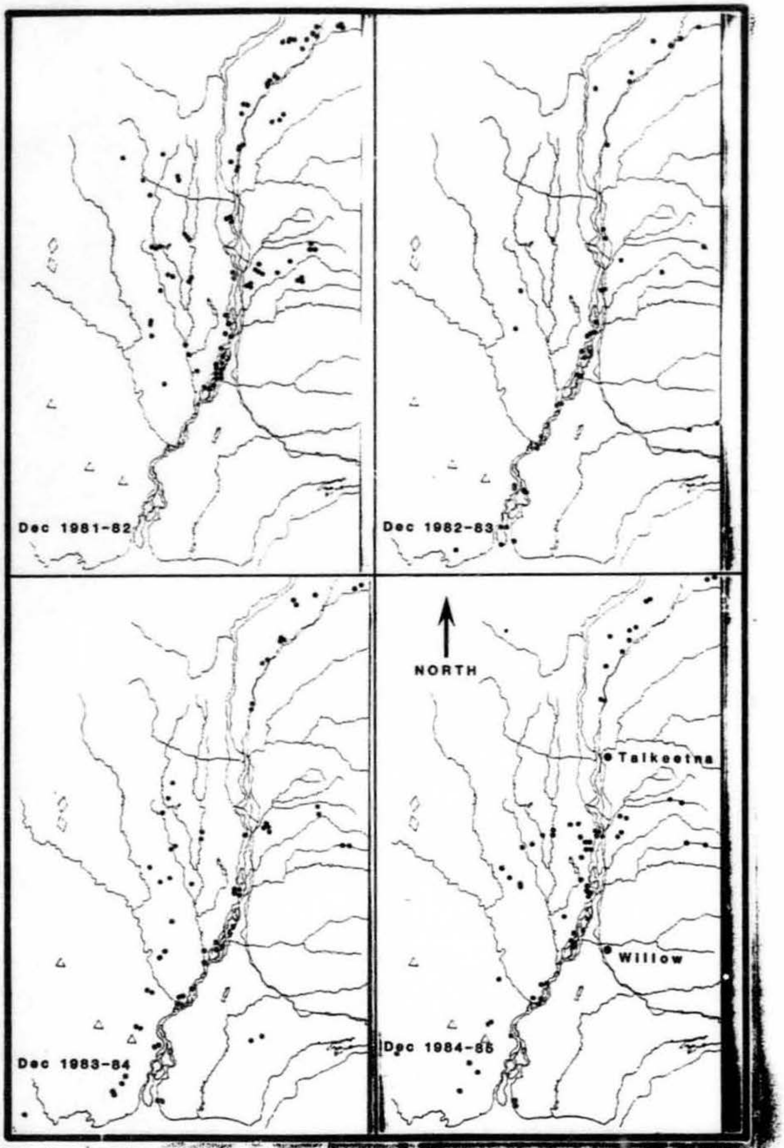


Fig. 11. Annual variation in distribution of moose radio-marked on the Susitna River floodplain during December in 1981-82, 1982-83, 1983-84, 1984-85.

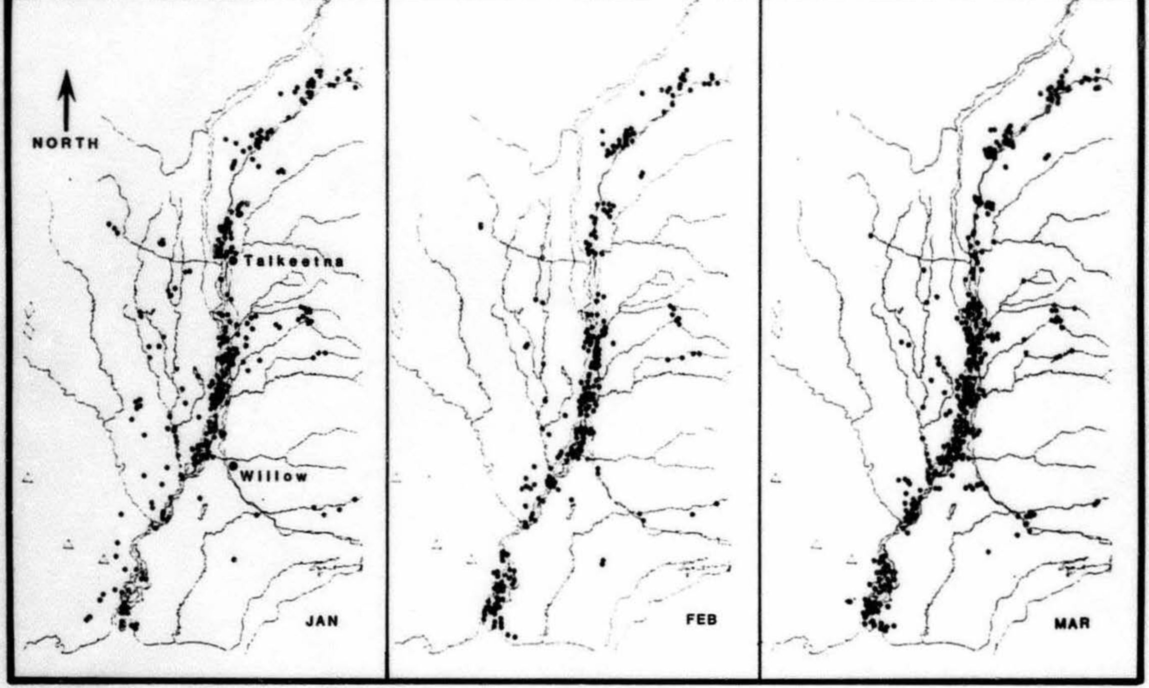


Fig. 12 . Late winter distribution of moose radio-marked along the Susitna River floodplain and relocated from 1980-85.

D31

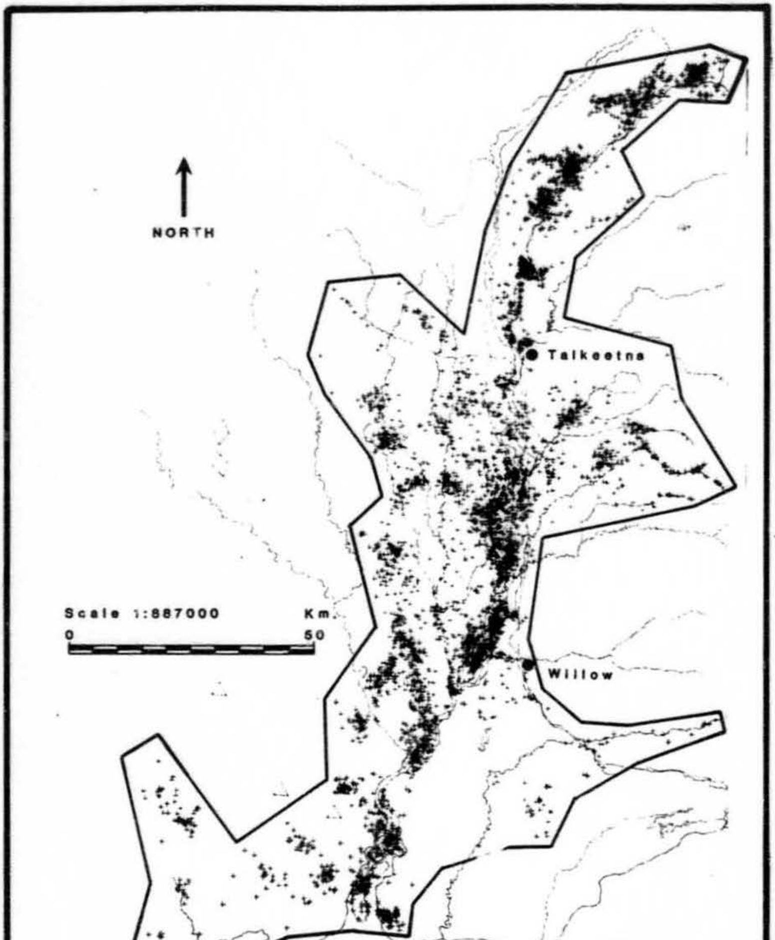


Fig. 13. Polygon encompassing 3852 relocation points for 52 female and 22 male moose captured and radio-marked along the Susitna River floodplain between Devil Canyon and Cook Inlet, Alaska, 1980-85. (Inclusive area = 8938 Square Kilometers)

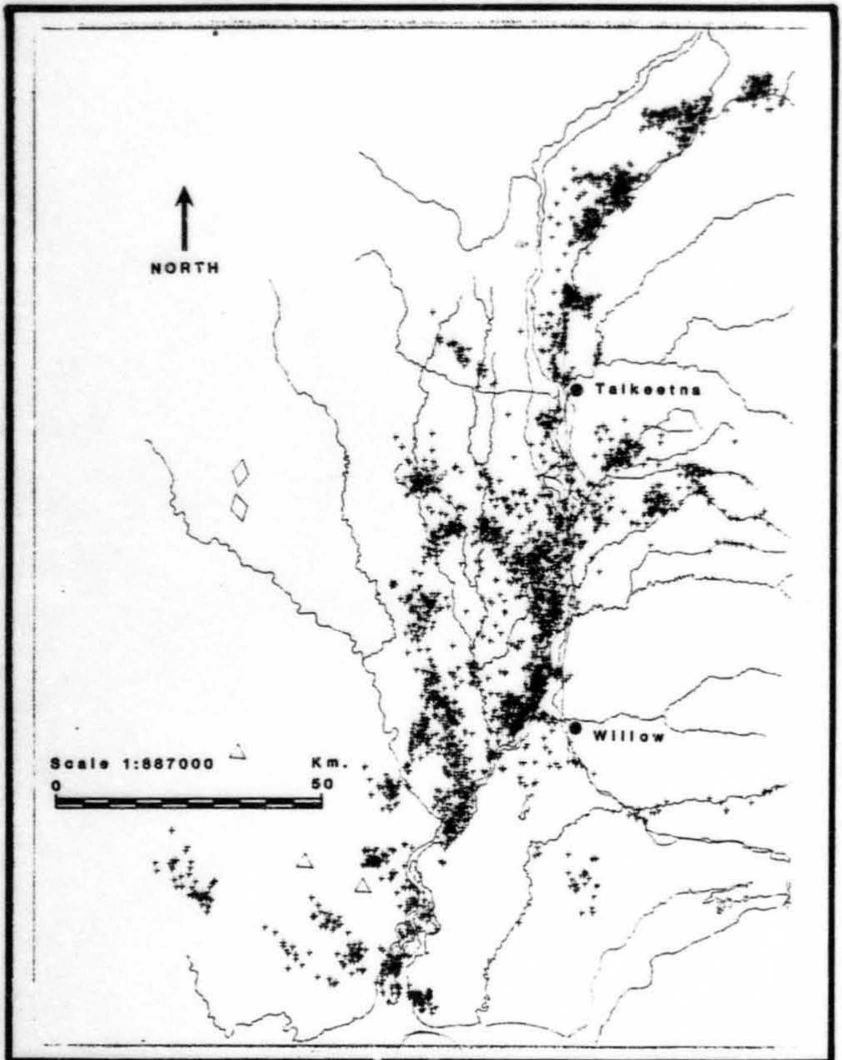


Fig. 14. Relocation points (3852) for ~~55~~ 51 female moose radio-marked along the Susitna River floodplain between Devil Canyon and Cook Inlet, Alaska, 1980-1985.

D33

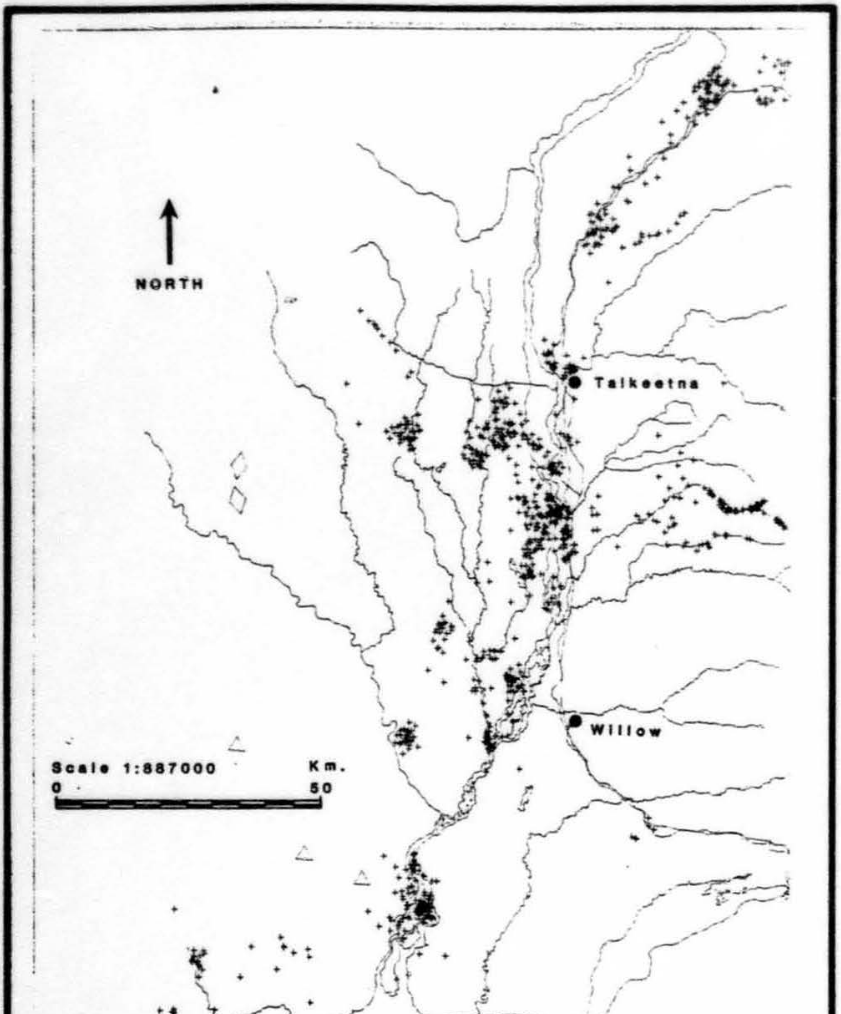


Fig. 15. Relocation points (946) for 12 male moose radio-marked along the Susitna River floodplain between Devil Canyon and Cook Inlet, Alaska, 1980-85.

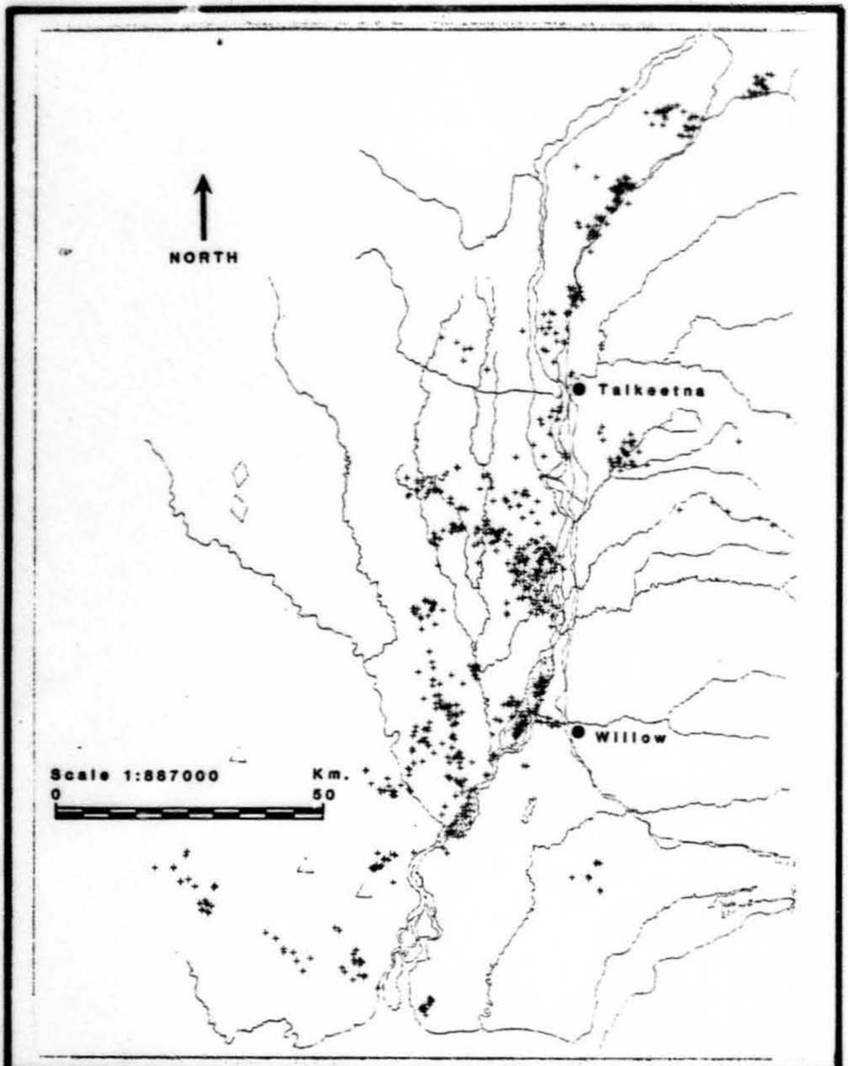


Fig. 16. Locations where female moose radio-marked on the Susitna River floodplain in winter were relocated during the calving period (May-June).

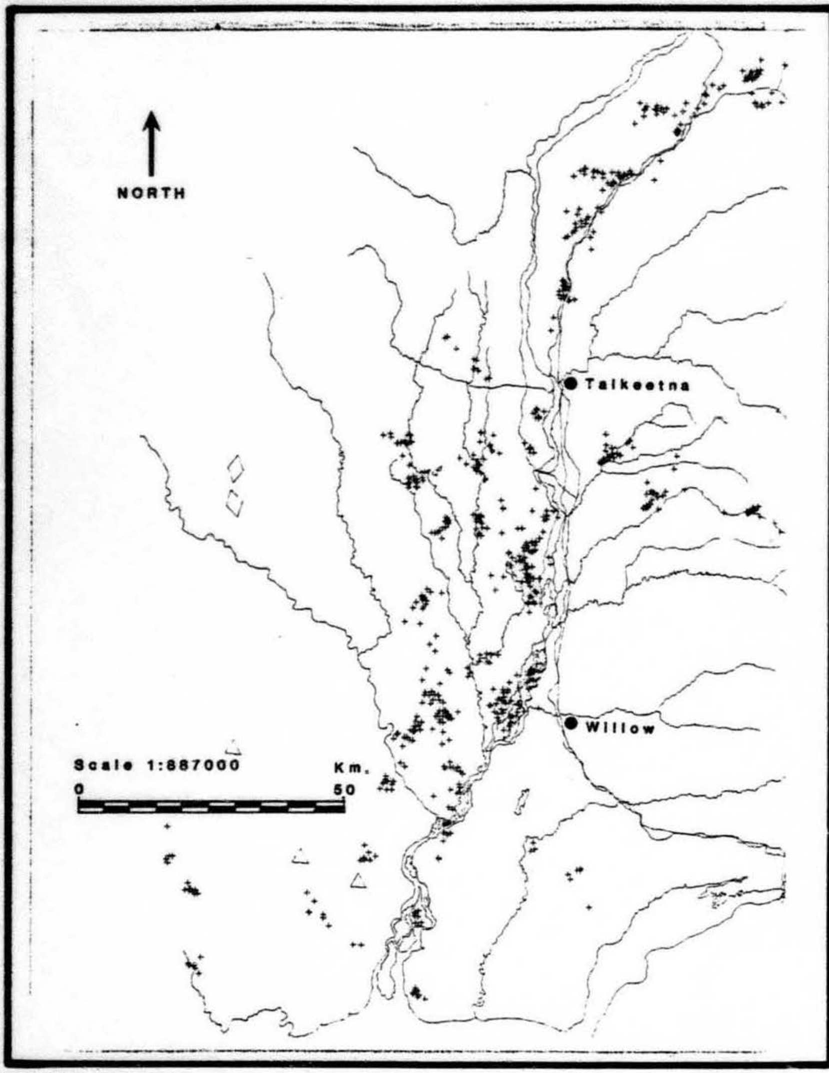


Fig. 17. Locations where male and female moose radio-marked on the Susitna River floodplain in winter were relocated during the summer period (July-15 August), 1980-85.

D36

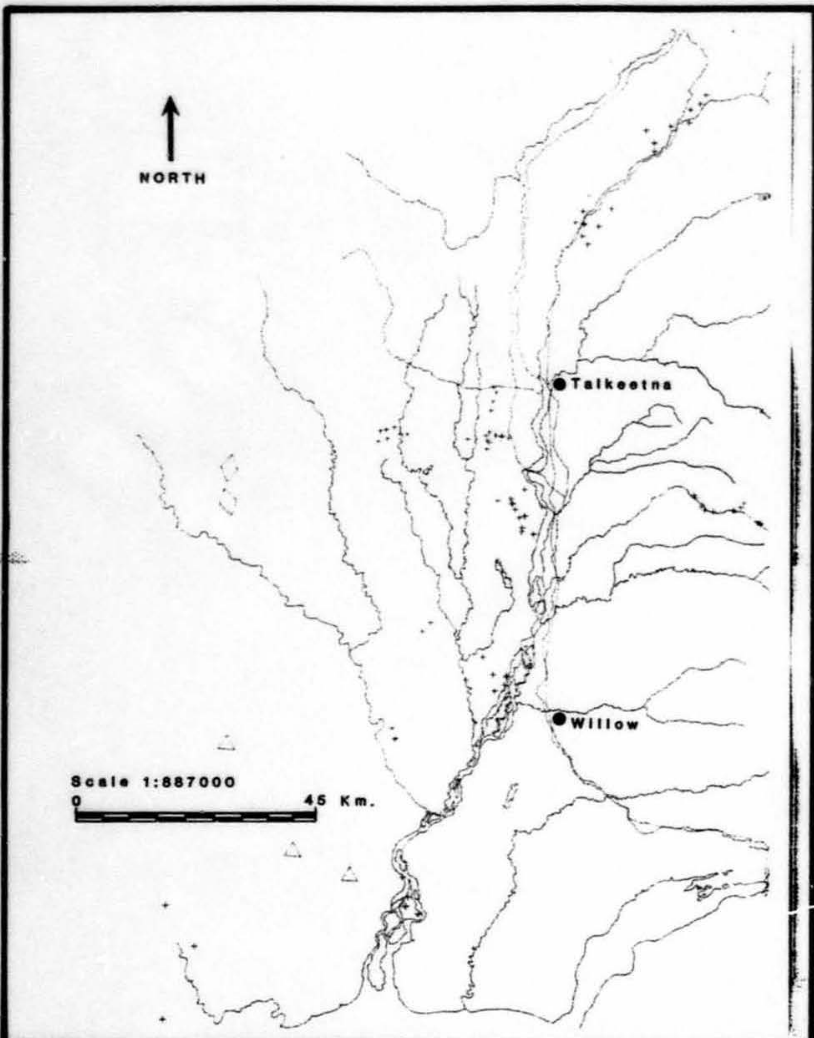


Fig. 18. Locations where male moose radio-marked along the Susitna River floodplain were relocated during September (open hunting season), 1981 -85.

D37

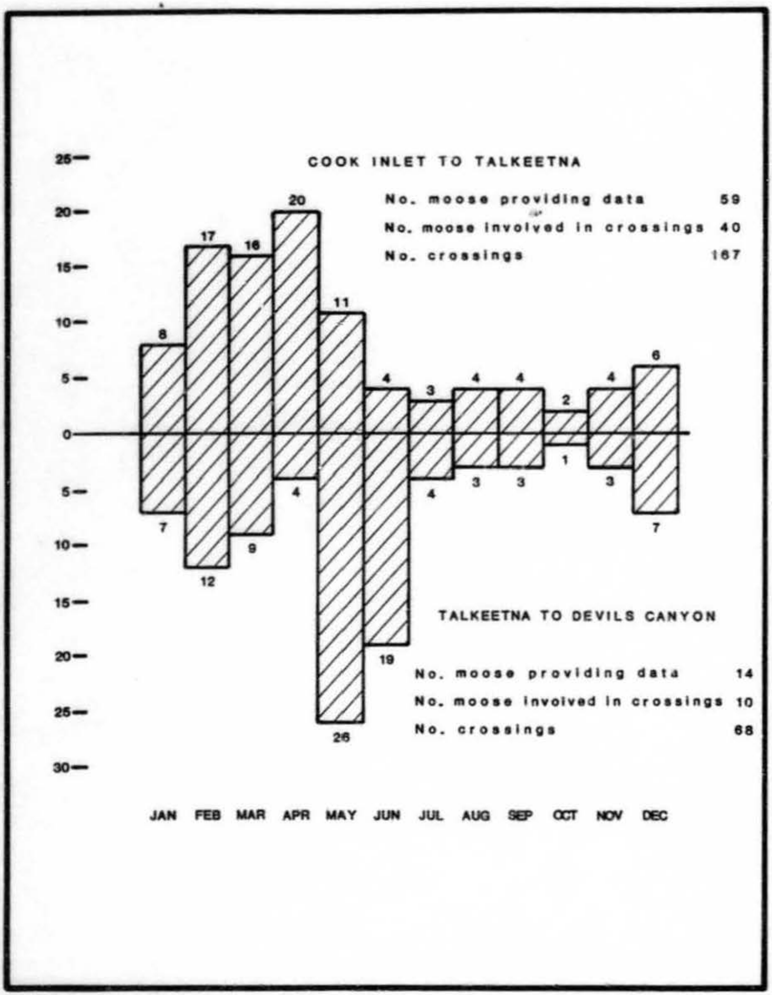


Fig. 19 Frequency and seasonal timing of Susitna River crossings by moose radio-marked in 2 areas between Devil Canyon and Cook Inlet and relocated between 1980-85. (Numbers=percent of observations in respective area category)

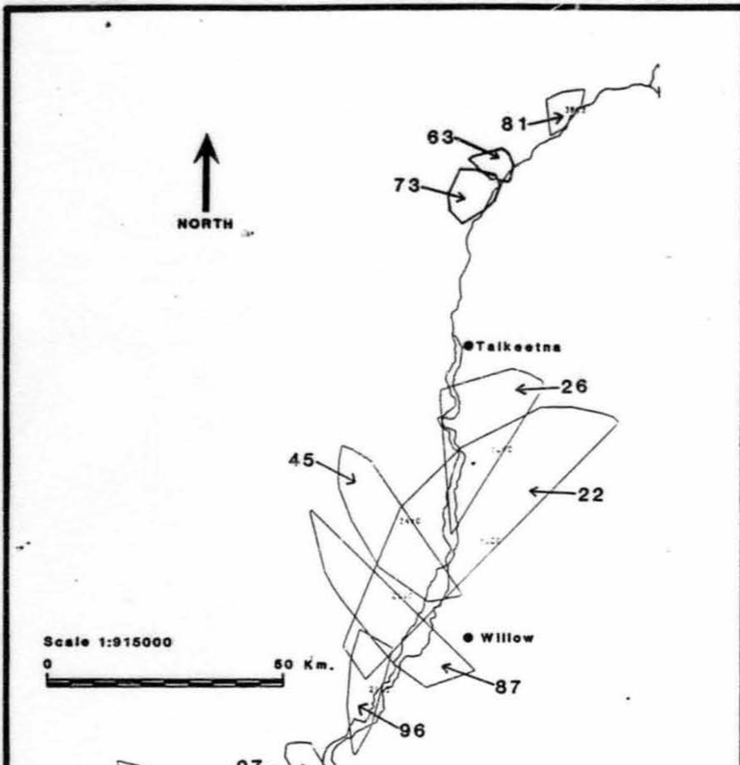


Fig. 20. Spatial relationship of radio-marked moose annual ranges with the Susitna River flood plain.

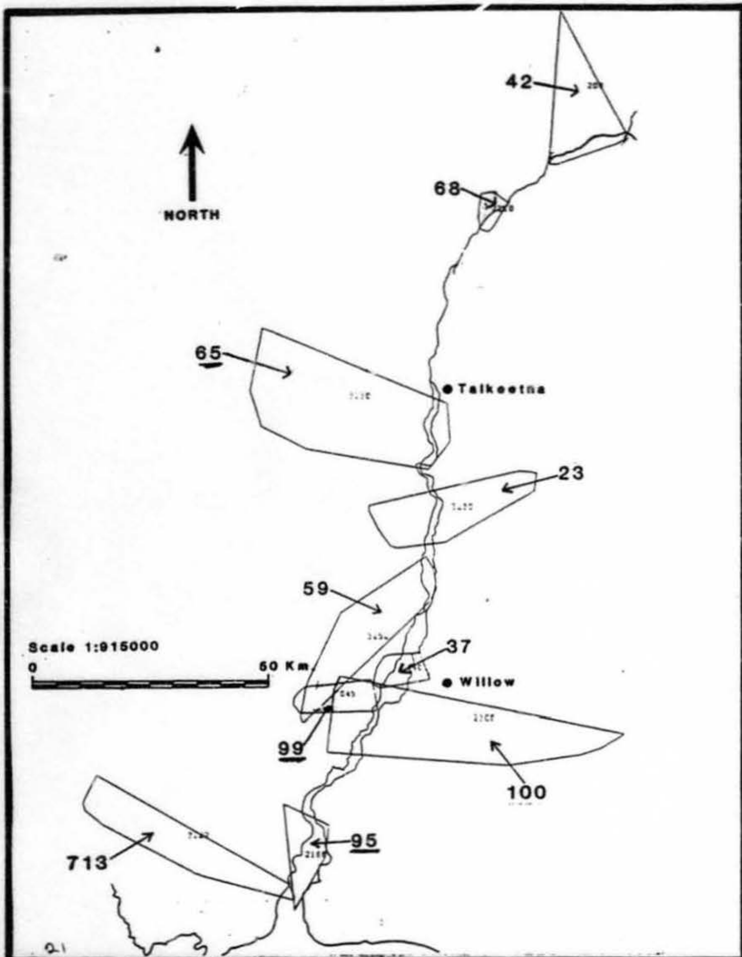


Fig. _ Spatial relationship of radio-marked moose annual ranges with the Susitna River flood plain. (_ = males)

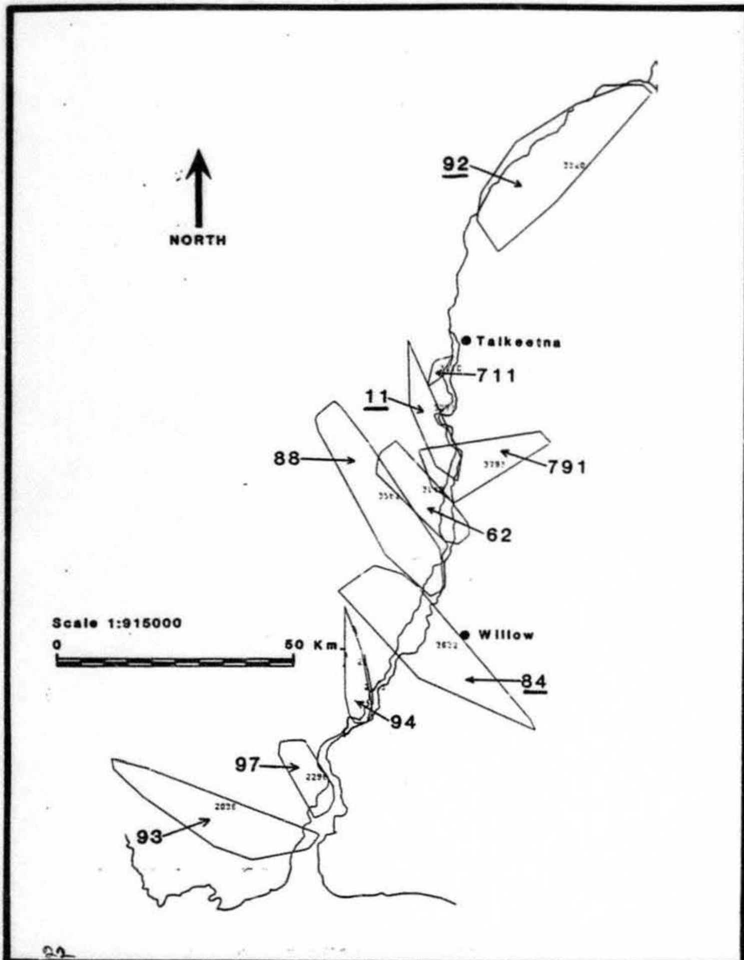


Fig. . Spatial relationship of radio-marked moose annual ranges with the Susitna River flood plain. (__ = males)

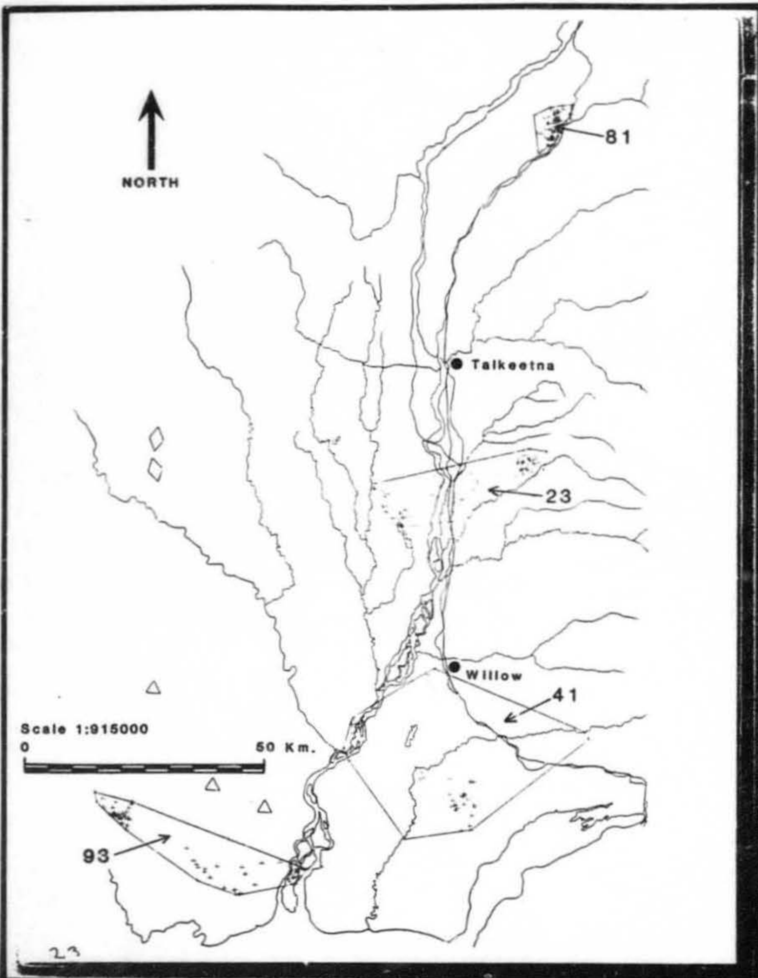


Fig. [illegible] grossly [illegible]

P42

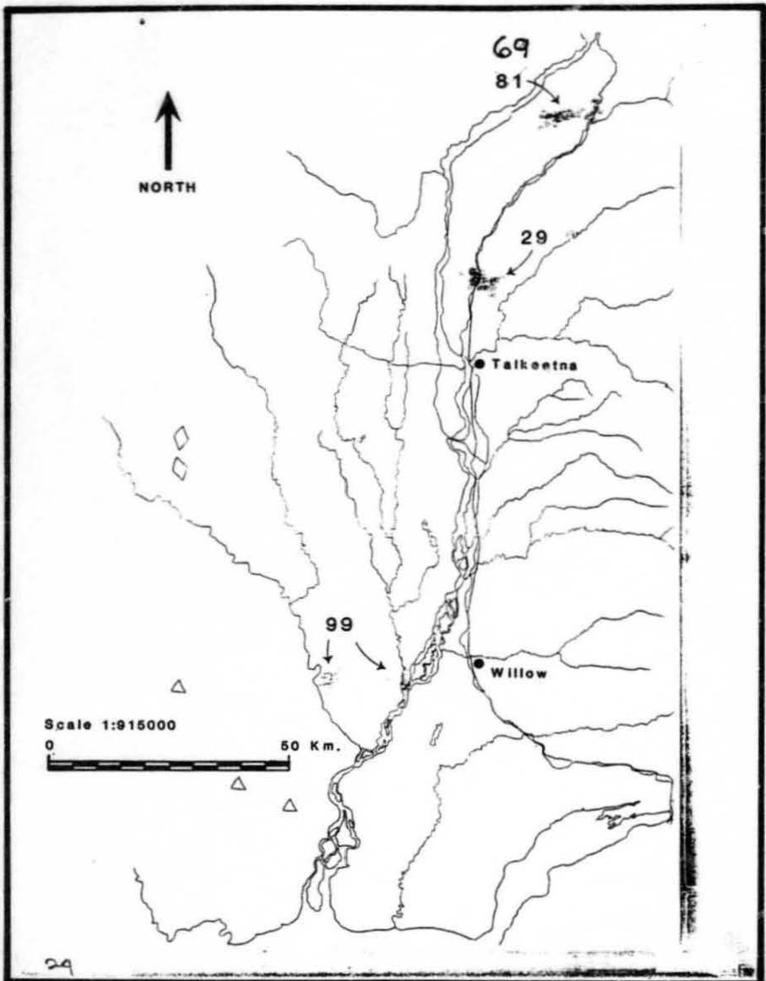


Fig. . Variation in spatial relationships of seasonal ranges for moose radio-marked on the Susitna River flood plain.

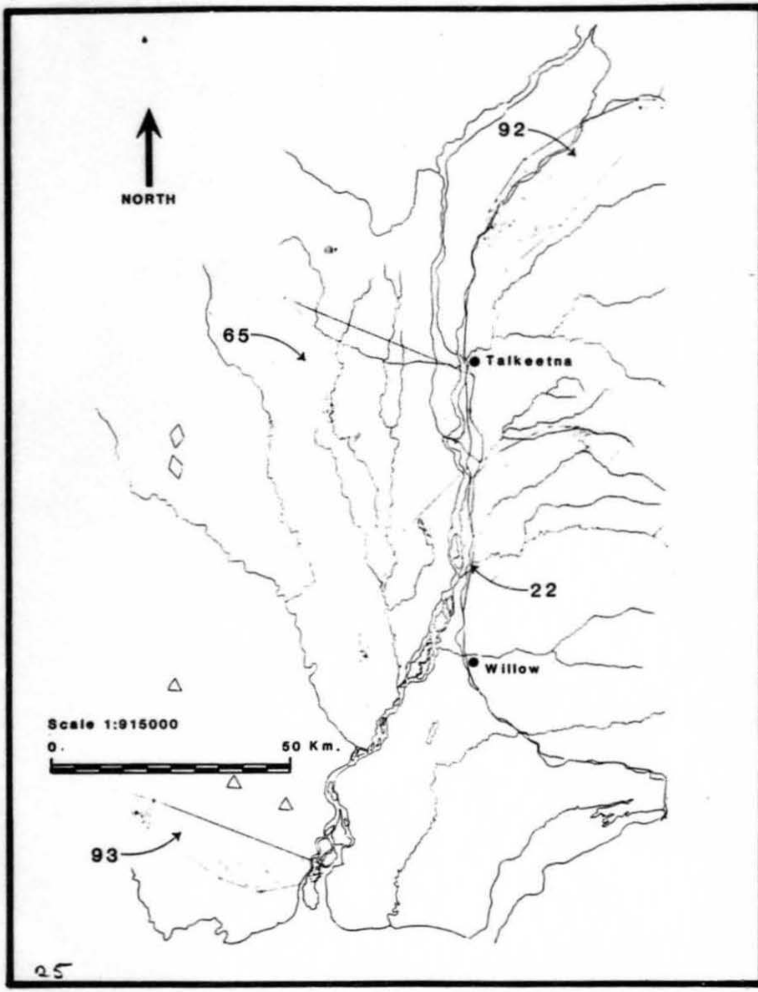
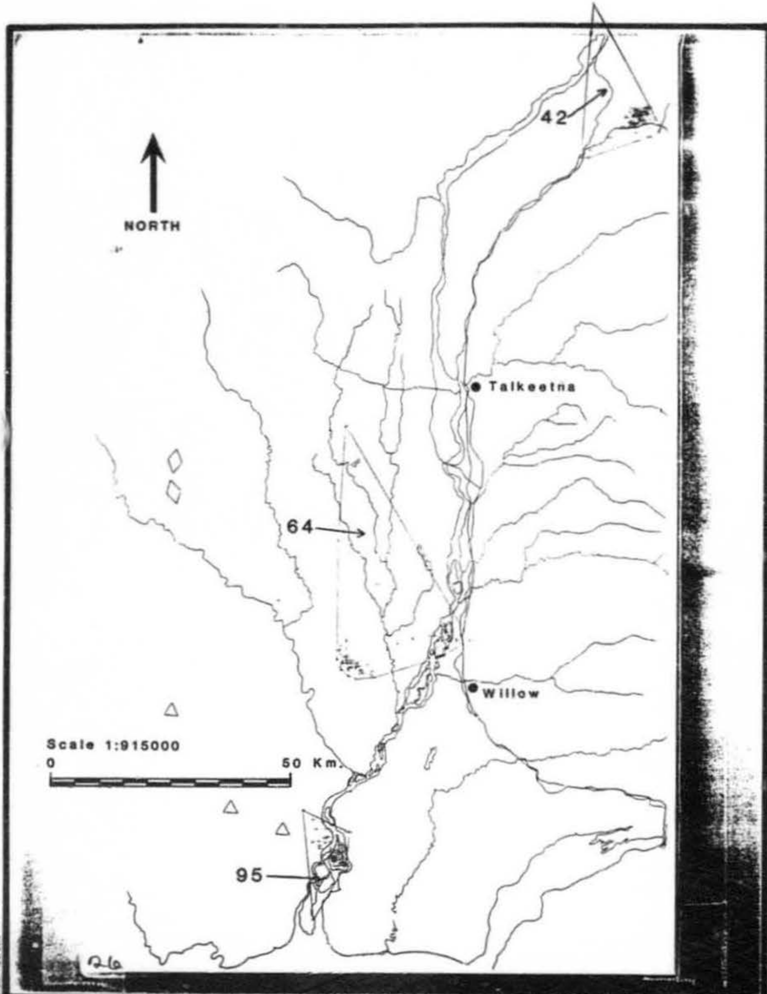


Fig. . Polygons enclosing relocation points for radio-marked moose which ranged over relatively large areas.



D45

Fig. [illegible]

Fig 27

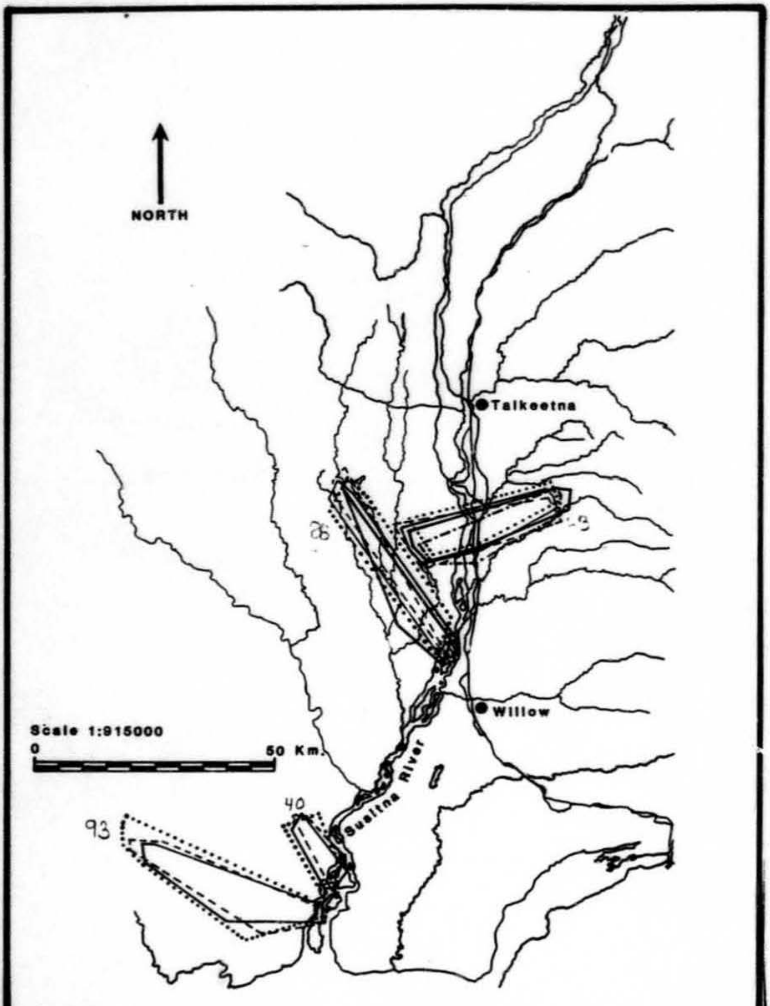


Fig. 27. Polygons encompassing annual ranges for radio-marked moose which exhibited relatively little "between year" variation in movement patterns. (-.-.-) 1980-81, (——) 1981-82, (——) 1982-83, (- - - -) 1983-84, (......) 1984-85.

D46

Fig 28

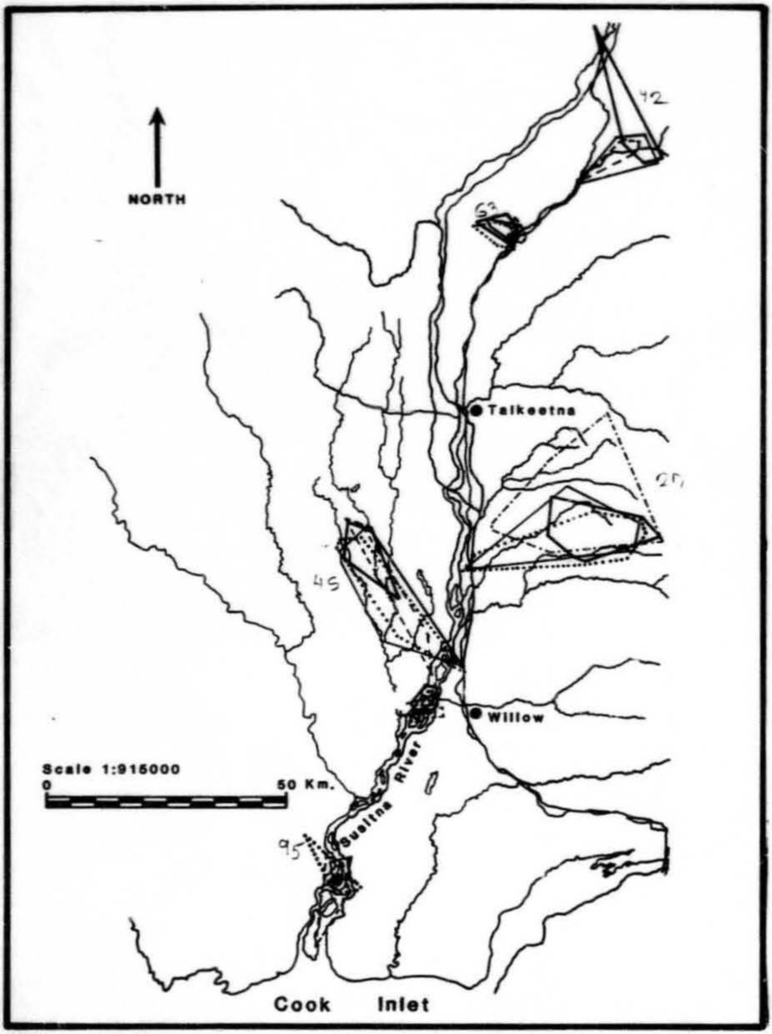


Fig. 28. Polygons encompassing annual ranges for radio-marked moose which exhibited noteworthy "between year" variation in movement patterns. (—·—·) 1980-81, (▬▬) 1981-82, (——) 1982-83, (- - - -) 1983-84, (·······) 1984-85.

D47

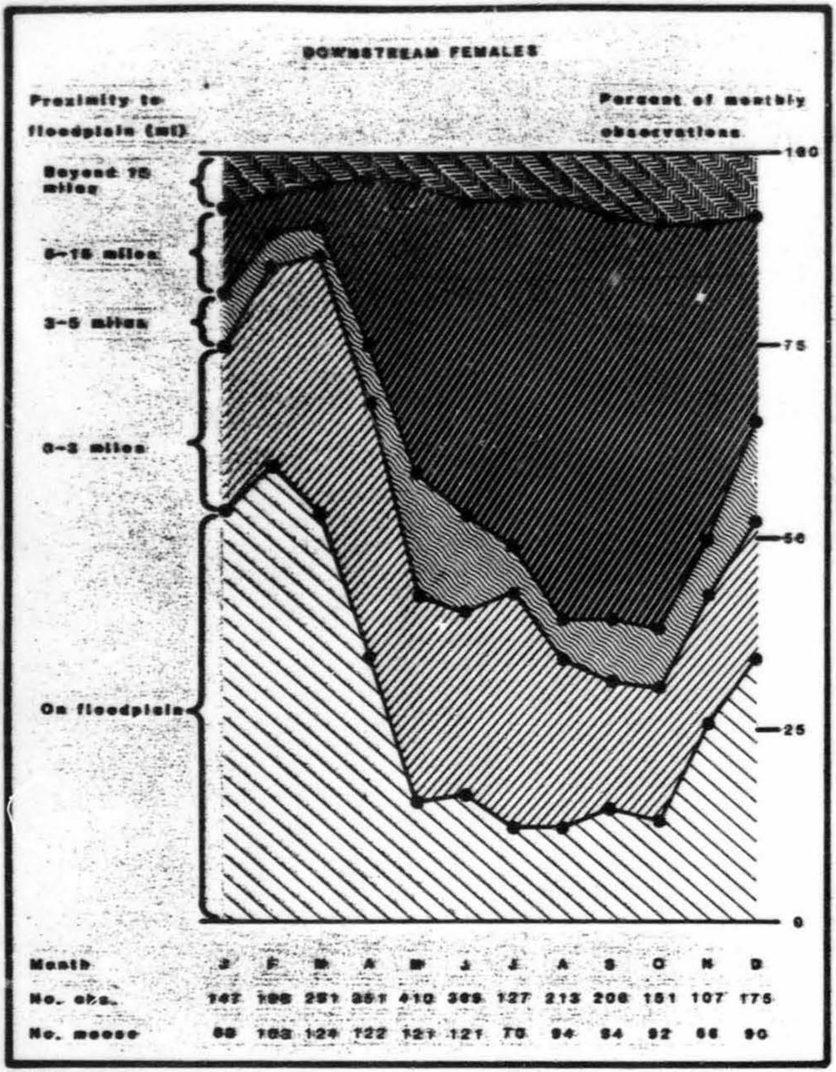


Fig. 19. Monthly variation in proximity to the Susitna River floodplain for female moose radio-marked in winter along the floodplain between Talkeetna and Cook Inlet and relocated periodically from April 1980 through July 1985. (No. moose summed over years)

D48

Fig. 32 Monthly variation in proximity to the Susitna River floodplain for male moose radio-marked on the floodplain between Talkeetna and Cook Inlet and relocated periodically from April 1980 through July 1985. (No. moose summed over years)

D49

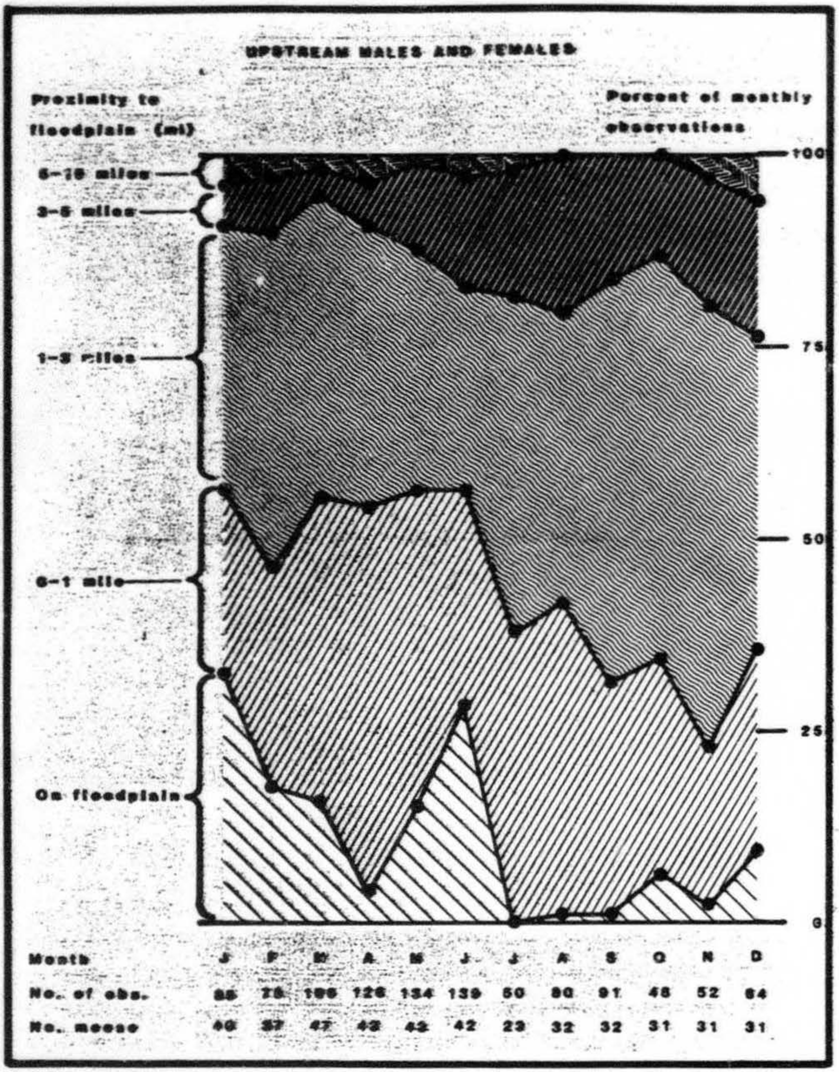
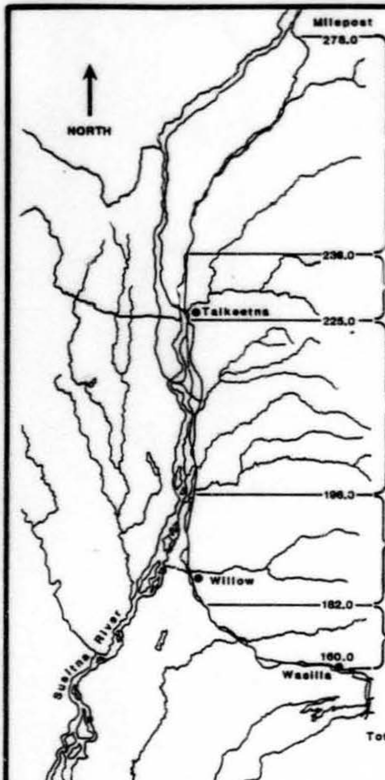


Fig. 31. Monthly variation in proximity to the Susitna River floodplain for male and female moose radio-marked in winter along the floodplain between Talkeetna and Devils Canyon and relocated periodically from April 1980 through July 1985. (No. moose summed over years)

D50



		WINTER PERIOD	
MI.	1978-79	1982-83	1984-85
42	13	14	22
11	25	5	60
29	88	33	151
14	6	6	29
22	9	34	63
Total 118	141	92	325

Fig. 32 Distribution and number of moose killed by trains in the Alaska Railroad (ARR) right-of-way between milepost 160.0 (near Wasilla) and 278.0 (near Chulitna Pass) during winter (October-April), 1978-79, 1982-83 and 1984-85.

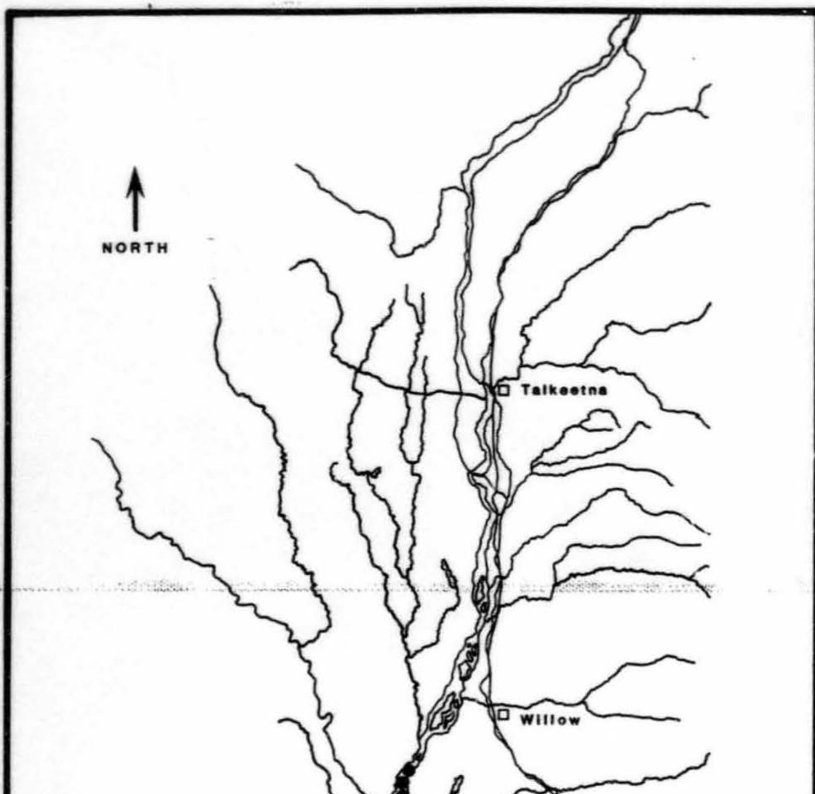


Fig. 33. Locations of moose carcasses observed during aerial surveys in winter 1981-82 (Susitna River=5).

D52

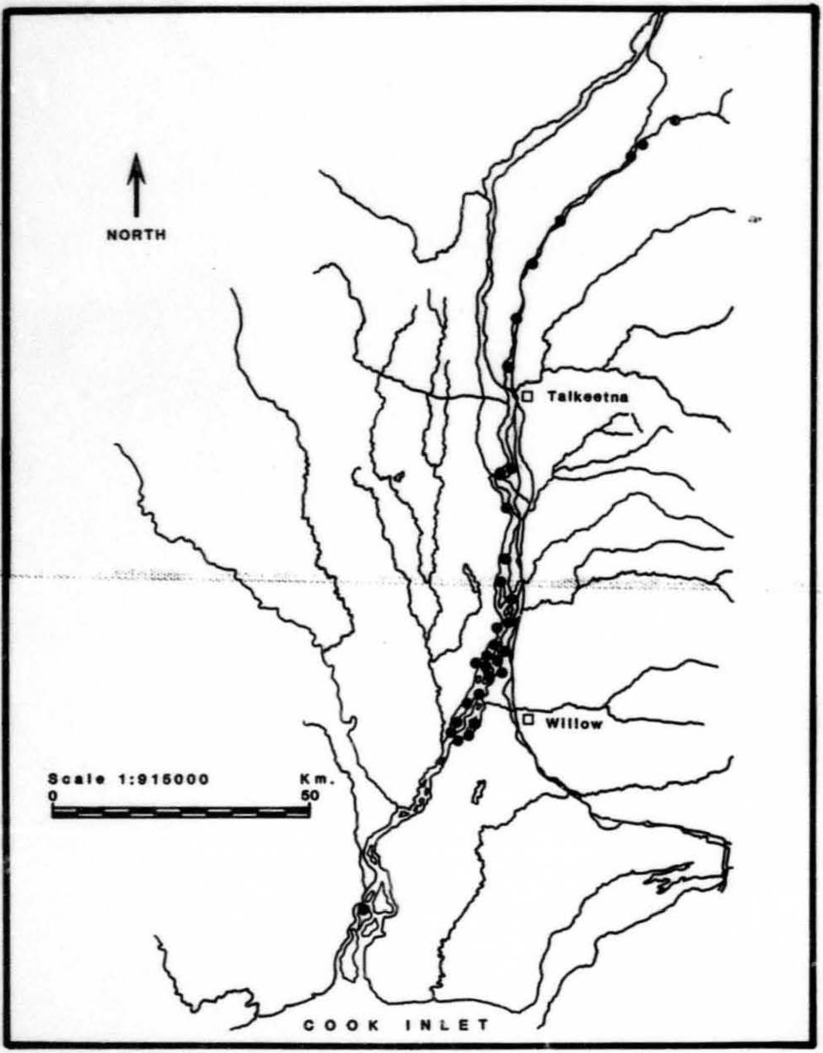


Fig. 34. Locations of moose carcasses observed during aerial surveys in winter 1982-83 (Susitna River=31).

D53

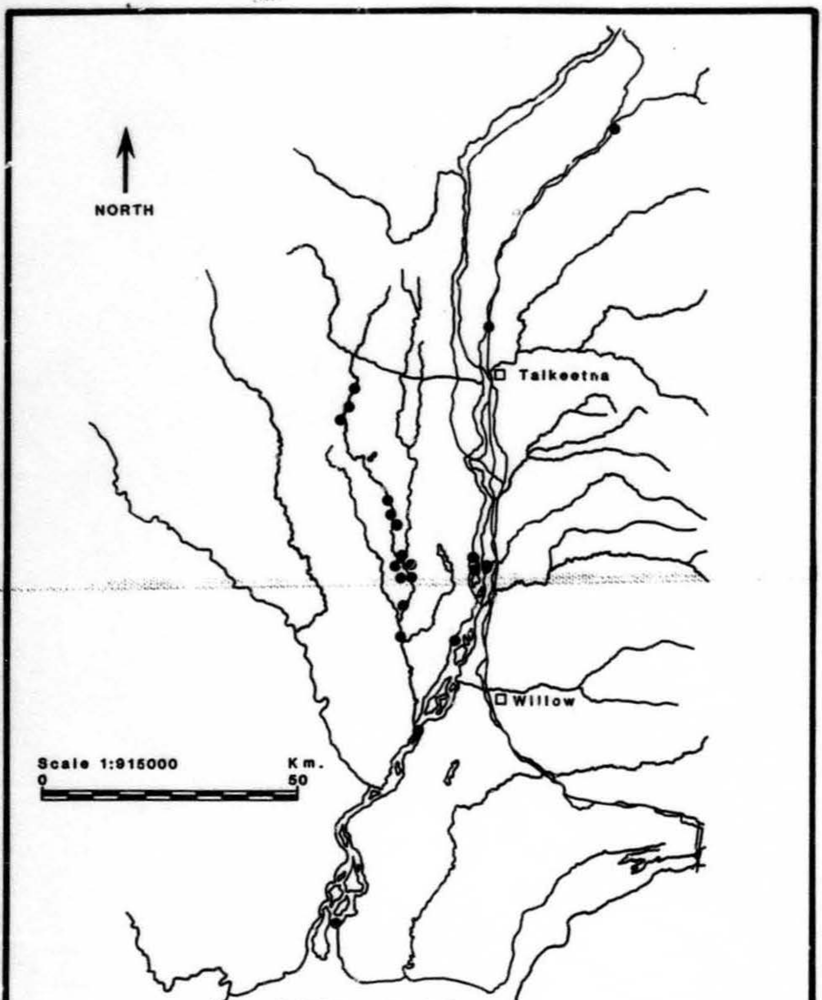


Fig. 35. Locations of moose carcasses observed during aerial surveys in winter 1983-84 (Kroto Creek=13, Moose Creek=0, Susitna River=8).

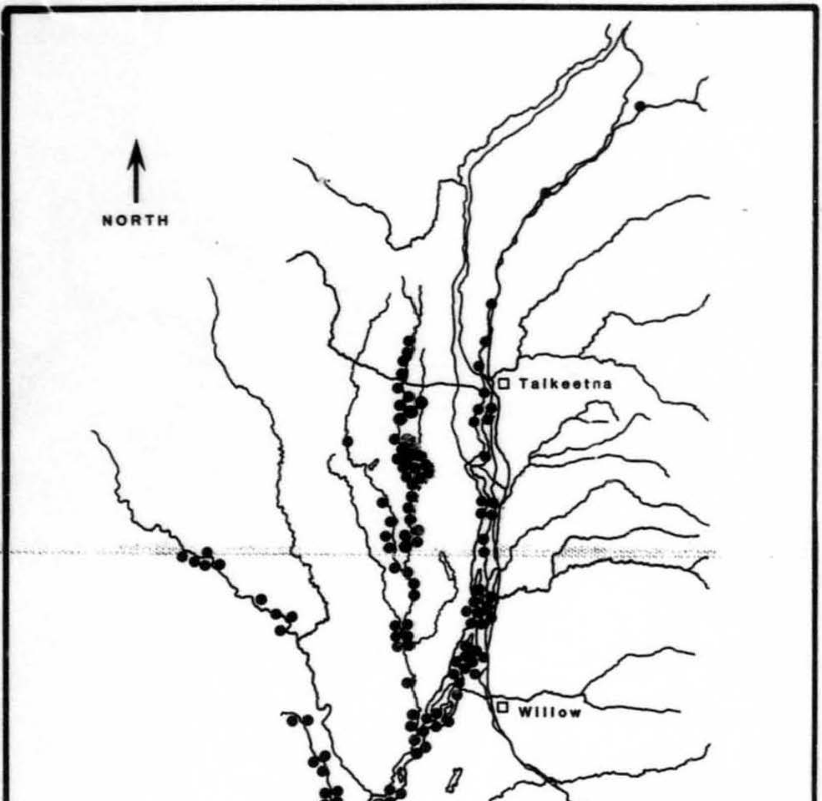


Fig. 36. Locations of moose carcasses observed during aerial surveys conducted in winter 1984-85 (Alexander Creek=17, Yentna River=9, Kroto Creek=18, Moose Creek=31, Susitna River=60).

D55

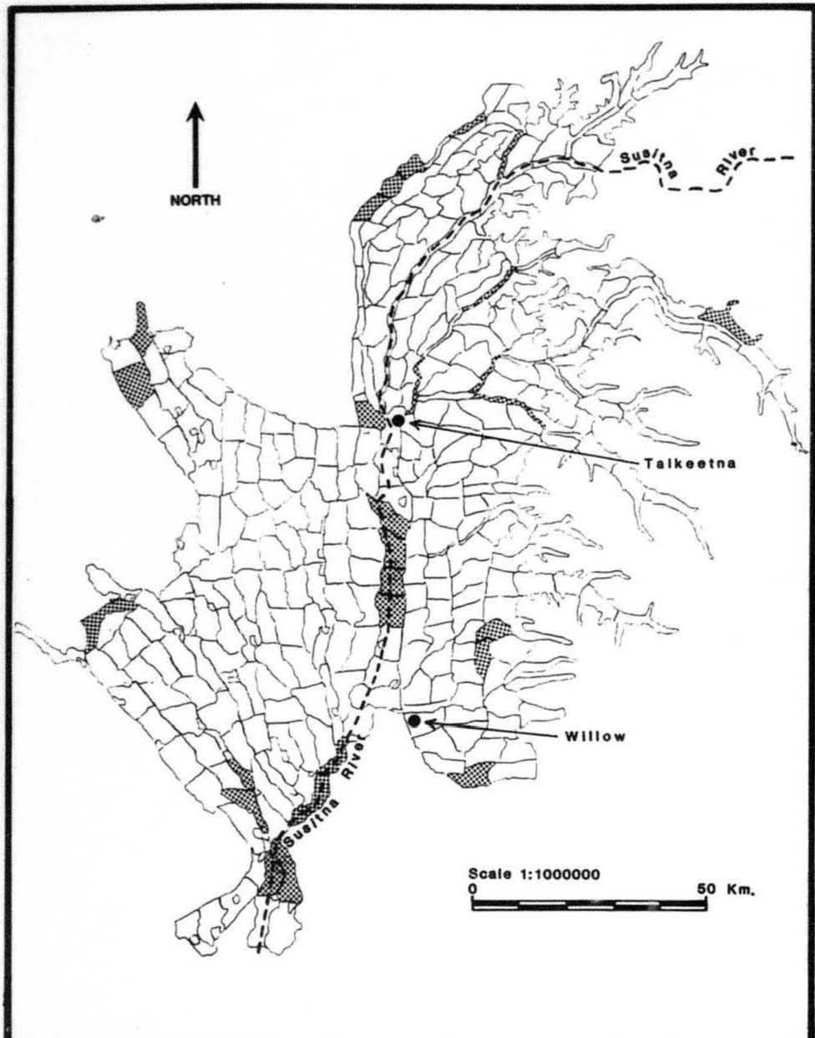


Fig. 39. Locations of areas that encompass lands with enhancement and/or replacement potential for mitigation with moose.

D56

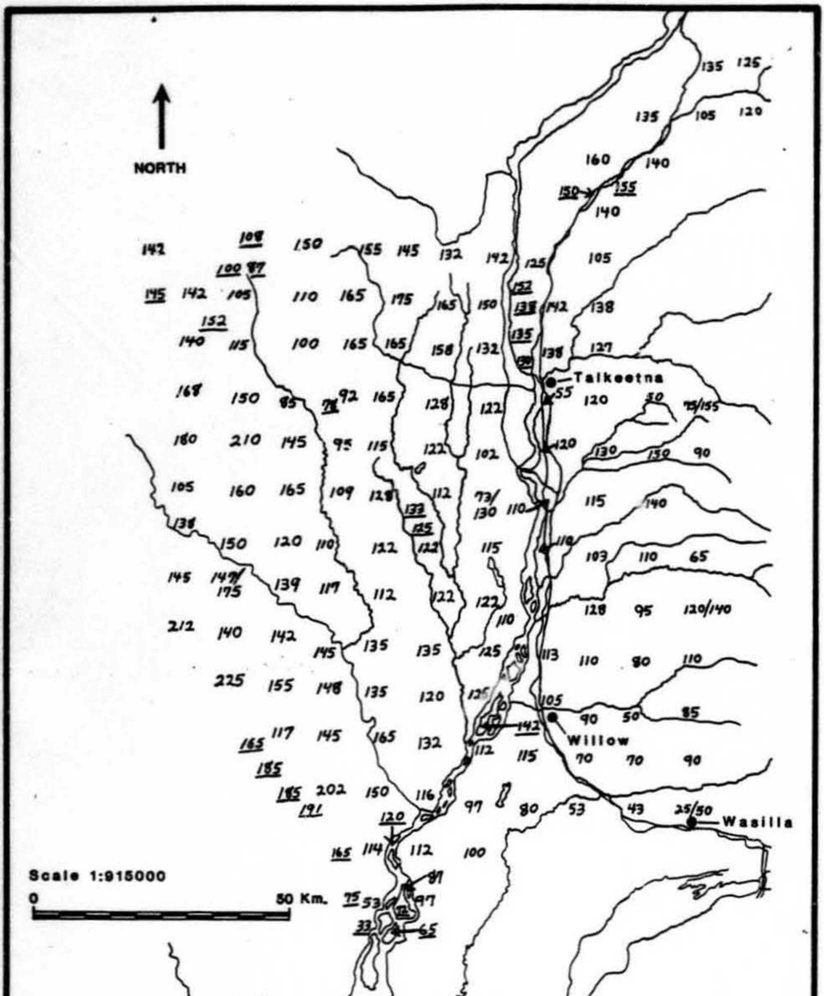


Fig. 38 . Snow depth (cm.) measurements recorded in lower Susitna River valley, March, 1985.

D57

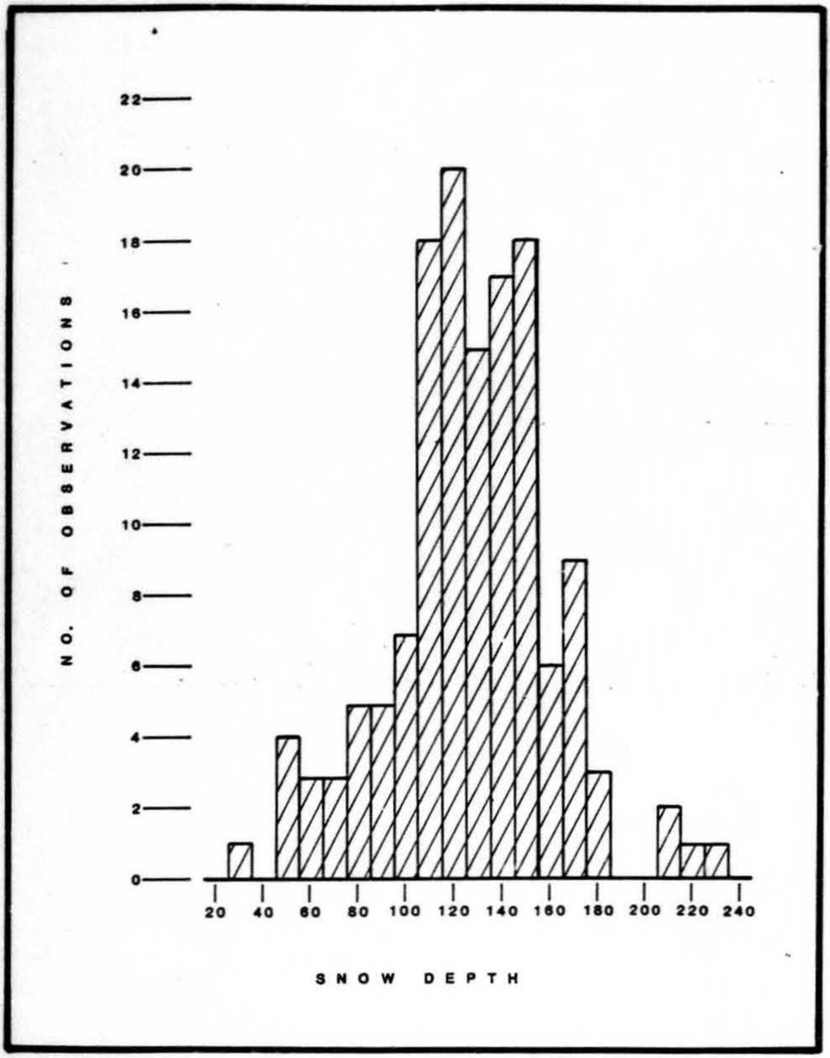


Fig. 29. Histogram of snow depth measurements (cm, ≤ table interval) recorded in lower Susitna River valley, 24-27 March 1985 (n = 138).

D58

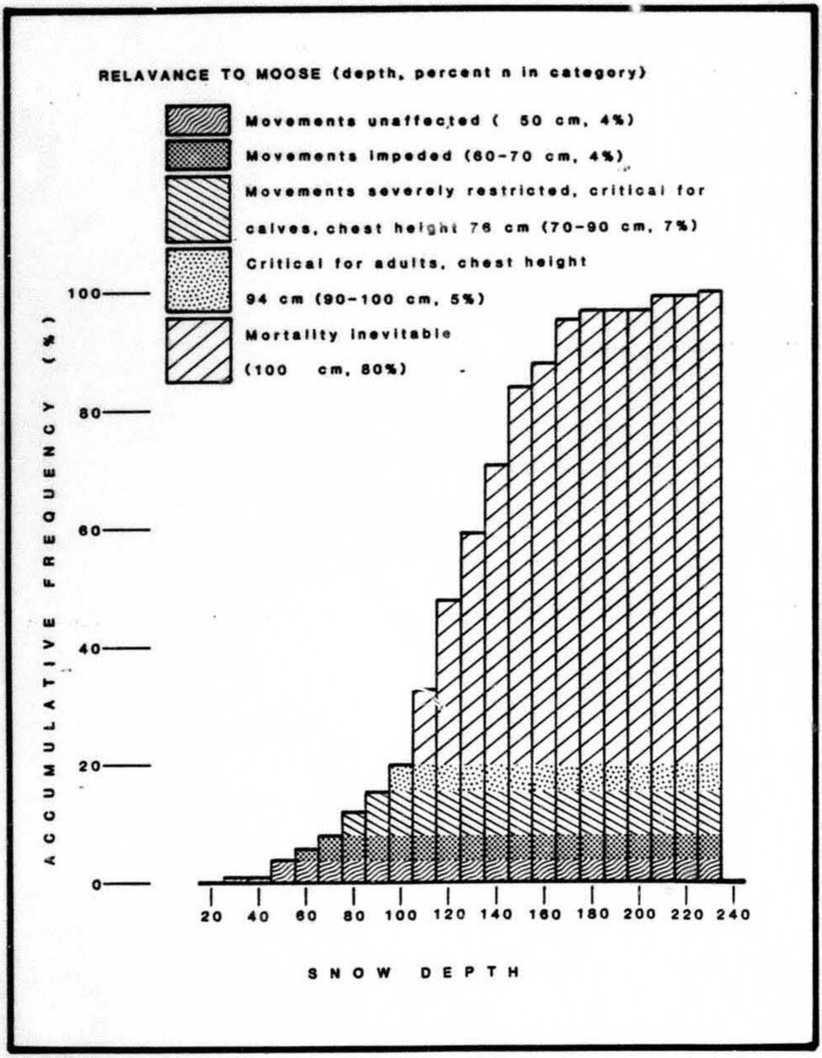


Fig. 40. Accumulative frequency distribution for snow depth measurements (cm. ≤table interval) recorded in lower Susitna River valley, 24-27 March 1985 (n = 138).

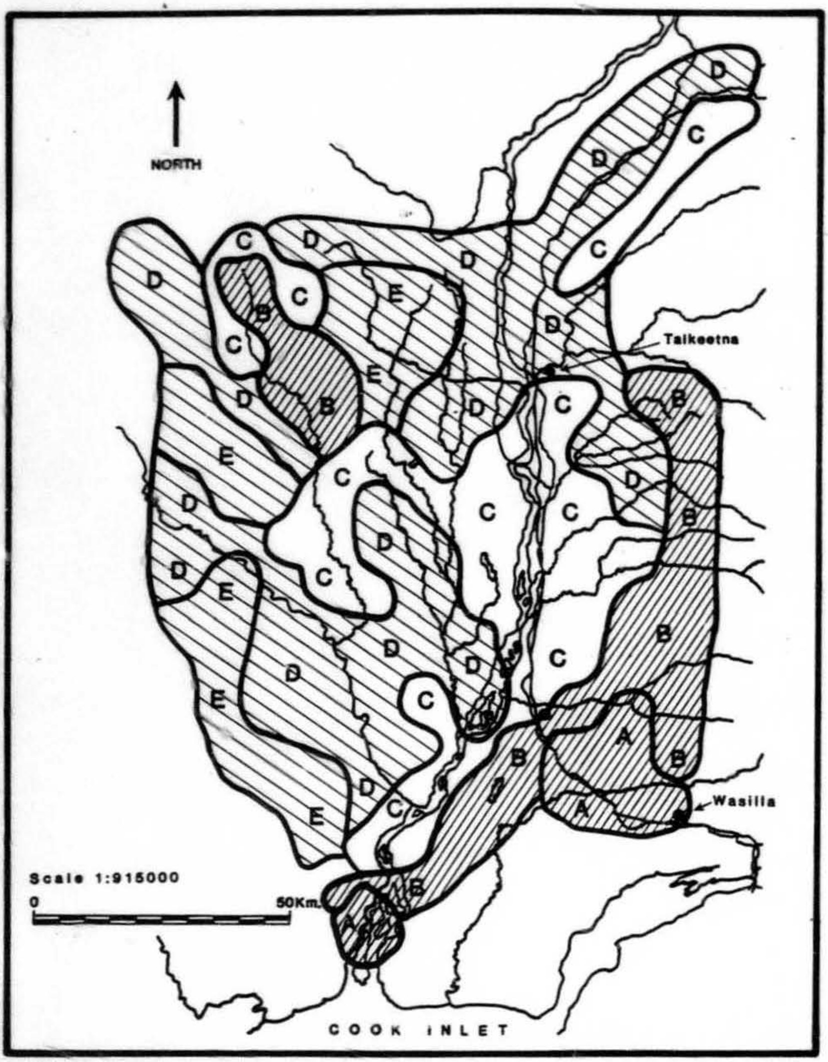


Fig. 41 . Geographical areas in the lower Susitna River valley where snow depths of ≤ 70 cm. (A), > 70 ≤ 100 cm.(B), > 100 ≤ 120 cm.(C), > 120 ≤ 155 cm.(D) or > 155 ≤ 212 cm.(D) were recorded on 24-26 March 1985.

D600

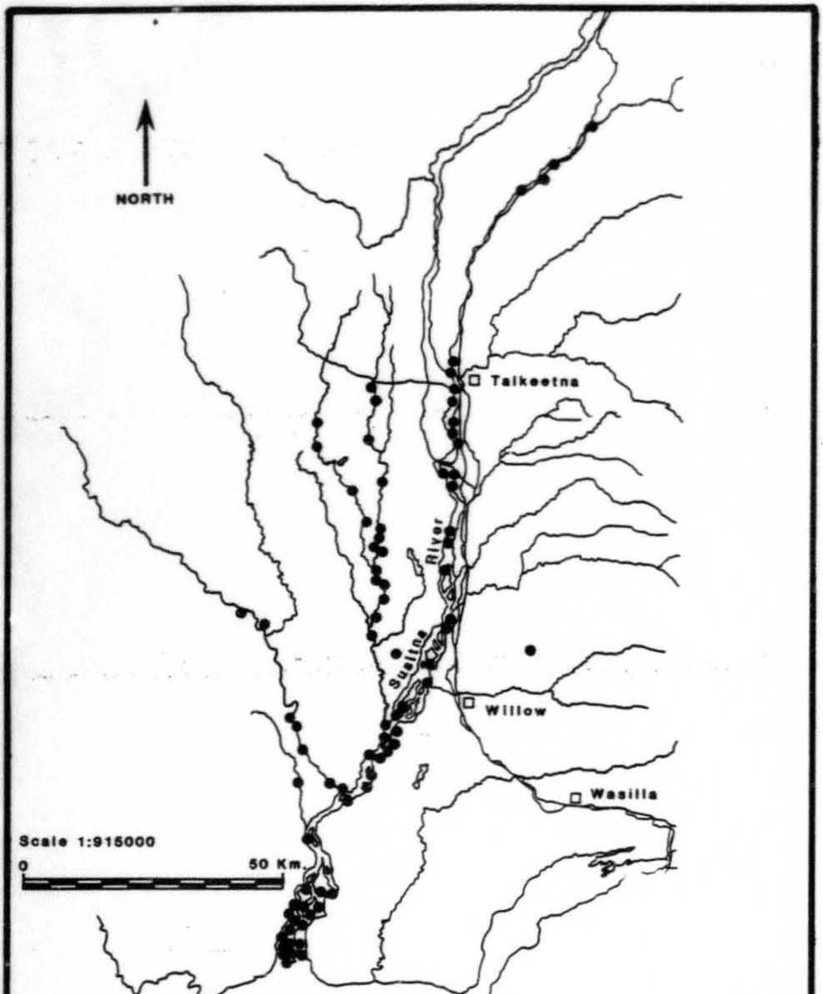


Fig. 42. Location of eagle nests in the lower Susitna River valley.

D61

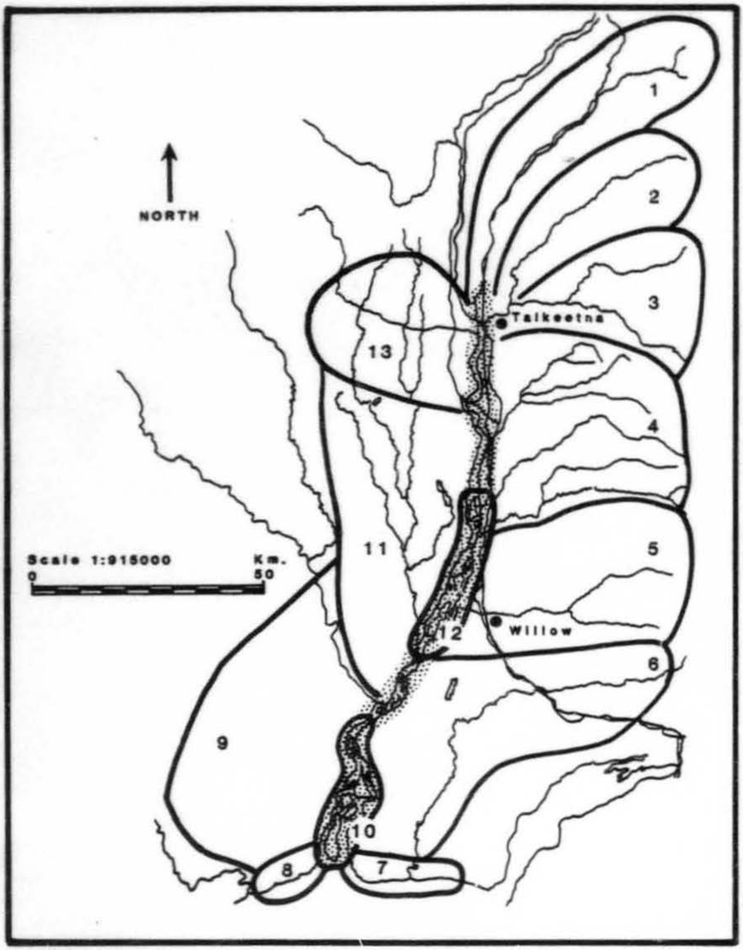
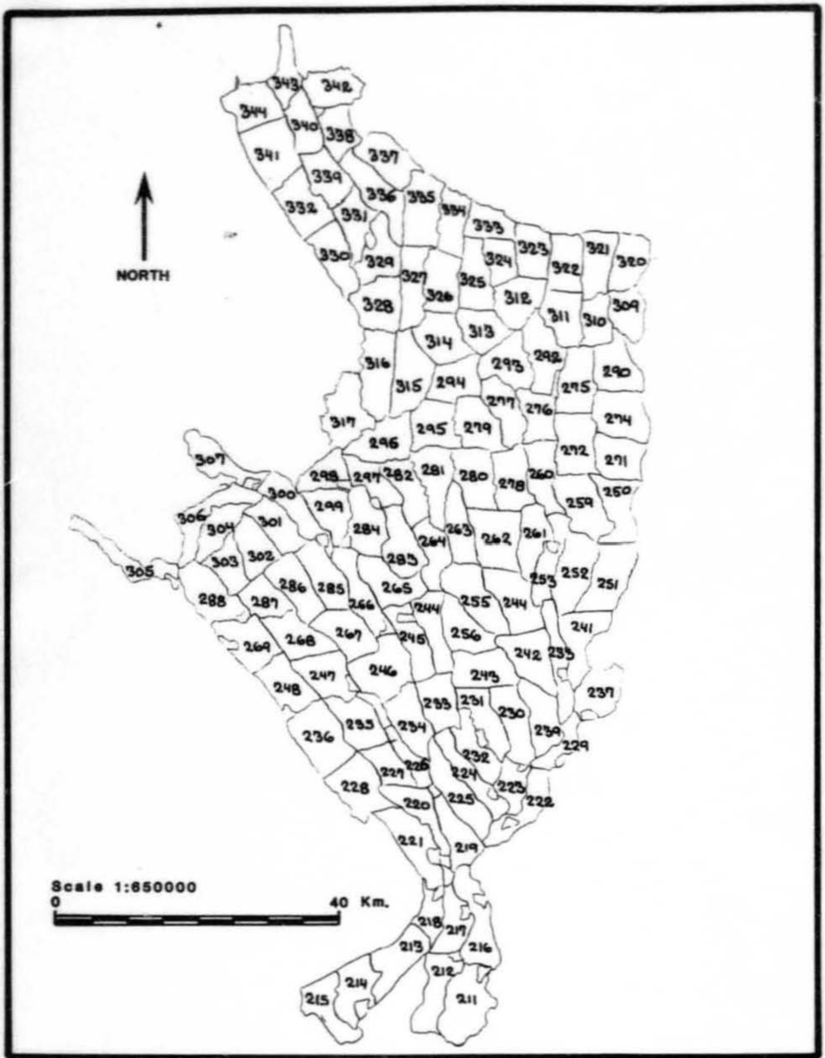
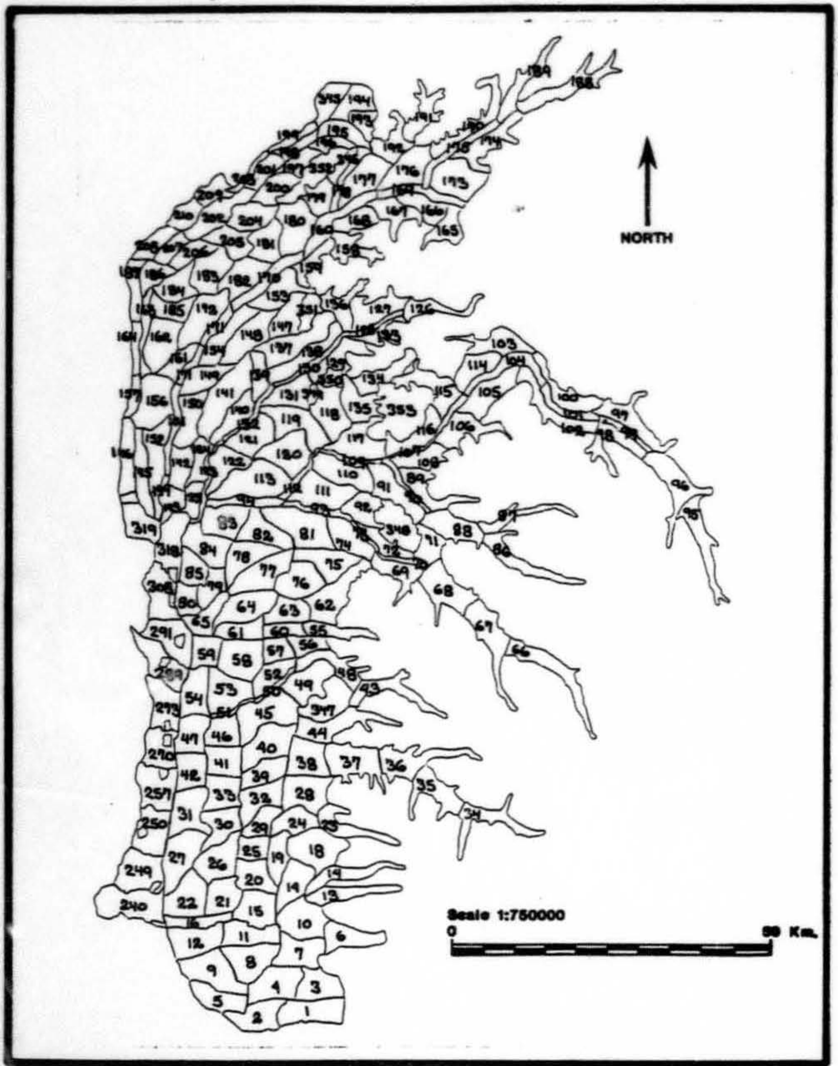


Fig.43. Delineation of annual ranges for 13 hypothetical moose subpopulations identified to use the Susitna River floodplain. (Shaded areas indicate range utilized by more than one subpopulation)

D62



Appendix 4. Identification number and location for sample units included in the western portion of the moose stratification survey, March 1985.



Appendix B. Identification number and location for sample units included in the eastern portion of the stratification survey, March 1985.

D64

APPENDIX C

Appendix C. Number and density of moose and moose tracks observed[a] in different size sample units during a stratification survey in the lower Susitna River Valley watershed, 13-15 and 18 March 1985.

Sample Unit		Number		Density[2]	
Number	Area (sq mi)	Moose	Tracks	Moose	Tracks
1	14.5	38	5	2.6	0.3
2	12.5	44	22	3.5	1.8
3	11.6	5	2	0.4	0.2
4	14.9	1	3	0.1	0.2
5	10.8	7	1	0.7	0.1
6	11.4	12	9	1.1	0.8
7	12.9	1	11	0.1	0.9
8	15.0	0	4	0.0	0.3
9	17.1	4	2	0.2	0.1
10	15.3	13	20	0.8	1.3
11	11.4	10	10	0.9	0.9
12	14.0	16	1	1.1	0.1
13	9.9	7	9	0.7	0.9
14	11.4	6	4	0.5	0.3
15	12.5	4	16	0.3	1.3
16	6.7	16	3	2.4	0.4
17	10.0	7	9	0.7	0.9
18	17.3	7	0	0.4	0.0
19	8.4	27	0	3.2	0.0
20	10.7	1	6	0.1	0.6
21	10.8	0	1	0.0	0.1
22	14.5	1	2	0.1	0.1
23	10.6	13	6	1.2	0.6
24	9.4	34	5	3.6	0.5
25	7.0	1	13	0.1	1.9
26	13.8	2	17	0.1	1.2
27	16.6	13	10	0.8	0.6
28	14.7	5	3	0.3	0.2
29	7.1	0	7	0.0	0.1
30	10.9	0	3	0.0	0.3
31	14.4	13	10	0.9	0.7
32	12.0	0	7	0.0	0.6
33	10.7	8	9	0.7	0.8
34	12.5	0	3	0.0	0.2
35	13.4	9	6	0.7	0.4
36	15.8	14	11	0.9	0.7
37	17.0	26	13	1.5	0.8
38	13.0	5	12	0.4	0.9

Appendix C. Continued.

Sample unit		Number		Density [2]	
Number	Area (sq mi)	Moose	Tracks	Moose	Tracks
82	11.8	0	3	0.0	0.3
83	12.7	0	2	0.0	0.2
84	13.0	7	9	0.5	0.7
85	8.1	2	15	0.2	1.9
86	12.1	25	10	2.1	0.8
87	7.5	0	3	0.0	0.4
88	12.3	11	6	0.9	0.5
89	11.0	0	1	0.0	0.1
90	3.5	7	9	2.0	2.6
91	13.4	1	3	0.1	0.2
92	9.2	18	1	2.0	0.1
93	4.3	15	8	3.5	1.9
94	6.3	10	10	1.6	1.6
95	13.5	29	10	2.1	0.7
96	16.4	14	13	0.9	0.8
97	13.5	52	8	3.9	0.6
98	10.7	20	13	1.9	1.2
99	3.5	0	0	0.0	0.0
100	11.3	13	4	1.1	0.4
101	5.2	8	11	1.5	2.1
102	11.8	30	8	2.5	0.7
103	11.6	1	20	0.1	1.7
104	9.2	5	17	0.5	1.9
105	13.7	3	6	0.2	0.4
106	12.2	0	0	0.0	0.0
107	4.1	10	10	2.4	2.4
108	8.6	5	4	0.6	0.5
109	3.2	8	0	2.5	0.0
110	13.5	0	2	0.0	0.1
111	15.6	6	1	0.4	0.1
112	3.2	10	0	3.2	0.0
113	20.3	3	6	0.1	0.3
114	9.7	4	8	0.4	0.8
115	13.5	4	4	0.3	0.3
116	10.4	7	0	0.7	0.0
117	14.5	1	0	0.1	0.0
118	13.8	0	0	0.0	0.0
119	15.4	1	1	0.1	0.1
120	15.1	3	0	0.2	0.0
121	12.2	0	3	0.0	0.2
122	10.2	3	1	0.3	0.1
123	3.6	47	4	12.9	1.1
124	6.8	1	2	0.1	0.3

D67

Appendix C. Continued.

Sample unit		Number		Density[2]	
Number	Area (sq mi)	Moose	Tracks	Moose	Tracks
125	5.3	0	0	0.0	0.0
126	7.6	5	0	0.7	0.0
127	12.9	4	5	0.3	0.4
128	2.8	4	1	1.4	0.4
129	10.2	1	2	0.1	0.2
130	4.6	16	2	3.5	0.4
131	10.3	7	5	0.7	0.5
132	3.5	10	3	2.9	0.9
133	4.9	1	0	0.2	0.0
134	10.4	0	0	0.0	0.0
135	11.2	2	1	0.2	0.1
136	9.1	1	1	0.1	0.1
137	16.8	13	2	0.8	0.1
138	11.7	7	1	0.6	0.1
139	6.6	3	0	0.5	0.0
140	9.2	22	0	2.4	0.0
141	20.4	39	1	1.9	0.0
142	8.4	0	2	0.0	0.2
143	6.5	0	3	0.0	0.5
144	3.1	8	8	2.6	2.6
145	10.1	0	10	0.0	1.0
146	10.1	28	14	2.8	1.4
147	9.9	1	1	0.1	0.1
148	14.1	21	2	1.5	0.1
149	9.6	1	3	0.1	0.3
150	11.3	1	3	0.1	0.3
151	6.0	8	8	1.3	1.3
152	12.4	0	6	0.0	0.5
153	11.8	0	2	0.0	0.2
154	11.2	3	3	0.3	0.3
155	2.8	3	4	1.1	1.4
156	16.2	1	9	0.1	0.6
157	4.0	0	7	0.0	1.8
158	9.0	4	2	0.4	0.2
159	6.6	0	0	0.0	0.0
160	10.8	5	14	0.5	1.3
161	6.5	1	3	0.2	0.5
162	14.5	27	6	1.9	0.4
163	5.9	2	0	0.3	0.0
164	4.4	11	2	2.5	0.5
165	8.4	8	2	1.0	0.2
166	8.7	0	2	0.0	0.2
167	10.0	1	1	0.1	0.1
168	7.6	8	3	1.1	0.4

Appendix 4. Continued.

Sample unit		Number		Density [2]	
Number	Area (sq mi)	Moose	Tracks	Moose	Tracks
169	7.3	0	4	0.0	0.5
170	9.0	7	8	0.8	0.9
171	4.1	5	1	1.2	0.2
172	15.1	12	0	0.8	0.0
173	16.1	2	10	0.1	0.6
174	12.8	0	4	0.0	0.3
175	7.2	14	8	1.9	1.1
176	13.3	2	3	0.2	0.2
177	13.8	1	3	0.1	0.2
178	5.0	19	3	3.8	0.6
179	8.0	3	4	0.4	0.5
180	15.9	4	9	0.3	0.6
181	10.3	0	0	0.0	0.0
182	12.5	0	2	0.0	0.2
183	12.7	4	1	0.3	0.1
184	9.9	0	5	0.0	0.5
185	8.6	0	4	0.0	0.5
186	6.9	0	5	0.0	0.7
187	7.5	4	13	0.5	1.7
188	14.3	15	9	1.0	0.6
189	9.4	0	0	0.0	0.0
190	12.0	15	2	1.3	0.2
191	9.7	2	0	0.2	0.0
192	9.8	2	2	0.2	0.2
193	5.5	0	0	0.0	0.0
194	8.9	4	1	0.4	0.1
195	7.5	1	2	0.1	0.3
196	4.7	3	1	0.6	0.2
197	6.3	0	1	0.0	0.2
198	4.5	0	1	0.0	0.2
199	3.9	15	6	3.8	1.5
200	9.0	1	0	0.1	0.0
201	6.5	0	3	0.0	0.5
202	13.6	2	0	0.1	0.0
203	2.8	7	6	2.5	2.1
204	10.8	5	2	0.5	0.2
205	9.8	0	0	0.0	0.0
206	7.2	0	1	0.0	0.1
207	5.5	5	2	0.9	0.4
208	7.1	97	3	13.6	0.4
209	6.7	29	0	4.3	0.0
210	6.9	45	0	6.5	0.0
211	23.3	49	2	2.1	0.1

Appendix C. Continued.

Sample unit		Number		Density[2]	
Number	Area (sq mi)	Moose	Tracks	Moose	Tracks
212	16.1	47	6	2.9	0.4
213	16.3	41	1	2.5	0.1
214	16.4	16	3	1.0	0.2
215	14.6	7	6	0.5	0.4
216	18.7	74	1	4.0	0.1
217	12.4	38	1	3.1	0.1
218	8.6	12	4	1.4	0.5
219	13.9	1	1	0.1	0.1
220	14.8	99	1	6.7	0.1
221	19.1	3	1	0.2	0.1
222	14.1	49	1	3.5	0.1
223	9.6	8	4	0.8	0.4
224	13.6	19	6	1.4	0.4
225	17.5	1	2	0.1	0.1
226	10.6	38	0	3.6	0.0
227	9.8	1	1	0.1	0.1
228	18.7	1	1	0.1	0.1
229	8.3	44	1	5.3	0.1
230	15.9	0	2	0.0	0.2
231	14.7	3	2	0.2	0.1
232	12.2	0	5	0.0	0.4
233	13.8	5	5	0.4	0.4
234	15.7	0	0	0.0	0.0
235	15.4	2	0	0.1	0.0
236	22.7	1	2	0.0	0.1
237	14.8	20	4	1.4	0.3
238	13.4	14	4	1.0	0.3
239	15.2	0	0	0.0	0.0
240	19.4	18	7	0.9	0.4
241	16.2	2	5	0.1	0.3
242	17.6	0	0	0.0	0.0
243	16.2	0	3	0.0	0.2
244	13.3	0	1	0.0	0.1
245	14.0	24	20	1.7	1.4
246	20.6	1	4	0.0	0.2
247	16.0	12	1	0.7	0.1
248	16.2	3	7	0.2	0.4
249	16.2	25	1	1.5	0.1
250	14.1	25	1	1.8	0.1
251	19.2	0	3	0.0	0.2
252	19.1	1	5	0.1	0.3
253	12.6	7	4	0.6	0.3
254	17.8	0	5	0.0	0.3
255	19.2	0	0	0.0	0.0

Appendix C. Continued.

Sample unit		Number		Density [2]	
Number	Area (sq mi)	Moose	Tracks	Moose	Tracks
256	14.3	0	2	0.0	0.1
257	15.1	61	1	4.1	0.1
258	15.3	0	4	0.0	0.3
259	18.9	0	0	0.0	0.0
260	14.1	5	12	0.4	0.9
261	13.3	0	1	0.0	0.1
262	19.4	1	2	0.1	0.1
263	13.1	0	0	0.0	0.0
264	12.2	1	10	0.1	0.8
265	15.7	21	13	1.3	0.8
266	15.3	19	21	1.2	1.4
267	15.5	0	4	0.0	0.3
268	15.4	0	0	0.0	0.0
269	17.4	45	3	2.6	0.2
270	11.5	71	1	6.2	0.1
271	14.6	0	2	0.0	0.1
272	17.7	1	4	0.1	0.2
273	13.1	98	0	7.5	0.0
274	18.3	0	0	0.0	0.0
275	16.6	2	3	0.1	0.2
276	12.0	5	4	0.4	0.3
277	14.0	0	0	0.0	0.0
278	15.7	2	1	0.1	0.1
279	15.4	0	2	0.0	0.1
280	16.3	0	1	0.0	0.1
281	16.1	0	0	0.0	0.0
282	13.1	1	6	0.1	0.5
283	15.0	0	4	0.0	0.3
284	15.7	0	4	0.0	0.3
285	15.7	2	6	0.1	0.4
286	16.1	0	2	0.0	0.1
287	11.3	1	1	0.1	0.1
288	18.7	5	5	0.3	0.3
289	14.4	53	0	3.7	0.0
290	16.0	0	3	0.0	0.2
291	14.6	26	1	1.8	0.1
292	17.6	17	1	1.0	0.1
293	15.5	0	7	0.0	0.5
294	13.9	0	3	0.0	0.2
295	15.1	0	0	0.0	0.0
296	16.7	1	6	0.1	0.4
297	11.1	1	4	0.1	0.4
298	11.4	1	5	0.1	0.4
299	14.0	22	12	1.6	0.9

D71

Appendix ~~A~~ C. Continued.

Sample unit		Number		Density[2]	
Number	Area (sq mi)	Moose	Tracks	Moose	Tracks
300	15.5	5	19	0.3	1.2
301	13.0	3	3	0.2	0.2
302	13.0	9	2	0.7	0.2
303	10.8	0	0	0.0	0.0
304	11.5	2	2	0.2	0.2
305	13.8	17	10	1.2	0.7
306	15.4	75	6	4.9	0.4
307	14.4	7	9	0.5	0.6
308	14.1	40	2	2.8	0.1
309	11.6	1	2	0.1	0.2
310	10.5	0	1	0.0	0.1
311	14.1	0	1	0.0	0.1
312	15.0	32	1	2.1	0.1
313	12.6	0	8	0.0	0.6
314	15.8	1	1	0.1	0.1
315	19.4	0	5	0.0	0.3
316	19.9	7	11	0.4	0.6
317	19.0	11	10	0.6	0.5
318	14.5	41	1	2.8	0.1
319	12.2	57	5	4.7	0.1
320	13.5	6	11	0.4	0.8
321	14.4	24	5	1.7	0.3
322	14.2	1	3	0.1	0.2
323	12.9	11	7	0.9	0.5
324	9.5	0	0	0.0	0.0
325	15.0	0	5	0.0	0.3
326	15.4	1	4	0.1	0.3
327	14.3	7	7	0.5	0.5
328	16.8	7	14	0.4	0.8
329	15.2	36	3	2.4	0.2
330	15.7	1	10	0.1	0.6
331	12.8	6	4	0.5	0.3
332	17.2	7	13	0.4	0.8
333	10.5	1	2	0.1	0.2
334	12.6	3	6	0.2	0.5
335	18.6	15	0	0.8	0.0
336	17.4	7	1	0.4	0.1
337	15.7	0	0	0.0	0.0
338	12.0	8	13	0.7	1.1
339	14.0	19	27	1.4	1.9
340	12.3	0	6	0.0	0.5
341	21.5	68	0	3.2	0.0
342	13.8	25	3	1.8	0.2
343	11.2	112	2	10.0	0.2

D72

Appendix 4. Continued.

Sample unit		Number		Density[2]	
Number	Area (sq mi)	Moose	Tracks	Moose	Tracks
344	15.7	20	9	1.3	0.6
345	8.5	7	5	0.8	0.6
346	3.8	0	0	0.0	0.0
347	13.7	0	0	0.0	0.0
348	14.5	0	0	0.0	0.0
349	1.7	0	0	0.0	0.0
350	3.4	0	0	0.0	0.0
351	5.8	0	0	0.0	0.0
352	12.4	0	0	0.0	0.0
353	25.4	0	0	0.0	0.0

[2] Density of moose and tracks = No. moose and tracks divided by area (sq mi) of sample unit, respectively.

space

Total	4252	3440	–	–	–

D73

APPENDIX D

Frequency distribution of moose density classes for numbers of moose observed in various size sample units on a stratification survey in the lower Susitna River valley watershed 13-15 and 18 March 1985.

Density class[1]	No. units	Total Moose	Total Area (mi^2)	Percent Total Moose	Percent Total Area	Accumulative % Total Moose	Accumulative % Total Area
13.1 +	1	97	7	2.8	0.2	2.8	0.2
12.1 - 13.0	1	47	4	1.4	0.1	4.2	0.3
11.1 - 12.0	0	0	0	0.0	0.0	4.2	0.3
10.1 - 11.0	0	0	0	0.0	0.0	4.2	0.3
9.1 - 10.0	1	112	11	3.5	0.3	7.7	0.6
8.1 - 9.0	0	0	0	0.0	0.0	7.7	0.6
7.1 - 8.0	1	98	13	2.8	0.3	10.5	0.9
6.1 - 7.0	3	215	33	6.3	0.8	16.8	1.7
5.1 - 6.0	1	44	8	1.3	0.2	18.1	1.9
4.1 - 5.0	4	222	49	6.5	1.2	24.6	3.1
3.1 - 4.0	16	557	158	16.2	3.7	40.8	6.8
2.1 - 3.0	23	615	248	17.9	5.8	58.7	12.6
1.6 - 2.0	18	383	220	11.1	5.2	69.8	17.8
1.1 - 1.5	24	313	253	9.1	6.0	78.9	23.8
0.6 - 1.0	41	411	523	11.9	12.3	90.8	36.1
0.1 - 0.5	116	324	1,479	9.4	34.8	100.2	71.1
0.0	96	2	1,168	0.0	27.5	100.2	98.7
0.0	7	0	77	0.0	1.2	100.2	99.9
Total	353	3,440	4,252	100.2	99.6	100.1	99.9

[1] Density class = number of moose observed in sample unit divided by area (sq mi) of sample unit. Seven sample units (77 sq mi) in density class 0.0 were comprised of habitat above 3,500 ft., an elevation above which moose are seldom observed.

APPENDIX E

Table . Numbers of moose observed on periodic surveys in two alpine areas of the western foothills of the Talkeetna Mountains, Alaska, 1985-87.

Area	1985-86								1986-87	
	4 Oct	17 Oct	8 Nov	18 Nov	3 Dec	23 Feb	31 Mar	17 Apr	26 Nov	24 Dec
Bald Mtn[a]	37	109	264	302	260	275	191	40	408	120
Willow Mtn	5	148	265	268	313	164	121	59	492	43

[a] Approximately 16 and 39 mi^2 of moose habitat were surveyed on Bald and Willow Mountain, respectively.

APPENDIX F

Table . Numbers of moose observed on sites in the lower Susitna River valley where natural vegetation has been altered by activities of man, 1981-85.

Winter	Date	Site[1] MW	MN	MM	TW	KL	MS	ME	GC	WC	KB	CW	CE	KE	TC
1981-82	2 Dec	41	-	-	-	-	-								
	10 Dec	8	0	23	4	-	17								
	14 Dec	28	-	-	-	-	-								
	28 Dec	25	-	11	7	-	-								
	6 Feb	1	-	9	4	4	-								
	1 Mar	24	1	2	1	1	6								
	24 Mar	6	0	4	1	6	0								
	12 Apr	4	0	0	0	1	1								
1982-83	29 Oct	13	0	0	-	-	-								
	6 Nov	22	0	2	4	3	-								
	10 Nov	-	-	-	-	-	14								
	18 Nov	68	0	11	8	3	-								
	2 Dec	67	1	45	16	23	-								
	6 Dec	56	3	47	-	21	-								
	20 Dec	-	8	-	-	21	-								
	21 Dec	36	-	42	25	19	-								
	22 Dec	41	-	42	-	10	-								
	5 Jan	28	6	41	9	22	-								
	20 Jan	21	0	59	-	36	5								
	24 Jan	48	0	63	14	29	13								
	7 Feb	-	-	-	-	14	11								
	9 Feb	57	0	7	27	-	-								
	22 Feb	-	-	-	-	8	2								
	23 Feb	30	2	16	6	-	-								
	7 Mar	-	-	-	-	7	-								
	8 Mar	43	3	22	8	-	2								
	20 Mar	-	7	-	-	-	-								
	22 Mar	17	-	43	-	17	-								
	23 Mar	21	-	45	10	16	-								
	30 Mar	-	-	-	8	1	-								
	8 Apr	2	-	6	1	1	-								
1983-84	17 Nov	6	0	4	4	11	0	-	-	1	0	0	-	3	-
	18 Nov	-	-	-	-	-	-	0	0	-	-	0	-	-	-
	25 Nov	22	-	-	-	-	-	-	-	-	-	-	-	-	-
	29 Nov	45	0	5	0	3	0	3	0	3	2	0	0	-	-
	9 Dec	32	0	5	9	14	2	10	0	7	2	0	3	5	-
	16 Dec	47	0	7	11	7	2	6	0	5	0	0	3	-	-
	24 Dec	72	0	5	18	3	0	7	0	2	2	2	0	1	-
	30 Dec	49	0	0	1	0	0	-	-	-	-	-	-	-	-
	3 Jan	23	-	5	1	-	-	-	-	-	-	-	-	-	-
	5 Jan	73	0	12	14	8	0	12	6	1	2	4	3	2	-
	13 Jan	29	1	18	14	4	5	0	2	2	4	2	2	0	-
	17 Jan	-	4	21	13	3	4	4	6	1	6	6	5	1	-

APPENDIX F

~~Table~~ . (Continued)

Winter	Date	MW	MN	MM	TW	KL	MS	ME	GC	WC	KB	CW	CE	KE	TC
		Site[1]													
1983-84	19 Jan	31	2	16	10	2	2	4	8	4	6	6	2	1	-
	27 Jan	49	4	25	5	16	6	7	22	8	15	7	4	2	-
	8 Feb	48	5	38	8	6	12	3	12	1	40	23	6	2	-
	20 Feb	49	6	26	21	8	25	3	21	1	27	22	9	1	-
	28 Feb	42	7	59	26	14	12	6	4	0	31	18	0	2	-
	5 Mar	19	0	43	10	16	5	0	4	2	33	34	2	0	-
	8 Mar	17	1	37	3	9	6	1	4	2	28	34	2	0	-
	15 Mar	3	0	38	3	8	6	0	1	5	16	16	0	0	-
	29 Mar	4	0	27	1	21	3	0	0	5	6	3	0	0	-
1984-85	27 Nov	50	0	0	0	6	0	0	-	0	0	0	0	3	3
	10 Dec	25	0	0	5	-	0	0	-	-	-	0	0	-	-
	11 Dec	-	-	-	-	7	-	-	3	0	0	-	-	2	2
	24 Dec	46	0	5	10	9	1	5	1	0	0	2	0	0	0
	28 Dec	43	1	0	-	5	0	2	0	3	1	-	2	0	0
	7 Jan	51	2	17	27	4	5	0	7	1	3	0	0	3	3
	18 Jan	48	4	22	11	6	9	-	5	2	6	2	0	2	2
	19 Jan	-	-	-	-	-	-	2	-	-	-	-	-	-	-
	29 Jan	24	4	37	17	5	18	2	7	0	11	7	0	3	3
	11 Feb	29	1	35	-	6	12	2	16	0	18	22	7	4	4
	13 Feb	43	7	51	18	13	11	6	11	0	22	22	8	5	5
	22 Feb	35	16	37	12	4	1	4	3	2	27	25	6	0	0
	1 Mar	-	-	-	17	8	-	-	-	1	32	43	13	1	1
	2 Mar	40	3	39	-	-	6	6	11	-	-	-	-	-	-
	9 Mar	34	4	24	20	6	1	0	3	6	21	50	6	1	1
	16 Mar	20	4	33	-	8	1	0	8	4	20	46	2	0	0
	21 Mar	18	0	39	20	2	0	0	7	2	18	40	4	2	2
	5 Apr	12	0	39	11	1	4	0	1	1	13	29	1	0	0
	16 Apr	10	0	50	16	0	2	0	2	3	7	2	3	0	0

1 - = Site not surveyed on that day. MW= Montana west, MN= Montana north, MM= Montana middle, TW= Talkeetna west, KL= Kashwitna Lake, MS= Montana south, ME= Montana east, GC= Goose creek, WC= Willow creek, KB= Kashwitna bluffs, CW= Chandalar west, CE= Chandalar east, KE= Kashwitna east and TC= Talkeetna cutoff. Sites ME, GC, WC, KB, CW, CE and KE were only surveyed during 1983-85. Site TC was only surveyed during 1984-85.