SUSITNA HYDROELECTRIC PROJECT

MOOSE BROWSE INVENTORY, FOOD HABITS, AND NUTRITIONAL QUALITY OF FORAGE IN THE MIDDLE SUSITNA RIVER BASIN-- A PROGRESS REPORT FOR FY85

Report by

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NOTICE

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

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

The Susitna Hydroelectric Project will comprise two major developments on the Susitna River approximately 180 miles north and east of Anchorage, Alaska. The first phase will be the Watana project which will incorporate an earthfill dam together with associated power and camp facilities. The Watana Dam will be located at river mile 184 above the mouth of the Susitna River, in a broad U-shaped valley approximately 2.5 miles upstream of the Tsusena Creek confluence. The dam will create a reservoir approximately 48 miles long with a maximum width of about five miles (excluding tributaries), and have a surface area of 38,000 acres at the normal maximum operating level of 2,185 feet MSL. The second phase will include the Devil Canyon concrete arch dam and associated facilities. The Devil Canyon Dam will be located in the Devil Canyon gorge at river mile 152 of the Susitna River, approximately 32 river miles downstream from the Watana Dam site. It will form a reservoir approximately 26 miles long with a surface area of 7,800 acres at the normal maximum operating level of 1,455 feet MSL.

Construction and operation of the Watana and Devil Canyon hydroelectric dams in the middle Susitna River basin (Figure 1) will result in both permanent and temporary loss of habitat for moose (*Alces alces gigas*). Approximately 72 square miles of land area will be permanently lost, and another 24 square miles will be temporarily lost as a result of the project. Loss of this land area, and the vegetation growing there, to reservoir inundation, camp facilities, borrow sites, and other sources represents a loss in its capacity to support moose

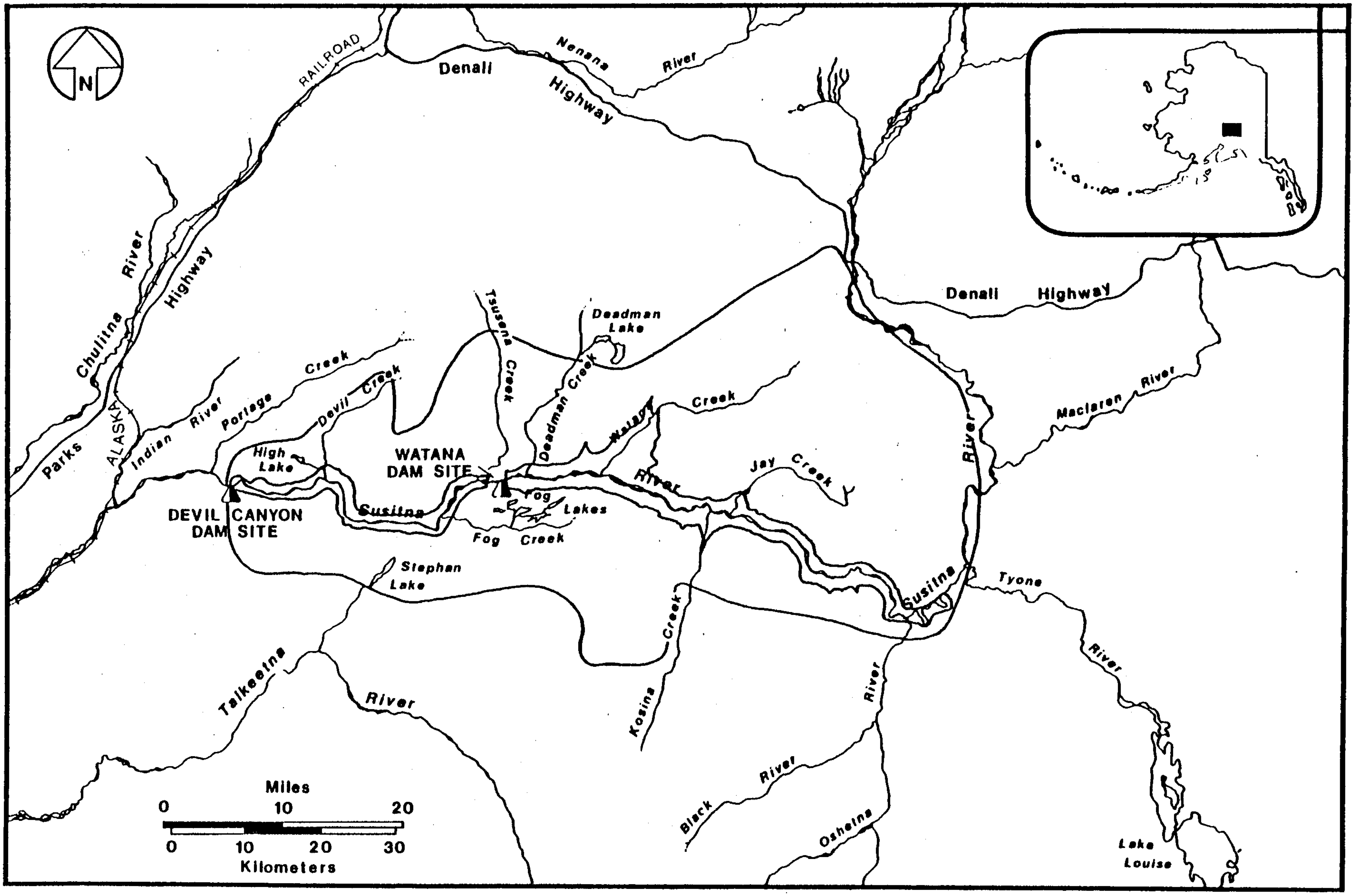

Figure 1. Watana, Devil Canyon, and surrounding area sampling populations for the browse inventory study.

populations. Loss of habitat carrying capacity will be the primary impact on moose of hydroelectric development of the Susitna basin (Alaska Power Authority 1983, LGL 1984).

Impacts of the Susitna Hydroelectric Project on moose will be based on an assessment of the loss of carrying capacity of the affected area. Carrying capacity was selected as the measuring rule for impact assessment for moose because it represents the current as well as future potential of the land to support a moose population. Measurements of potential carrying capacity can be used as a base from which to make adjustments to decrease or increase actual carrying capacity as determined by availability of forage and use of an area. The primary proximate factor limiting availability of forage for moose is winter snow depths. Accumulated snowfall covers and restricts access to forage during the winter. Late winter and early spring are considered to be the critical periods of the year for Alaskan moose (Gasaway and Coady 1974, Gasaway et al. 1983). During winter, energy requirements for moose are normally somewhat greater than the energy metabolized from the food they consume (Coady 1974, Gasaway and Coady 1974), and slight changes in the food available for consumption may have major effects on the survival or productive capability of individuals.

To mitigate loss of potential carrying capacity, the primary option that is available to offset the loss is compensation (Figure 2). Through land acquisition and manipulation of vegetation, winter forage will be provided to compensate for habitat losses resulting from project development. To provide the information necessary to determine the acreage of compensation land required to mitigate impacts to moose, a

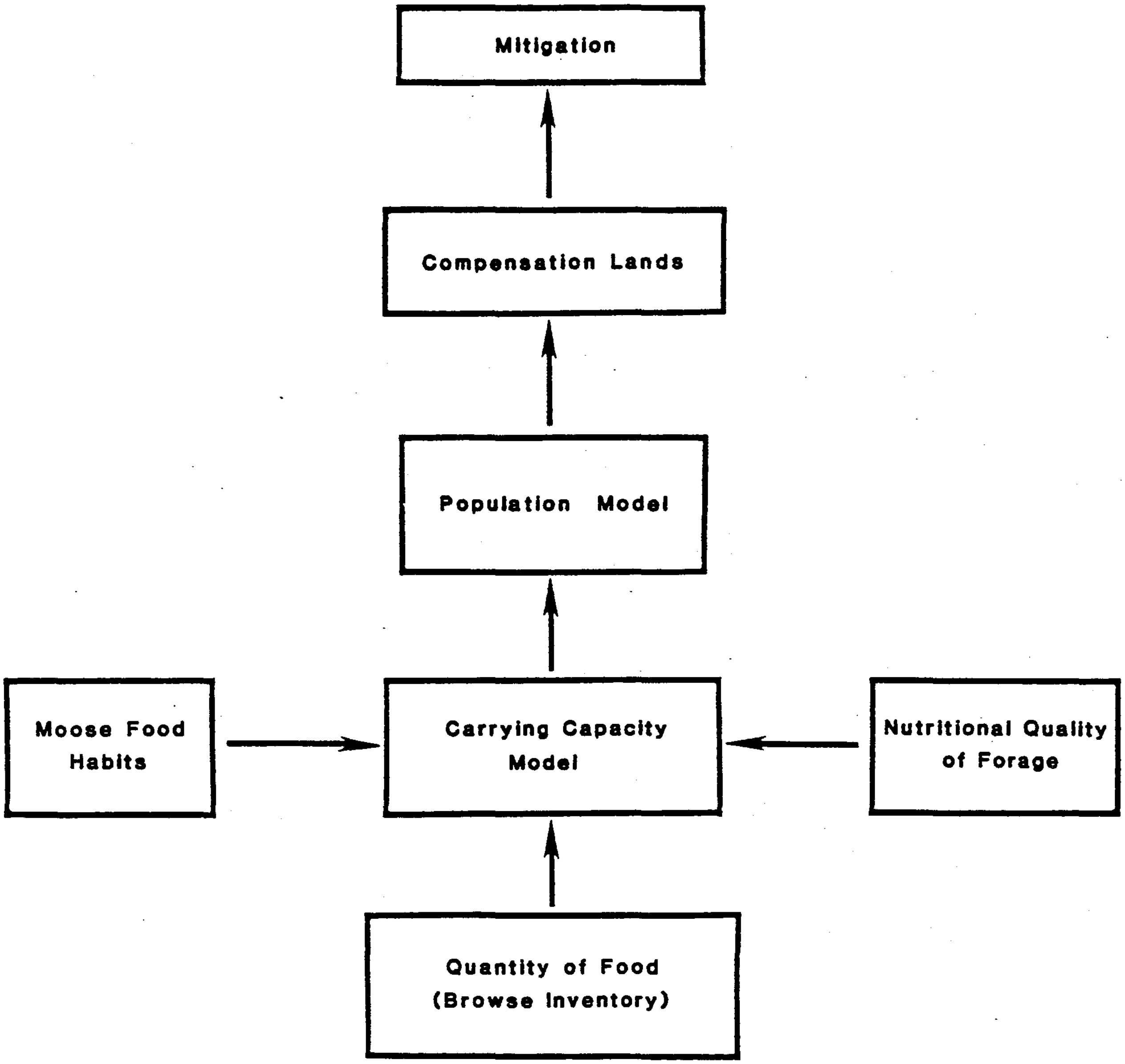

Figure 2. Flow chart showing the relationship of the food habits, nutritional quality of forage, and browse inventory studies to mitigation planning.

computer simulation model of ruminant energy and nitrogen balance (Swift et al. 1981, Swift 1983) adapted for moose (Regelin et al. 1981, Schwartz and Franzmann 1981) by the Alaska Department of Fish and Game (ADF&G) on the Kenai Peninsula will be used. The concept of biological carrying capacity is based on the nutritional needs of the animal, and requires an understanding of ungulate nutrition, the nutrients the animal must obtain from the range, and the ability of the range to meet those nutritional needs. The carrying capacity model predicts the daily energy and nitrogen requirements of adult moose based on dry matter digestibility and nitrogen concentration of food items in the winter diet. The model will be used to estimate daily forage intake and changes in lean body mass and body weight during the winter months, and will predict carrying capacity in terms of either the number of moose or total number of days a moose could forage in a given area over a given time period.

Three area-specific inputs are required to adapt this model from the location of its development on the Kenai Peninsula to the middle Susitna River basin. A major required input is the quantity of forage that is available on a sustained-yield basis to wintering moose in the middle basin (Figure 2). Data collection and analysis for this input is the objective of the browse inventory study. Identification of the major food items in winter diets of moose, as well as the nutritional quality and digestibility of those food items are two other inputs required by the model (Figure 2). Data collection and analysis are the objectives of the food habits and nutritional quality studies.

Results and discussion presented in this progress report are preliminary. The authors request that this report be viewed with the understanding that the findings presented here may likely change with the collection of data scheduled for completion during summer 1985.

2 ACKNOWLEDGEMENTS

Many people of several state and private organizations have contributed to the design and implementation of the studies presented in this report. Dr. Wayne Regelin of ADF&G provided guidence in the field sampling design of all three studies and served as a consultant whenever problems arose. SuzAnne Miller of ADF&G provided program guidance, computer programming, and statistical support. Randy Fairbanks of Harza-Ebasco Susitna Joint Venture, Dr. Robin Sener of LGL Alaska Research Associates, and Karl Schneider of ADF&G provided overall program guidance and funding. Dr. Richard Flemming of the Alaska Power Authority was instrumental in the acceptance of the carrying capacity approach for moose impact assessment and for securing the funding necessary to see these studies in support of this assessment to completion.

Connie Lucas and Karen Arola provided clerical services for this report. Figures were prepared by Graphic Definitions. Funding for these studies was provided under contract to Harza-Ebasco Susitna Joint Venture and ADF&G for the Alaska Power Authority.

3 SUSITNA BASIN STUDY AREA

The general study area for all three studies is located in the Susitna River basin upstream of the mouth of Devil Canyon (Figure 1). Elevations range from about 900 feet (274 meters) on the river at the mouth of Devil Canyon to 6,255 feet (1,907 meters) at the top of Mt. Watana. The river elevation rises to approximately 2,449 feet (746 meters) where the Denali Highway crosses the Susitna River.

Topography of the study area has been strongly influenced by past glacial action and associated stream and river erosion. Generally, the area is a broad U-shaped valley occupied by the Susitna River. Numerous streams and rivers drain into the river along its course. The channel slopes are very steep near Devil Canyon, rising approximately 900 feet (274 meters) vertically in about 0.5 mile (0.8 km) horizontal distance. The benches above the river channel are approximately 2,000-2,500 feet (610-762 meters) in elevation and make up a majority of the study area. At the eastern end of the study area, north of the confluence of the Tyone River, the river channel is relatively less steep and much wider.

Various plant communities are found in the study area. McKendrick et al. (1982) mapped 16 vegetation types in the middle and upper Susitna River basins at levels III or IV of the classification system developed by Viereck and Dyrness (1980). The plant communities are strongly influenced by site topography, soils, and moisture regimes. The steep, well-drained river channel slopes are dominated by forest communities such as the mixed paper birch (*Betula papyrifera*)-spruce (*Picea*) forest and open coniferous forests on both sides of the river. The benches above the river contain primarily shrub communities dominated by resin birch (*Betula glandulosa*) on the drier sites, with white spruce (*Picea glauca*) forests on well-drained slopes, and black spruce (*Picea mariana*) forests on the wetter sites. Willows (*Salix*), primarily diamondleaf willow (*Salix planifolia* ssp. *pulchra*), grayleaf willow (*Salix glauca*), Richardson willow (*Salix lanata*), and feltleaf willow (*Salix alaxensis*), dominate the shrub communities in wetter sites on upland slopes and in coniferous forests. Alpine vegetation types occur at the highest elevations.

4 STUDIES

4.1 BROWSE INVENTORY

4.1.1 Introduction

A decision was made in early 1984 to adapt the moose carrying capacity model under development at the Kenai Moose Research Center to assess impacts of the Susitna Hydroelectric Project on moose. In anticipation of this decision, the Alaska Power Authority had conducted a number of preliminary habitat-oriented studies designed to establish baseline information on moose habitat types in the Susitna basin and to determine the most viable approach to impact assessment. Vegetation maps of the Susitna drainage basin upstream of Gold Creek were first prepared during 1980 and 1981 in anticipation of the project license application submitted in February 1982. During spring and summer 1982, a plant phenology study designed to determine the importance to moose of availability of early spring forage in the impoundments was conducted. A preliminary browse study was also conducted at that time to make a first determination of the vegetation types and browse species most heavily utilized by moose within the areas to be affected by the project. During both of these field studies, different methods of sampling vegetation were used as determined by the study objectives.

A plant phenology study was conducted during early spring 1983 to further identify differential development of vegetation in the impoundment zones. Fecal samples to be used for moose food habits were also collected during this phenology study. To ascertain the most statistically defendable and cost-effective field method of sampling biomass of browse species, a pilot study investigating various methods of sampling vegetation was implemented in summer 1983. During early 1984, vegetation mapping in support of the upcoming browse inventory and other needs was undertaken in response to the availability of new aerial photography not previously available and the need for finer detailed maps. The Alaska Power Authority also provided support to studies for field validation of the carrying capacity model at the Kenai Moose Research Center.

The browse inventory study is a carefully designed program involving a number of professionals of various interacting diciplines. All of the preceding studies have contributed to the design and implementation of the browse inventory study. The concept of assessing impacts through a nutritional-based carring capacity model is unique in application and design, and represents the state-of-the-art in impact assessment for moose in Alaska.

4.1.2 Acknowledgements

The list of people that have either contributed to the implementation of or participated in the browse inventory study during 1984 and 1985 are not few. All have been integral parts of the study, for without the assistance and guidance of these we would not have reached our goal of being ready for the final summer of data collection. Certain people have been instrumental in the development of the study and in overseeing its operation. We would like to especially thank Dr. Wayne Regelin of ADF&G for his guidance in the initial planning stages and for his assistance in implementing the ADF&G intern program. SuzAnne Miller of ADF&G has been of invaluable aid for biometrical counciling, computer programming expertise, program guidance, and trouble-shooting. Randy Fairbanks of Harza-Ebasco Susitna Joint Venture, Dr. Robin Sener of LGL Alaska Research Associates Inc., and Dr. Karl Schneider of ADF&G have been responsible for funding and overall guidance, and for perceiving the long-term benefits of impact assessment through carrying capacity modelling. Warren Ballard of ADF&G assisted in defining the perimeter boundary of the study area.

Field technical assistance was acheived through the efforts of: ADF&G interns Dan Ashby, Becky Barkuloo, Jim Chumbley, Michele Hertzic, Nic Larter, Tim McKinley, Lori Restad, Janice Wiegers, and Ellen Wood; ADF&G employees Nancy Tankersley and Tammy Otto; and volunteers Peggy Wood and Carol Burns. Danny Anctil of ADF&G provided computer programming and digitizing support, and Larry Aumiller assisted with digitizing transect lines. Deborah Heebner and Ray Koleser of R.A. Kreig and Associates provided assistance with transfer of transects from maps to aerial photography and with training of field personnel.

Granville Couey and Vincent Volpe of Harza-Ebasco Susitna Joint Venture, Roy Goodman of KNIK-ATNU, Inc., and Robert "Freddy" Friedrich, Merle Handley, Bill "Murph" Murphy, and Hal Sipes of Air Logistics of Alaska are thanked for their logistical support during the course of the 1984 field season.

4.1.3 Study Area

The study area for the browse inventory was divided into three sampling populations (Figure 1). Three sampling populations were defined so that varying sampling intensities could be allocated to the populations based on their perceived importance and expected level of impact on moose. The outer perimeter of the study area for sampling Population "A" was based upon all point locations of radio-collared moose that were captured in or known to have used areas within the borders of the impoundments and other project facilities (Figure 1). This area was defined by Ballard et al. (1983), who called it the "primary zone of impact" for moose. It was selected as the outer boundary because it represented the area in which moose which were known to use the impoundment zoones would be constrained following filling of the reservoirs. Areas above 3,400 feet in elevation were excluded from Population A. Sampling Population "B" was defined by the 2,200 foot contour interval for the Watana impoundment, beginning at the dam site and extending upstream to just upriver of the Oshetna River confluence (Figure 1). The boundary for Population B was extended beyond the 2,200 foot contour interval wherever necessary to maintain a minimum width of 0.5 miles. Sampling Population "D" was defined by the 1,500 foot contour interval for the Devil Canyon impoundment, beginning at the dam site and extending upstream to the Watana dam site (Figure 1). The boundary for Population D was also extended beyond the 1,500 foot contour interval wherever necessary to maintain a minimum width of 0.5 miles. Total area for the three sampling populations was approximately 1,400 square miles.

4.1.4 Methods

4.1.4.1 Field Methods

A two-stage sampling design that incorporated the stratification of willow forage biomass and non-mutually exclusive primary sampling units (transects) was used. During the first phase of the 1984 summer sampling effort, a subset of transects was randomly selected from five 1:60,000 scale photographs for which advance vegetation mapping had been made available. The photographs each covered approximately 49 square miles. The five color infrared (CIR) photographs were distributed along the Susitna River over the east-west length of the entire study area to capture the variability in the major biomass classifications along elevational gradients of the Susitna canyon. Seven transects were randomly located on four photographs and eight transects on one photograph. These initial transects were oriented on a north-south axis to capture the greatest amount of variability in moose forage biomass over their one-mile length. These 36 transects were the first to be completed, and were designed to provide the data base for stratification of forage biomass over the study area. Vegetation mapping at 1:24,000 scale was also prepared immediately around each of the 36 transects for comparison of levels of variability captured by the two scales of mapping. Data from the first 36 transects was not differentiated into the three sampling populations (Figure 1).

An additional 72 transects were randomly located throughout the study area during the second phase of the 1984 summer sampling effort. A random compass heading was assigned to these transects. During the first summer, the number of transects assigned to each sampling population was based primarily upon relative areal size of the three areas and perceived complexity of the vegetation patterns. Fifteen 0.5-mile transects were located in Population B (Watana), eight 0.5-mile transects in Population D (Devil Canyon), and 49 one-mile transects in Population A (surrounding area). One-half mile transects were used in Populations B and D in order to sample transects in those areas more intensely, and to reduce the probability of transects crossing the river. Conducting transects which crossed the river were minimized because they decreased productivity of field effort and increased helicopter logistic costs. Portions of transects in Population A that extended above the 3,400 foot elevation contour were terminated at that elevation. Transects crossing a population boundary into another population or beyond the outer population boundary were terminated at the boundary line. Transects at boundary edges were terminated rather than completed to provide equal sampling intensity to all portions of a sampling population. In total, 108 transects were completed during summer 1984 (Figure 3).

A group of transects were first randomly located and drawn on a 1:63,360 scale USGS topography map of the study area. Transects were then transferred to both 1:60,000 scale CIR and 1:24,000 scale true color photographs (when available) for use by the field crews. Accurate transfer of transects to the aerial photographs was facilitated through use of a Map-O-Graph. Crews used 1:24,000 scale photography for actually locating transect start points when it was available; the smaller 1:60,000 scale photography was used when the area was not covered by the larger scale photography. Transects were not necessarily completed in order of their selection, but each group of selected transects was completed before a subsequent group of transects was undertaken.

Field work began on July 9, 1984 with training of the field crews. Ten technicians were organized into five crews of two persons per crew. During the first three days in the field, each crew member was trained in the following skills that were required before the actual field program could begin: recognition of Viereck et al. (1982) level IV vegetation classifications; recognition of forage cover classifications; identification of willows and other vegetation species; helicopter safety; location of transect start point from a helicopter using aerial photographs; use of map, aerial photograph, and compass for orienteering to transect start point; proper placement of plots along the transects; plot frame set-up techniques; recognition of current annual growth on the shrub species of interest; clipping techniques at the plot level; leaf

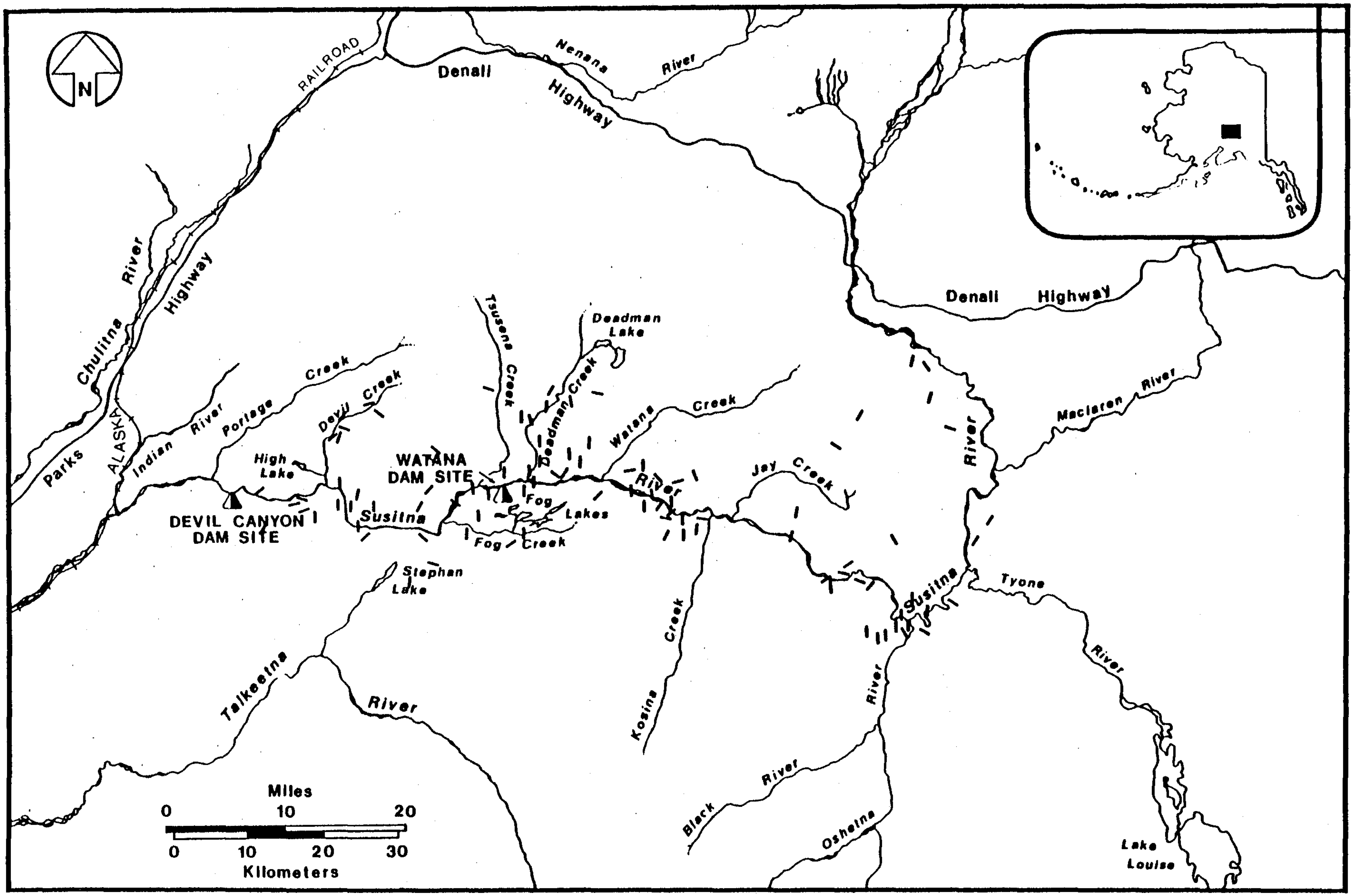

Figure 3. Transect locations for summer 1984 browse inventory study.

removal from clipped twigs; bag labelling and techniques to check for missing bags; orientation to the Epson field computer and proper response to prompting of the computer program; use of altimeter for measuring elevation; use of inclinometer for measuring slope; and recognition of local physical site characteristics. Commencement of actual transects began immediately following field training.

Plots were randomly located along each line transect. Plots were first selected at random without replacement from the available plots for each transect length (1,609 meters for the one-mile transect and 805 meters for the 0.5-mile transect), and then re-ordered to facilitate ease of sampling along the line transect. The number of plots per transect varied from 20 to 30 as we attempted to balance it against the maximum number of plots that could, on the average, be completed in a single day by a two-person crew. The number of plots per transect stabilized at 22 after one or two weeks of field effort, and remained there throughout the sampling period.

Each field crew normally completed one transect per day. All assigned plots were completed on each transect. Crews that finished early with their assigned transect often were able to assist another crew to finish their transect, or returned to assist in the laboratory. In the event that a transect was not completed on the day it was assigned, the same crew went back the following morning to complete it and then usually went on to complete another transect in that same day. Crews were given the option of beginning the line transect at either end. This was done to optimize their ability to accurately locate the start point using more prominant land marks, and to make use of nearby helicopter landing sites. When the helicopter could not be landed right at the start point, it would be landed at the nearest landing site that was identifiable on the aerial photograph. If the start point was visible from the landing site, crews would walk directly to the start point. If the start point was not visible from the landing site, a compass heading (to the nearest degree) toward the start point would be determined, and the distance needed to travel would be measured (to the nearest millimeter) from the aerial photograph using a caliper. The measurement was then converted to ground distance (meters) using the corrected scale of the photograph, and the distance then measured off on the ground using a 100-meter fiberglass retractable tape measure. Stereo photographs or an 8-power magnifying eye lens were used to verify the exact location of the start point.

Once the transect start point was found, the crew would orient themselves along the random compass heading they were to follow for that particular transect. The distance between plots (meters) was pre-determined prior to entering the field. All distances were measured along transects using a 100-meter tape measure. When moving between plots, one crew member advanced ahead pulling the trailing tape measure and following the compass heading while the other crew member remained behind to hold the tape at the desired stopping distance. It was also the responsibility of the person remaining behind to sight along the path of the advancing person to help direct a straight-line path to the next plot. These precautions were taken to minimize subconcious observer bias in the location of plots along the transect. If the average straight-line slope between succesive plots exceeded 15 degrees, the distance travelled between those plots was corrected to the nearest meter. This was done to adjust ground distance so it matched planar distance on the two-dimensional aerial photographs. Flagging was prominantly displayed at each plot to facilitate relocation of the transect from the aircraft to check its straightness and to confirm its actual location on the aerial photograph. Discrepancies between field transect locations and map locations were documented to assure accurate post-stratification.

At each plot, the following information was recorded: transect number; plot number; date; crew identification code; distance measured from last plot; corrected distance if average slope was greater than 15 degrees; elevation (feet); aspect (degree azimuth); slope (degrees); local topography within 100-foot radius of the plot (convex, simple slope, concave, or complex); surface drainage or runoff within 100-foot radius of the plot (fast, intermediate, or ponded); site moisture within 100-foot radius of the plot (very dry, dry, moist, or wet); landscape setting within 0.5-mile radius of the plot [flat, undulating flats, or hills or mountains (if hills or mountains, then whether the landscape setting was on valley floor, lower one-third of slope, mid-slope, upper one-third of slope, or ridge crest)]; Viereck et al. (1982) level IV vegetation classification (see Appendix A for the classifications and codes used); and percent canopy cover each for willows, resin birch, and alder (Alnus) (0 = 0-4 percent, 1 = 5-25 percent, 2 = 26-50 percent, 3 = 51-75 percent, and 4 = 76-100 percent cover).

A 1 x 1 meter square plot was positioned with the left side (when facing foreward) exactly parallel to the line of travel, and the left, rear corner (when facing foreward) placed at the end point of the measurement from the preceeding plot. The plot frame was elevated 50 cm from the ground level by metal stakes at each of the four corners to permit clipping of shrubs by height categories. The plot was oriented parallel to the ground surface. For five erect low shrub species (diamondleaf willow, grayleaf willow, Richardson willow, feltleaf willow, and paper birch) and one shrub genera (other willow species), the current annual growth twigs were clipped and placed in paper bags by height categories. Height strata will be used to adjust the amount of winter forage that is available at various snow depths. The two height categories used were 0-50 cm and 50-250 cm. However, the 250 cm maximum height was not observed if the diameter-at-breast-height (dbh) of the shrub stem was less than 2.5 cm. All current annual growth twigs were clipped within the boundaries of the plot extending upward in a vertical plane and originating perpendicular to the ground surface. A 20 x 50 cm subplot was positioned at ground level within the larger one-meter square plot in the left, rear corner (when facing foreward). The long axis of the subplot was placed parallel to the line of travel. All mountain cranberry (Vaccinium vitis-idaea) leaves and twigs occurring within the vertical borders of the subplot as defined above were clipped and bagged.

All field data was recorded on Epson HX-20 notebook computers which were programmed to prompt crew members for data input at each plot. The Epson computers were enclosed in plastic bags and encased in aluminum pistol cases for protection from the physical elements while in the field. Each Epson was programmed to accept data for two transects before it required downloading of the data. Data was down loaded directly from the Epson to an IBM PC-XT computer located at the field base camp (Watana Camp) at the end of each day. Field work ended on August 22, 1984.

4.1.4.2 Laboratory Methods

Collected plant material was brought to the field laboratory each evening. Bags of samples brought into the laboratory were checked against a list of the bags that should have been present as determined by data entered into the field computers. Bags were placed in drying ovens and dried at 100 C for at least 72 hours prior to processing. Leaves and foreign material were separated from the twigs, and the twigs then replaced in the original paper bags and put back into the drying ovens while they awaited weighing. Dried twigs were weighed to the nearest one hundredth gram on a Mettler PC4400 electronic balance. Laboratory weight data was recorded on an Epson computer. Laboratory data was downloaded directly from the Epson to an IBM PC-XT computer.

In an effort to reduce the manpower effort required to process the clipped plant material in the laboratory--specifically, to reduce the time required to separate diamondleaf willow leaves from the twigs--leaf material was retained for all plant species except mountain cranberry during a 2-3 week period in August. Dried leaves were weighed to the nearest one hundredth gram during this time for comparison with the weight of their associated twigs to determine if a valid weight relationship could be found.

4.1.4.3 Data Management and Analysis

Collected data was processed several ways while still in the field in an effort to maintain a high level of quality control. First, print-outs of the actual field data as recorded by the Epson computers, including any necessary corrections, were turned in by field crews at the end of each day. Data transferred to the IBM computer from the Epson was formatted to remove extra blanks and then edited using the print-outs provided by the crews. The edited data was then processed through a program that checked individual entries against a master list of acceptable entries. This program was useful to spot obvious errors in the data in a timely manner so crews could identify the source of the error and replace it with the proper input. At regular intervals (e.g., weekly), field data and laboratory data were merged. Another program was then used to compare field data with weight data from the laboratory. When errors were discovered, all effort was immediately made to determine the source and to rectify it. Errors originated in the laboratory during processing of the plant samples and entry of data while weighing.

After returning from the field, acetate overlays from preliminary vegetation mapping on aerial photography were obtained and the transect lines physically transferred to the overlays. Distance from the transect start point to the first intersection with a vegetation polygon boundary was then measured using a Data General MV4000 digitizer, as were the distances between subsequent polygon boundary intersections and between the last intersection and the end of the transect. Using the calculated distances between polygon intersections along the transect, and the known distances between plots along a transect, individual plots could then be assigned the appropriate vegetation type-forage cover classification as delineated on the vegetation map. This provided the means for post-stratification of individual plots rather than entire transects.

The digitized data was compiled and merged with the field data to relace the information on Viereck et al. (1982) level IV vegetation type and forage cover classifications recorded by field crews. Plots occurring at the border of polygon intersections (within 50 meters) were checked against calls made by the crews to prevent improper classification because sources of error were introduced in the transect transfer and digitizing process. Given the scale to which a plot location can be found in the field and the accuracy of digitizing a transect line, the accuracy of the plot location is roughly plus or minus 50 meters. As a result, some of the plots had to be reclassified. At this point, the biomass data collected from the first summer's work was used to begin developing the stratification scheme that would be used for other similar classifications in the study area.

4.1.5 Preliminary Results

A hierarchical approach was taken in stratifying available forage for moose in the study area. Initially, each vegetation type-forage cover call made in a vegetation polygon and each distinct complex of multiple vegetation type-forage cover calls made in a polygon was treated as a separate biomass stratum. For stratification purposes, all species of willows were combined into a single willow category. In addition, height categories were also combined for willows and paper birch. Point estimates and variances of current annual growth of willow, paper birch, and mountain cranberry in each of the populations was calculated using two-stage sampling with replacement estimators coupled with ratio estimation theory.

Strata were then visually inspected to note the number of transects associated with each stratum, the inherent variation of the willow biomass component of the forage cover call supplied by the field crews, and the variance of willow biomass for each stratum. Relationships between willow biomass and other recorded site factors such as elevation, slope, and aspect were also investigated to determine if strata should be further subdivided based on these criteria. The willow component of the forage cover call was inadequate to determine its proper strata in some polygons. In these cases, the resin birch and alder portions of the forage cover call were used, as well as site information on elevation, slope, and aspect.

Cluster analysis was conducted on the total willow biomass of the data set to obtain the boundaries of the willow strata. A k-means cluster analysis was run on a CDC Cyber 700 computer using BMDP (Dixon 1981). A centroid linkage algorithm with Euclidean distances was used on the average willow biomass in strata, variances of willow biomass in strata, and coefficients of variation of willow biomass in strata analyses. Results of clustering were further examined to determine the stratification scheme for the study area.

The k-means cluster analysis using the average willow biomass in grams per square meter resulted in a willow strata classification scheme based on the vegetation type-forage cover classification from map polygons (Table 1). Cluster analysis of the variance and coefficients of variation by vegetation type-forage cover classification were unsuccessful, since the resultant stratification schemes were difficult to apply to vegetation type-forage cover classifications for which no data was available. It was more difficult, by several orders of magnitude, to attempt to classify the variance and mean willow biomass characteristics of a vegetation type-forage cover classification in a polygon that was not sampled (no available biomass information) than to classify the mean willow biomass of a polygon for which biomass information was available.

Table 1. Stratification classifications for average willow biomass per square meter plot.

Strata Classification	Range of Average Willow Biomass (gm/m^2)
Zero	0 - 0.0015
Scarce	0.0015 - 0.75
Very Low	0.75 - 2.0
Low	2.0 - 4.0
Medium	4.0 - 6.25
Medium-High	6.25 - 9.5
High	9.5 - greater

Once the willow stratification was complete, a stratification scheme was developed for paper birch within each of the strata developed for willow biomass. The stratification process was repeated using paper birch with the provision that strata based on willow biomass could not be re-combined but rather only further subdivided. The stratification of the paper birch was primarily done from the vegetation maps, with the field data being used to verify the stratification scheme. The data suggested that the distribution of mountain cranberry was fairly ubiquitous throughout the study area; as a result it was not stratified.

The actual point estimator that was used is slightly biased and has a low mean square error (MSE) compared to the unbiased estimators (Cochran 1977). A simulation on a population of 14 transects using this estimator with a sample size of two had a bias of -0.065022 for an estimate of the population mean. When the unbiased estimator was used, it had a bias of 1.580357. Thus, the bias of this point estimator was so small as to be insignificant; it was therefore ignored.

A visual inspecion of the data collected for comparison of twig and leaf weights revealed that there was very little consistent correlation. There appears to be no good means, then, to predict twig weight biomass from twig and leaf weight totals. Leaves must continue to be removed from twigs to obtain twig weight biomass.

4.1.6 Discussion

Although the preliminary stratification scheme has been completed and has been applied to the digitized Talkeetna Mountains D-4 quadrangle (see Appendix B), there still remains the task of testing the stratification scheme against the entire study area. At the time of this writing, the 12 individual quadrangles that compose the entire study area are being pieced together into a single large digitized map. When completed in early June 1985, any necessary final adjustments will be made to the stratification scheme prior to entering the field in July 1985. Questionable polygons (those where calls made on the vegetation maps and calls made by the field crews differ widely) will be investigated during June 1985 to eliminate known possible sources of error in the stratification. Preliminary biomass estimates prepared from the stratification of moose forage in the three sampling populations will be used to allocate selection of approximately one-fourth of the transects anticipated to be completed during the July and August 1985 field season. Transects will be randomly selected from vegetation polygons that compose the various biomass strata within the three populations. Selection of transects is actually weighted in favor of larger polygons because polygons with larger areas have a greater probability of having points selected from within their boundaries. Selection of polygons to be sampled will be accomplished with the aid of the digitized map. Points selected by the digitizer will become the midpoints of one-half mile transects that are oriented on random compass angles. Transect lines will be transferred to aerial photography, which will be used by the field crews to locate the transects on the ground. Plots along a transect that occur beyond the boundaries of the target polygon will be sampled. If the adjacent polygon is not of the same strata type, those plots will contribute to the strata type of the specific polygon in which they occurred.

Though the study area is large, a substantial proportion of the same vegetation types found in the area outside of the impoundment populations are also represented in the impoundments. Therefore, the same stratification scheme will probably be used for all three populations though the sampling intensity will be greatest within the impoundment populations.

A fairly large proportion of the data points collected during summer 1984 were utilized to develop the stratification scheme. This is to be expected, as the complexity of the vegetation and the size of the study area strains our ability to accurately estimate the true availability of winter forage biomass. There is no doubt, however, that the sampling scheme developed for this study is statistically solid and legally defendable, and will produce the best estimates that are possible with the resources that are available.

4.1.7 Summer 1985 Field Season

During July and August 1985 the second of two field seasons will be conducted. New sampling techniques will be implemented as field effort is optimized through the use of optimal allocation procedures. Transects will be allocated to the three sampling populations based in part upon the need to derive more accurate estimates of biomass in the Watana and Devil Canyon impoundments than in the surrounding area, the areal size of the respective sampling populations, and the number of different polygons in each population that contain unquantified levels of forage biomass. The impoundment populations will receive the highest priority in allocation of the sampling effort. Though the sampling intensity will vary among populations, it is anticipated that the same biomass strata will be used for all sampling populations. One-half mile transects with approximately 11 plots per transect will be used during the second field season. Each field crew will conduct two transects per day.

Small inclusions of riparian willows growing in stream bottoms and along the riverbank of the Susitna River and river islands within the impoundments are too small to be mapped either at the 1:60,000 scale of the vegetation maps or at the 1:24,000 scale of other available photography. It is very likely that the availability of this forage resource for wintering moose would not be accounted for by the ongoing sampling effort because sampling is based entirely upon the 1:60,000 scale vegetation maps. Because it is important not to overlook this small but obviously heavily utilized resource, a special effort will be made during the second field season to sample these areas. Because these types do not appear on any of the vegetation maps, they will be individually mapped with the aid of 1:24,000 scale photography. To accomplish this, the river corridor and major stream channels will be aerially surveyed. Inclusions will be mapped by indicating on aerial photographs the beginning and ending points of stands along the riparian stream or river channel and recording the approximate width of each stand. The mapping will provide the basis for calculating approximate acreage and for allocating sampling effort. A crew will then spend a proportion of the summer sampling riparian willows within the two impoundments.

4.2 MOOSE FOOD HABITS

4.2.1 Introduction

Several studies on moose and moose habitat in the middle Susitna River basin have implicated certain browse species as probable major components of winter diets. McKendrick et al. (1982) reported that willows were observed to be the most heavily browsed species in all vegetation stands sampled. Resin birch shrub communities were noted to have received moderate use, while only certain individuals of American green alder (Alnus crispa) appeared to be heavily browsed (McKendrick et al. 1982). Ballard et al. (1982) suggested that distribution of willow strongly influenced seasonal distribution of moose, and that willow distribution was useful in determining the importance of habitats to the moose population. Steigers et al. (1983) reported utilization by moose of twigs in 9 vegetation types of the middle Susitna River basin classified to level IV of the Viereck et al. (1982) classification scheme. In that study, average utilization in the 9 vegetation types ranged from 4% to 26% for willows, 0% to 30% for resin birch, and 0% to 33% for sitka alder (Alnus sinuata). Steigers et al. (1983) based their calculations of utilization on the ratio of browsed to the total of browsed and unbrowsed twigs. However, their count of unbrowsed twigs included current annual growth because the study was conducted during July and August. This resulted in conservative estimates of percent utilization, particularly for the willows which exhibit growth of adventitious new leaders as a result of winter browsing of terminal shoots. These studies have supported the apparent importance of certain browse species in moose winter diets, but did not provide the relative proportions of each species consumed. In addition, they did not provide information on the relative importance of non-browse foods, such as forbs, graminoids, and lichens, in winter diets. The objective of this study was to provide quantification and the relative importance of forage species in the winter diets of moose in the middle Susitna River basin. Results from this study will be used as inputs to the carrying capacity simulation model described earlier.

4.2.2 Acknowledgements

Appreciation for assistance in collecting pellet samples is expressed to Dr. Dot Helm, Patrick V. Mayer, and particularly James G. MacCracken of the University of Alaska Agricultural and Forestry Experiment Station, Palmer. Dr. Charles L. Elliott conducted the laboratory analysis of the fecal samples using the microhistological technique. Randy Fairbanks of Harza-Ebasco Susitna Joint Venture and Dr. Robin Sener of LGL Alaska Research Associates, Inc. reviewed drafts of this report. Wayne L. Regelin of ADF&G provided valuable direction and council to this study and also reviewed drafts of this report.

4.2.3 Study Area

The study area borders the Susitna River for approximately 76 miles (122 km) from Devil Creek on the west to the Oshetna River on the east (Figure 4).

Transects began on the benches at elevations above the proposed Devil Canyon and Watana dam impoundment zones and extended downslope to the Susitna River, or major creek-bottom. Four transects were located at each of seven areas, and two transects located at each of two areas. Two transects were located on each side of the Susitna River valley near the Devil Creek, Watana Mouth, Cassie Creek, Kosina Creek, and the Oshetna River areas (Figure 4). Two transects were also located on each side of Watana Creek in the area designated Watana Slide, which terminated on Watana Creek. Two transects were positioned on the north side of the Susitna River at Tsusena Creek, and on the south side at Clarence Creek. Two transects were located on each side of Fog Creek (Figure 4). The Devil Creek and Tsusena Creek areas are referred to as downstream areas while the other seven areas are referred to as upstream areas.

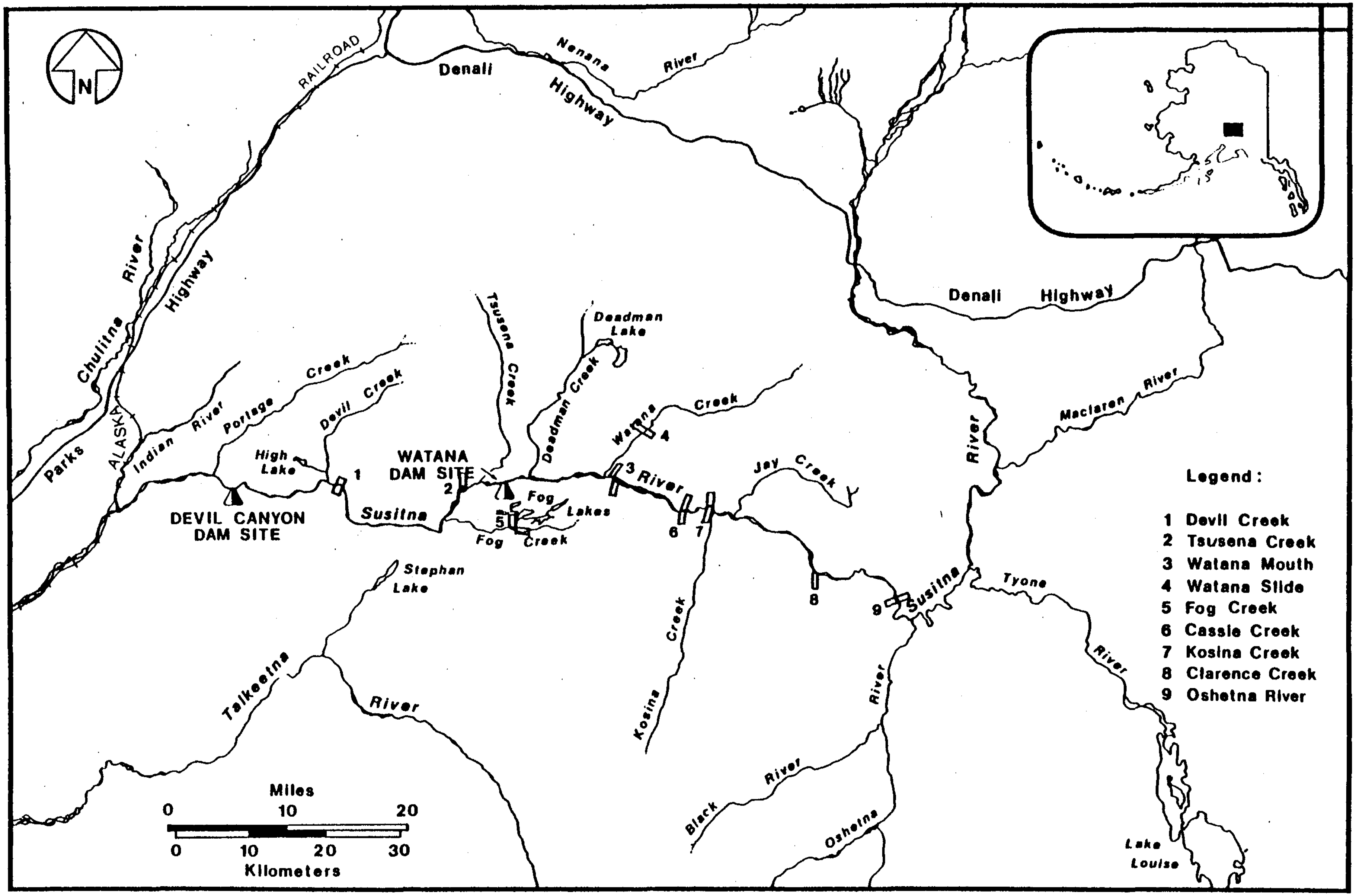

Figure 4. Transect locations for collection of winter moose fecal pellets for the moose food habits study.

4.2.4 Methods and Materials

Winter fecal samples of moose were collected along 32 line transects during early spring (late April through early May) 1983, concurrent with a plant phenology study (Helm and Mayer 1984). The 32 transects ranged in length from 1.5 to 2 km.

Fecal pellets were collected opportunistically from atop melting snow along the transects. Four representative pellets, taken together as a sample to represent the dietary variation in the defecation, were selected from each pellet group. Efforts were taken to ensure that the fecal samples collected were reliably deposited during the winter months.

The four pellets from each pellet group were composited by transect, and the samples from each transect were composited by area. Because pellets were collected opportunistically, total sample size in the composite varied among the nine areas. Fecal samples were forced-air oven-dried at 60 C for 48 hours, then ground once through a Wiley mill using a 1 mm screen (Holechek and Gross 1982). For each area, subsamples were taken equal to one-half (one extra if a fraction) of the total number of samples in each composite. Three slides were prepared from each subsample. Three slides per subsample were considered to provide adequate sampling intensity for major species in the diet, but not an adequate sampling intensity for rare species.

Microhistological examination of moose fecal samples was used to estimate moose food habits (Sparks and Malecheck 1968, Free et al. 1970, Dearden et al. 1975). This procedure has many advantages as discussed by Holechek et al. (1982). Twenty valid microscope fields were read at 125x on each slide using the microhistological technique (Holecheck and Gross 1982). A valid field had to contain at least two discernible plant

plant fragments. A discernible plant fragment has been defined by Johnson et al. (1983) as a fragment "having at least two distinct anatomical characteristics, such as silica bodies, trichomes, or stomates". Data was recorded as frequency of occurrence of discernible plant fragments in a field in relation to the total number of fields read. This has been called the "percent frequency" method by Holecheck and Gross (1982), and was statistically evaluated in their study. Only the frequency of occurrence of discernible plant fragments in a microscope field were recorded. Discernible plant fragments included both known and unknown species. Ubiquitous fragments of plants such as xylem, phloem, and protoxylem were not recorded.

Based on prior studies and observation conducted in the study area (Ballard et al. 1982, McKendrick et al. 1982, Steigers et al. 1983, Steigers and Helm 1984, Helm and Mayer 1984), certain plant species were initially identified as probable important components of winter moose diets in the study area: diamondleaf willow, grayleaf willow, Richardson willow, feltleaf willow, resin birch, sitka alder, paper birch, quaking aspen (Populus tremuloides), and mountain cranberry. All plants were identified to species when technically possible. Forbs and graminoids were identified and compiled as unknowns within life form categories. Efforts were made to identify to genera and species all unknown plant fragments that made up a substantial proportion of the diet within each sample area.

Viereck and Little (1972) was used as the vernacular authority for scientific and common names of plant species.

4.2.5 Preliminary Results

A total of 199 fecal samples were collected from the nine areas. Twenty-six samples were collected from Devil Creek, nine from Tsusena Creek, 31 from Fog Creek, 33 from Watana Mouth, 14 from Watana Slide, 14 from Cassie Creek, 23 from Kosina Creek, 11 from Clarence Creek, and 38 from Oshetna River areas. A total of 102 subsamples were prepared from fecal samples in the nine areas.

Identification of individual species of Salix using the microhistological technique proved to be an insurmountable task. The epidermal trichomes used to distinguish willows from other genera were not consistently characteristic enough to distinguish among the different species of willows. We were, however, able to distinguish between resin birch and paper birch based on epidermal cell size, shape, and pattern.

Willow was the dominant component of winter diets of moose for all sampled areas in the middle Susitna River basin (Table 2). Based on percent dry weight composition of fragments identified in the diet, willow ranged from a high of 66 percent of the diet at the Watana Slide area to a low of 25 percent at the Tsusena Creek area. Within the seven areas in the upriver reach (Watana Mouth to Oshetna River areas), willow comprised 59 percent of the diet. The transects in the upriver reach generally traversed a greater proportion of upland benches and coniferous forests where density of willow was probably higher than in the deciduous forests common to the lower reach (Devil Creek to Tsusena Creek) (Steigers et al. 1983, Helm and Mayer 1984). Composition of willow in the diet was lowest in the downriver stretch, where it comprised 31 percent in the two areas.

Composition of resin birch in the diet was 10 percent for all areas, ranging from 2 percent at the Tsusena Creek area to 15 percent at the

Table 2. Winter food habits of moose based on percent dry weight[1] composition of the diet for nine areas in the middle Susitna River basin, Alaska.

Dietary Component	Devil Creek	Tsusena Creek	Watana Mouth	Watana Slide	Fog Creek	Cassie Creek	Kosina Creek	Clarence Creek	Oshetna River	All Areas
Willow	32	25	51	66	56	61	57	63	64	54
Resin Birch	10	2	13	7	8	7	9	8	15	10
Paper Birch			4							<1
Mountain Cranberry	26	40	1	<1	2	10	14	<1	<1	8
Quaking Aspen			4						1	1
Alder									<1	<1
Lichen		1		<1						<1
Moss	15	14	20	19	23	17	12	20	15	18
Unidentified Graminoid	12	13	2	2	4	<1	4	4	1	4
Unidentified Forb & Shrub	2	1	2	2	3	2	1	2	2	2

[1] Due to rounding error, the dry weight may not total 100%.

Oshetna River area (Table 2). Excluding the Tsusena Creek area which was very low, resin birch composed a fairly consistent but relatively low percentage of the diets of moose over the study area.

Composition of mountain cranberry in moose diets was greatest in the downstream reach of the Susitna River (Table 2). Forty percent of the diet was mountain cranberry at the Tsusena Creek area, and the diet contained 26 percent mountain cranberry at the Devil Creek area. Percent composition in the diet was low for all other areas except Cassie Creek and Kosina Creek, which had 10 percent and 14 percent, respectively. The increased component of mountain cranberry in the diets at the two downriver areas seemed to be fairly closely tied to the decreased component of willow for those same areas.

Similarly, percent composition of unidentified graminoids was also greater at the downriver areas than upriver (Table 2). Presumably, moose are foraging more at the dwarf shrub and ground layer vegetation levels in the downriver stretch where the primary food source of willow is less abundant. Percent composition of graminoids was relatively low in the diets of all other areas (Table 2).

Moss was a fairly major component of winter moose diets in all areas, totaling 18 percent for all areas and ranging from 12 percent to 23 percent of the diet. Moss is not highly digestible (Dearden et al. 1975), so it is probably not selectively consumed by moose. It is likely that moss is consumed in the process of eating dwarf shrubs such as mountain cranberry.

Paper birch was present only in the diet at the Watana Mouth area (Table 2). Quaking aspen, alder, lichens, and unidentified forbs and shrubs were minor components of the winter diets of moose throughout the study area (Table 2). Quaking aspen occurs relatively infrequently in the middle Susitna River basin. Snow cover persists throughout most of the winter, which would make lichens unavailable as winter forage. Alder is a relatively common species, but observations during previous studies (Steigers et al. 1983, Helm and Mayer 1984) have documented that moose tend to browse certain individual alder plants, especially those experiencing regrowth following previous browsing or those growing on a recently disturbed site, and avoid browsing alders growing in dense stands.

4.2.6 Discussion

The species of willows that are dominant components of the vegetation communities of the study area all contribute as a forage resource that combines to make up the bulk of the diet of wintering moose. Studies conducted by Steigers et al. (1983) documented that diamondleaf willow, grayleaf willow, Richardson willow, and feltleaf willow were the most common species, based on stem density counts, in most vegetation types; diamondleaf willow was generally considered to be the most common of the four species. Other species of *Salix* also grow in the study area, but they are confined to localized areas that generally make up a small proportion of the study area. Steigers et al. (1983) reported that the individual species of willows they sampled were browsed in approximate relative proportion to their stem density within the vegetation types they sampled. They found a slight preference for grayleaf willow over diamondleaf willow, but this was probably an artifact of their sample size, their use of current annual growth twigs, and unequal stem densities among the species being compared. Both Crête and Bédard (1975) and Nyström (1980) concluded that counts of browsed and unbrowsed twigs did not give accurate information on preference or utilization of browse species. Thus, comparison of the results of this food habits study with the utilization estimates obtained by Steigers et al. (1983) would not be beneficial.

Although pellets from moose were collected along a known transect, there is no definite means to determine exactly the area where the forage that was the source of the pellets was consumed. Additionally, the pellets were collected opportunistically along approximate one-mile transects that passed through numerous different vegetation types and elevational gradients. The pellets were collected from high above the river on shrub benchlands, down steep canyon slopes among spruce and paper birch forests, and finally along the edges of the river or stream floodplain. Other than collecting samples opportunistically along known transect lines, no other attempt was made to stratify the collection of pellets. Pellets from both north and south-facing exposures were also grouped together to facilitate their analysis by geographic area. Therefore, extrapolation of diets of each area to the types of nearby vegetation communities can only be done in generalities because of the heterogeneity inherent in each sample. Other than the fact that many of the transects were positioned to pass through known wintering areas of moose subpopulations, the pellets were grouped by geographic area primarily to represent possible variation in diets along the east-west linear length of the Susitna River. Basically, however, the results indicate very similar diets in the entire upriver stretch, with willow predominating.

The downriver stretch has fewer willows in the understory layer of the river canyon, and the diets reflect this difference from the upriver stretch. At least 24 of the 16 pellet samples were collected from the north side of the river at Devil Creek, and all nine of the samples at Tsusena Creek were from the north side of the river. At both areas, mixed forests of paper birch and spruce predominate as overstory cover. Willow is uncommon in the understory of these steep, forested canyon hillsides (Steigers et al. 1983), and this is born out in the low willow component of the diet.

Resin birch is a common shrub species in the middle basin. It is not considered a preferred forage species for moose, and is utilized only lightly in relation to its availability (Steigers et al. 1983). However, it appears that moose will consume resin birch up to approximately 15 percent of the diet. Murie (1944) reported that dwarf birch (Betula nana) was regularly browsed by moose in Mount McKinley National Park.

The frequency of occurance of mountain cranberry was suprisingly high in the diets of moose, particularly in the downstream reach in the Devil Creek and Tsusena Creek areas. As mentioned previously, willow was less abundant in these areas than in many other areas upstream. Apparently, moose are spending more effort locating and consuming mountain cranberry growing at the dwarf shrub layer. While tracking moose through snow near the mouth of Tsusena Creek, it was observed that mountain cranberry was exposed directly beneath the canopies of white spruce trees while between tree canapies the snow was approximately 30 inches deep. Tracks led from tree to tree as the moose were apparently feeding on the exposed mountain cranberry.

In the Cassie Creek area on the north side of the river, numerous craters in approximately 28 inches of snow were also observed on the hillside where moose had dug down to the ground level. Upon closer observation, it was obvious that mountain cranberry had been heavily browsed within the craters. Possibly a greater abundance of mountain cranberry grows in the adjacent Cassie Creek-Kosina Creek areas (Figure 4) or snow depths are generally less which would contribute to greater availability than in other upstream areas.

Paper birch as forage for moose occurs in the study area primarily as stump sprouts and suckers from mature trees, and to a lesser extent in disturbed areas such as streambanks and slides. Observations of only light browsing pressure on paper birch throughout the study area support the conclusion of low utilization found in this food habits study. However, it is unknown whether this is a result of fewer numbers of moose utilizing the steeper canyon slopes where paper birch grows, or the possibility that the paper birch forage available to moose is in some way less palatable than paper birch regrowth available in other areas of the state (e.g. the Kenai Peninsula). Viereck and Little (1972) described the variety of paper birch occurring in the study area (Alaska paper birch, *Betula papyrifera* var. *humilis*) as having many raised resinous dots on the twigs, whereas the Kenai birch (*Betula papyrifera* var. *kenaica*) has resin dots only on young twigs. These, or other, differences between the varieties of paper birch may affect their degree of utilization by moose as forage.

The prevalence of moss in all diets is not easily explained. It is presumably consumed in the process of eating mountain cranberry, but we would expect mountain cranberry and moss to appear in the diets in approximately relative proportions. They do not necessarily appear that way; the reverse almost seems to be true. The only explanation at this time might be that most if not all moose consume moss in the process of eating mountain cranberry. However, some areas may have a higher ratio of moss to mountain cranberry in which case moose would tend to eat more moss for a given amount of mountain cranberry eaten. Some moose may also be more efficient at finding and eating mountain cranberry and eating less moss than other moose. The former explanation may be more likely than the latter.

The diet analyses presented here have not been calibrated based upon differential digestibility of the different forage items. For example, both resin birch and moss are less digestible than either willow or mountain cranberry. In vitro dry matter disappearance (IVDMD) trials on various diet mixtures using the major plants found in moose diets, and the relationships between the IVDMD and accuracy of microhistological analysis of the residue, are in progress. The results of these studies will provide the means to calibrate the dietary analysis presented here. Calibration of proportions of the various plant species consumed will provide more accurate input to the carrying capacity model.

4.3 NUTRITIONAL QUALITY OF FORAGE

4.3.1 Introduction

The nutritional quality of the forage items specific to the diets of moose in the middle Susitna River basin was required as input to adapt the carrying capacity model to the study area. Both dietary nitrogen concentrations and digestibility of the diet are necessary components of nutritional quality. It was the objective of this study to collect plant samples and to conduct the necessary laboratory analyses to provide the values for input to the model.

4.3.2 Acknowledgements

Dr. Wayne Regelin from ADF&G assisted with defining the study objectives, planning the field sampling procedures, and conducted in vitro digestion trials. Mike McDonald, Tammy Otto, and Bob Castle of ADF&G assisted with the collection of plant samples. Bob Pollard of LGL Alaska Research Associates participated in the collection of plant samples and prepared samples for laboratory analysis. Larry Aumiller of ADF&G separated, cleaned, and dried plant samples in preparation for analysis. Mike Hubbert of ADF&G aided in conducting the in vitro digestion trials.

4.3.3 Study Area

The study area was the middle Susitna River basin (Figure 5). Sites for sampling were selected based on prior knowledge of the number and type of different plant species present, proximity to the Watana and Devil Canyon impoundments, and ease of access during the winter. Refer to Appendix C for detailed descriptions of sampling sites and the physical parameters found at each site.

4.3.4 Methods

Fifteen sites were visited during the first collection period of December 11-13, 1985 to collect samples of shrub species known to be eaten by wintering moose (Figure 5). Fourteen of those sites were re-visited during the second collection period of March 5-7, 1985 to again collect samples of the same species. Refer to Appendix C for the list of species collected from each site. At each site, current annual growth twigs of the shrub species present were clipped and bagged. Approximately 15 twigs from diamondleaf willow, grayleaf willow, and Richardson willow, 20 twigs from resin birch, 10 twigs from paper birch,

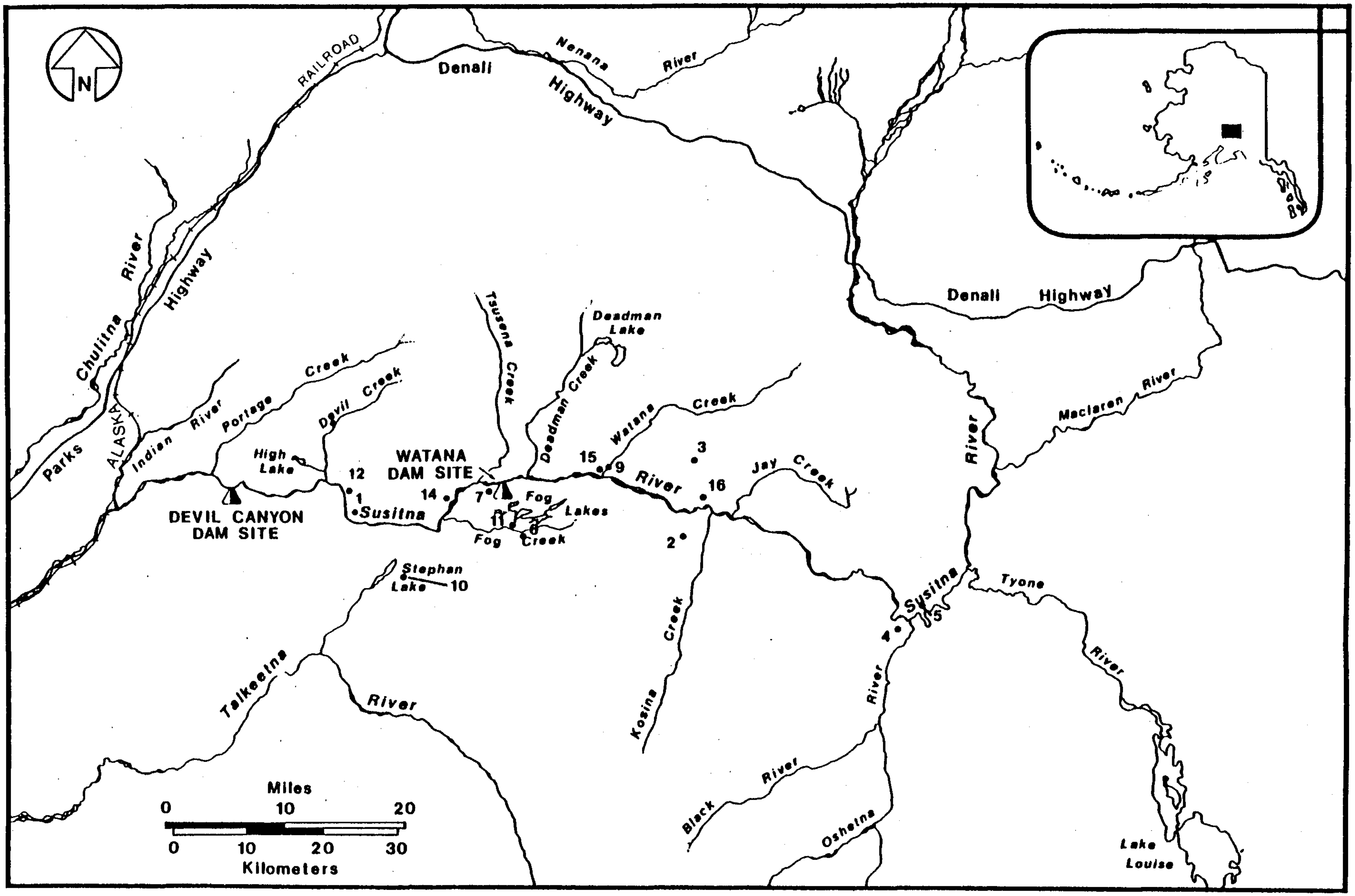

Figure 5. Sites where shrub samples were collected for nutritional quality of forage study.

and three twigs from feltleaf willow were collected from each shrub. One or more handfuls of entire mountain cranberry plants were collected from pits dug through the snow cover to ground level. During each collection period, approximately 50-100 grams wet weight of plant material was collected from each species present at each site. As many different individual plants as required to meet the minimum total weight goal were sampled at each site. Slope, aspect, elevation, vegetation classification, forage cover, ambient temperature, and average snow depth were also recorded at each site (Appendix C). Photographs were taken of the general site when possible.

Plant samples were kept frozen until immediately prior to processing. Samples were then removed from the freezer and oven-dried at 60 C for approximately 72 hours. After drying, leaves and other litter were removed from the twigs of all shrub species except mountain cranberry, which is an evergreen shrub and retains its leaves during winter. Equal proportions of each species were composited for all areas by sampling period. Samples were evaluated for in vitro dry matter disappearance (IVDMD) using moose rumen inoculum taken from a captive moose on the Kenai Moose Research Center. IVDMD trials were run in triplicate for each sample.

4.3.5 Preliminary Results

Results from the IVDMD trials for both sampling periods are shown in Table 3. Mountain cranberry had the highest levels of dry matter disappearance (or digestibility) of all the forages tested, averaging nearly 43 percent. Percent disappearance was approximately equal in the three most abundent willow species diamondleaf willow, grayleaf willow, and Richardson willow (Table 3). Feltleaf willow had the lowest dry

Table 3. In vitro dry matter disappearance for shrub species from the middle Susitna River basin.

Species	December 11-13					March 5-7				
	Rep.[a] 1	Rep.2	Rep.3	Mean	SD	Rep.1	Rep.2	Rep.3	Mean	SD
Diamondleaf willow	37.2	36.5	36.6	36.8	0.4	33.3	35.2	34.3	34.3	1.0
Grayleaf willow	32.5	35.2	37.1	34.9	2.3	35.3	35.1	34.8	35.1	0.3
Richardson willow	36.3	34.3	33.4	34.7	1.5	35.2	36.0	35.1	35.4	0.5
Feltleaf willow	29.2	27.1	30.2	28.8	1.6	25.3	26.8	27.5	26.5	1.1
Paper birch	26.5	22.2	--[b]	24.4	3.0	25.5	23.9	23.9	24.4	0.9
Resin birch	26.1	25.2	25.3	25.5	0.5	26.0	26.5	28.6	27.0	1.4
Mountain cranberry	43.1	42.7	42.0	42.6	0.6	--[c]	--	--	--	--

[a] Rep.= IVDMD replication.

[b] Missing sample.

[c] Not collected during March 5-7 sampling period.

matter disappearance of all willow species tested. Paper birch and resin birch were similar in percent disappearance, although paper birch actually had the lowest digestibility of all forage species tested. Average percent digestibility between the December and March sampling periods was significantly different ($P<0.01$) only for diamondleaf willow.

4.3.6 Discussion

Digestibilities of individual willow species reported here are similar to those reported in other studies. Oldemeyer (1974) reported in vitro digestion trials using moose rumen inoculum averaging 34.5 percent and 37.5 percent for samples of willow (Salix arbusculoides) collected during February and March, respectively, on the Kenai Peninsula. Digestibilities using moose inoculum of 34.7 percent were reported for Salix sp. collected during January on the Kenai Peninsula (Oldemeyer et al. 1977). Although the willow species are different, the digestibilities are similar to the values found for the Susitna basin. In separate digestion trials using rumen inoculum from a domestic cow, diamondleaf willow and feltleaf willow collected during September from the Susitna basin were 39.8 percent and 28.0 percent, respectively (Steigers, data files).

Digestibility values found in this study for paper birch (24.4 percent) are notably lower than those reported in other studies. LeResche and Davis (1973) found paper birch stems from the Kenai Peninsula were 36.9 percent digestible using rumen inoculum from a domestic cow. Oldemeyer et al. (1977) reported 33.8 percent digestibility using moose inoculum from samples of paper birch collected during January. Availability of paper birch growing in the middle Susitna River basin is confined primarily to stump sprouts, whereas on the Kenai Peninsula stem regrowth of paper birch shrubs following fire composed almost the entire forage source available to browsing moose (LeResche and Davis 1973). The location of the current annual growth twigs on the plant and whether the plant is an actively growing shrub or a mature tree may somehow affect their digestibility by moose.

Several other studies suggest that the digestibility of mountain cranberry is consistently high. LeResche and Davis (1973) reported 50.1 percent and Oldemeyer et al. (1977) found 41.8 percent digestibility of mountain cranberry on the Kenai Peninsula, where this plant is an important winter forage for moose. Mountain cranberry collected from the Kenai Peninsula during February and March was 36.0 percent and 37.4 percent digestible, respectively (Oldemeyer 1974). Mountain cranberry collected from the Devil Canyon area averaged 44.2 percent digestibility when domestic cow rumen fluid was used as an inoculum source (Steigers, data files). High digestibility of mountain cranberry is presumably the result of the presence of the evergreen leaves and very small twigs that make up the plant.

The reason the average digestibility of diamondleaf willow was significantly lower for the March sample than in the December sample is not clear. The data suggest, at least for diamondleaf willow, that digestibility decreases through the winter. However, there are several compounding factors that may mask the real reason why digestibility appears to be lower during March. Though the diamondleaf samples were collected from the same areas during both time periods, the same plants were not necessarily sampled. There was substantially more snow on the ground during March than during December, which limited the collection of plant parts to those exposed above deeper snow. Many plants were much more heavily browsed during March than during December, particularly the taller portions of stems exposed above the snow. Although we avoided the collection of twigs that had been previously browsed, often it cound not be avoided because browsed twigs composed the bulk of those available in a given area. The decrease in digestibility may be a real event primarily because of decreased digestibility of the plant parts collected rather than the decreased digestibility of the same plant parts over time. In either case, it probably represents a real-life situation to the foraging moose who must eat what is available or move to another area in order to survive the winter.

5 SUMMARY

The results of the studies presented in this report are all interconnected in some way to each other and to the end product of impact assessment and mitigation planning through use of the carrying capacity model. The studies have been carried out in parallel, but are to a large extent dependent upon inputs from each other. The food habits analysis defined the important food items in the diets of middle basin moose, which was needed before the plant species to be sampled for either the browse inventory or nutritional quality studies could be determined. Data from the summer 1984 browse inventory directed the selection of sites for sampling shrubs for the nutritional quality study. During the process of conducting the nutritional quality study, insight was gained relative to the effect of snow depths on availability of forage in areas sampled during the browse inventory the previous summer. These and other facts learned during the course of these studies will help in interpreting output from the carrying capacity model.

The results presented here are helpful to understanding the objective of determining carrying capacity for moose of the study area, but they are preliminary because the three studies have not yet been completed. Calibration analysis of the moose food habits results to account for differential digestion of the various food items have not been completed. Nitrogen and protein analysis have yet to be conducted for the nutritional quality study. The final, but very crucial, second of two planned summers of data collection for the browse inventory study has yet to be conducted. Completion of the final stages of data collection and analysis for all three studies by fall 1985 will bring to fruitation the results of the collective labor of many.

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APPENDIX A

Susitan Hydroelectric Project Vegetation Mapping
Source: R.A. Kreig & Associates, Inc.
Mapping Legend (Revision 2)
June 15, 1984

Mapping legend is based primarily on the 1982 Revision of Preliminary Classification for Vegetation of Alaska (Viereck et al. 1982). Modifications to the classification made as a result of the Alaska Vegetation Classification Workshop (Anchorage - February 21, 1984) are also incorporated. Level 4 categories recognized in this study area, but not listed in Viereck et al. (1982), are indicated by an asterisk (*).

The following symbology design is used on the maps:

Viereck Level I, II, III call		Viereck Level IV call
Community Classification	$\frac{\text{Do:b}}{\text{002}}$	
Shrub Cover Classes		5 point scale-
		0 = 0-4% cover
Willow		1 = 5-25% cover
Birch (Shrub & Dwarf only)		2 = 26-50% cover 3 = 51-75% cover
Alder		4 = 76-100% cover

Complexes are shown as: $\frac{\text{Do:b}}{\text{002}} + \frac{\text{SLo:bw}}{\text{240}}$

Major component

Minor component
(not less than 25%
of unit area)

Alaska Vegetation Classification Unit Name (Viereck et al. 1982)				Susitna Vegetation Mapping Unit Symbol
1. Forest	A. Conifer	1. Closed (60-100%)	K) White Spruce	Cc:w
			L) Black Spruce	Cc:m
			M) Black & White Spruce	Cc:mw
		2. Open (25-60%)	F) White Spruce	Co:w
			G) Black Spruce	Co:m
			H) Black & White Spruce	Co:mw
		3. Woodland (10-25%)	C) White Spruce	Cw:w
			D) Black Spruce	Cw:m
			E) Black & White Spruce	Cw:mw
	B. Broadleaf	1. Closed (60-100%)	B) Black Cottonwood	Dc:o
			C) Balsam Poplar	Dc:p
			D) Paper Birch	Dc:b
			E) Aspen	Dc:a
			F) Birch - Aspen	Dc:ba
		2. Open (25-60%)	A) Paper Birch	Do:b
			B) Aspen	Do:a
			C) Balsam Poplar	Do:p
		3. Woodland (10-25%)	A) Paper Birch	Dw:b
			B) Poplar	Dw:p
			C) Paper Birch - Poplar	Dw:bp
	C. Mixed	1. Closed (60-100%)	A) Spruce - Birch	Mc:sb
			B) Spruce - Birch - Poplar	Mc:sbp
			C) Spruce - Birch - Aspen	Mc:sba
			D) Aspen - Spruce	Mc:as
			E) Poplar - Spruce	Mc:ps
		2. Open (25-60%)	A) Spruce - Birch	Mo:sb
			B) Aspen - Spruce	Mo:as
			C) Spruce - Birch - Poplar	Mo:sbp
			D) Spruce - Poplar	Mo:sp
		3. Woodland (10-25%)	A) Spruce - Birch	Mw:sb
			B) Spruce - Poplar	Mw:sp
			C) Spruce - Birch - Poplar	Mw:sbp
2. Scrub	A. Dwarf Tree Conifer	1. Closed (60-100%)		FCc
		2. Open (25-60%)		FCo
		3. Woodland (10-25%)		FCw

	Broadleaf			
	1. Closed (60-100%)			FDc
	2. Open (25-60%)			FDo
	3. Woodland (10-25%)			FDw
	Mixed			
	1. Closed (60-100%)			FMc
	2. Open (25-60%)			FMo
	3. Woodland (10-25%)			FMw
B. Tall Shrub	1. Closed (75-100%)	A)	Willow	STc:w
		B)	Alder	STc:l
		C)	Shrub Birch	STc:b
		D)	Alder - Willow	STc:lw
		E)	Shrub Birch - Willow	STc:bw
		*)	Alder - Shrub Birch - Willow	STc:lbw
	2. Open (25-75%)	A)	Willow	STo:w
		B)	Alder	STo:l
		C)	Shrub Birch	STo:b
		D)	Alder - Willow	STo:lw
		E)	Shrub Birch - Willow	STo:bw
		*)	Alder - Shrub Birch	STo:lb
C. Low Shrub	1. Closed (75-100%)	A)	Dwarf Birch	SLc:b
		B)	Low Willow	SLc:w
		C)	Dwarf Birch - Low Willow	SLc:bw
		D)	Ericaceous Shrub Tundra	SLc:e
	2. Open (25-75%)	A)	Dwarf Birch	SLo:b
		B)	Low Willow	SLo:w
		C)	Dwarf Birch - Willow	SLo:bw
		D)	Low Alder	SLo:l
		J)	Ericaceous Shrub - Sphagnum Bog	SLo:eu
		S)	Willow Grass Tundra	SLo:wg
		T)	Birch & Ericaceous Shrub	SLo:be
		*)	Ericaceous Shrub	SLo:e

	D. Dwarf Shrub	1. Closed (75-100%)		SMc
			A) Mat & Cushion - Sedge	SMc:s
			B) Mat & Cushion - Grass	SMc:g
			D) Cassiope	SMc:j
			G) Low Ericaceous Shrub	SMc:e
		2. Open		SMo
		(25-75%)	E) Low Willow	SMo:w
			*) Ericaceous Shrub	SMo:e
3. Herbaceous	A. Graminoid	1. Dry		HGd
		2. Mesic		HGm
		3. Wet		HGw
			A) Wet Sedge Meadow	HGw:s
			C) Wet Sedge - Herb	HGw:sh
			M) Sedge - Moss Bog	HGw:sm
	B. Forb	1. Dry		HFd
			C) Alpine Herbs	HFd:h
		2. Mesic		HFm
		3. Wet		HFw
	C. Bryoid	1. Mosses		HBm
		2. Lichens		HBl
	D. Aquatic	1. Fresh water		HAf
4. Sparse Vegetation	A. Forest			Pf
	B. Scrub			Ps
	C. Herbaceous			Ph
5. Barren				O
	A. Bedrock			Ob

APPENDIX B

Preliminary stratification scheme for the forested vegetation classifications of the Talkeetna Mountains D-4 quadrangle.

SITE:	3
ELEVATION:	3,000 feet
SLOPE:	5 degrees
ASPECT:	South
DATE:	12/12/84
SNOW DEPTH:	8 inches
TEMPERATURE:	-10 degrees F
DATE:	3/7/85
SNOW DEPTH:	28 inches
TEMPERATURE:	19 degrees F
VEGETATION TYPE-FORAGE COVER CLASSIFICATION:	STo:w / 400

SPECIES COLLECTED: Richardson willow, feltleaf willow

SITE:	4
ELEVATION:	2,250 feet
SLOPE:	1 degree
ASPECT:	North
DATE:	12/11/85
SNOW DEPTH:	10 inches
TEMPERATURE:	--
DATE:	3/5/85
SNOW DEPTH:	19 inches
TEMPERATURE:	6 degrees F
VEGETATION TYPE-FORAGE COVER CLASSIFICATION:	SLo:w / 310

SPECIES COLLECTED: diamond leaf willow, grayleaf willow, Richardson willow, resin birch, mountain cranberry

APPENDIX C

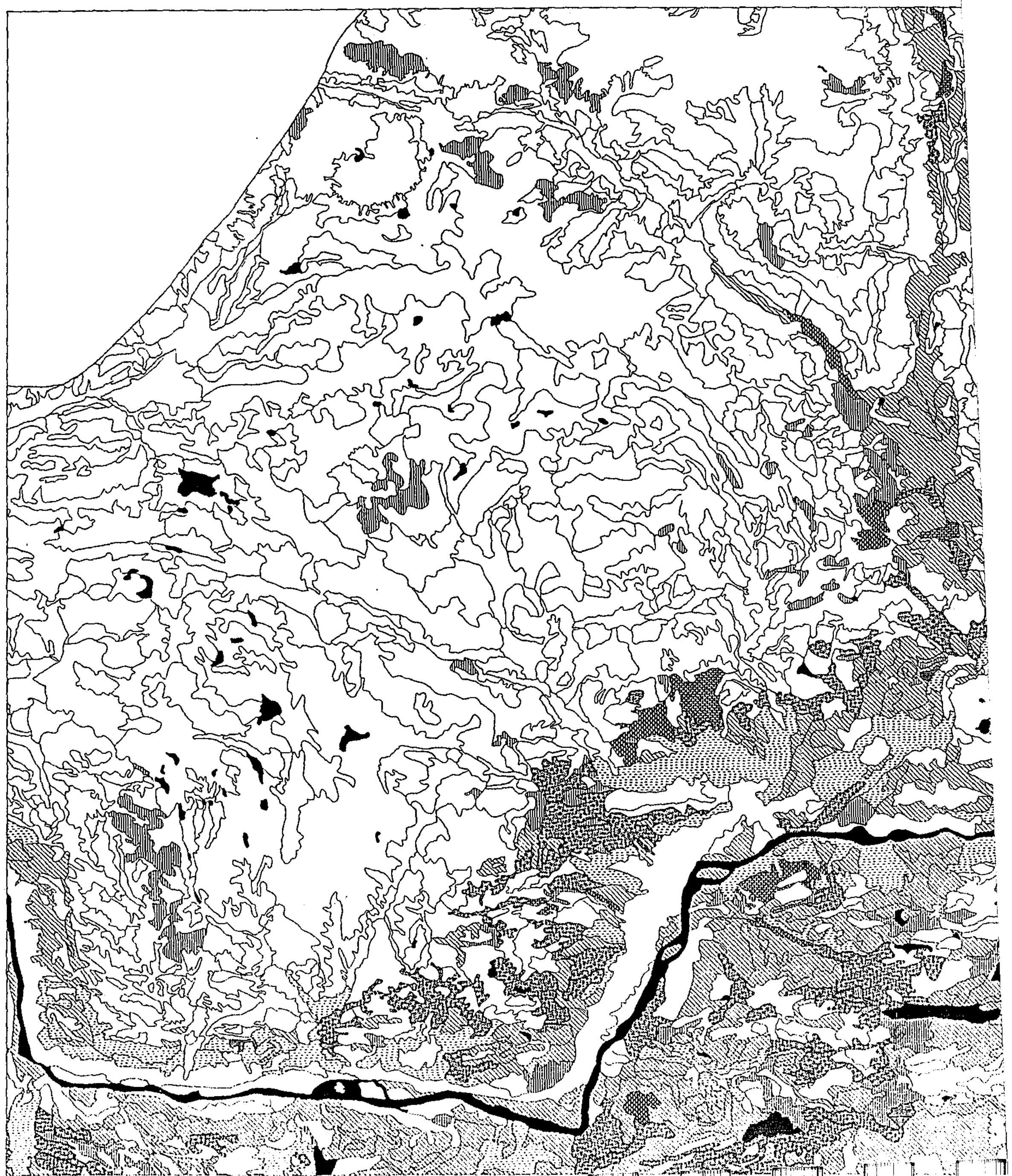
SITE:	1
ELEVATION:	2,020 feet
SLOPE:	3 degrees
ASPECT:	South
DATE:	12/13/84
SNOW DEPTH:	5 inches
TEMPERATURE:	-12 degrees F
DATE:	3/7/85
SNOW DEPTH:	35 inches
TEMPERATURE:	21 degrees F
VEGETATION TYPE-FORAGE COVER CLASSIFICATION:	Mo:sb / 210

SPECIES COLLECTED: feltleaf willow, paper birch, mountain cranberry

SITE:	2
ELEVATION:	2,650 feet
SLOPE:	5 degrees
ASPECT:	Northwest
DATE:	12/12/84
SNOW DEPTH:	5 inches
TEMPERATURE:	-8 degrees F
DATE:	3/5/85
SNOW DEPTH:	12 inches
TEMPERATURE:	12 degrees F
VEGETATION TYPE-FORAGE COVER CLASSIFICATION:	SLo:bw / 321

SPECIES COLLECTED: diamondleaf willow, Richardson willow, feltleaf willow, resin birch

SUSITNA MOOSE BROWSE - FOR
TALKEETNA MOUNTAINS



SITE:	7
ELEVATION:	2,440
SLOPE:	20 degrees
ASPECT:	North
DATE:	12/12/84
SNOW DEPTH:	4 inches
TEMPERATURE:	-2 degrees F
DATE:	3/7/85
SNOW DEPTH:	30 inches
TEMPERATURE:	21 degrees F
VEGETATION TYPE-FORAGE COVER CLASSIFICATION:	Cw:m / 222

SPECIES COLLECTED: diamondleaf willow, grayleaf willow, Richardson willow ,resin birch, mountain cranberry

SITE:	8
ELEVATION:	2,470 feet
SLOPE:	4 degrees
ASPECT:	South
DATE:	12/13/84
SNOW DEPTH:	9 inches
TEMPERATURE:	-15 degrees F
DATE:	3/7/85
SNOW DEPTH:	43 inches
TEMPERATURE:	21 degrees F
VEGETATION TYPE-FORAGE COVER CLASSIFICATION:	STc:w / 410

SPECIES COLLECTED: feltleaf willow

SITE: 5

ELEVATION: 2,580 feet

SLOPE: 2 degrees

ASPECT: Southeast

DATE: 12/11/84

SNOW DEPTH: 8 inches

TEMPERATURE: --

DATE: 3/5/85

SNOW DEPTH: 22 inches

TEMPERATURE: 5 degrees F

VEGETATION TYPE-FORAGE COVER CLASSIFICATION: Cw:m / 320

SPECIES COLLECTED: diamond leaf willow, grayleaf willow, Richardson willow, resin birch, mountain cranberry

SITE: 6

ELEVATION: 2,450 feet

SLOPE: 4 degrees

ASPECT: North

DATE: 12/12/84

SNOW DEPTH: 6 inches

TEMPERATURE: -6 F

DATE: --

SNOW DEPTH: --

TEMPERATURE: --

VEGETATION TYPE-FORAGE COVER CLASSIFICATION: SLo:bw / 321

SPECIES COLLECTED: grayleaf willow

SITE:	11
ELEVATION:	2,180 feet
SLOPE:	3 degrees
ASPECT:	South
DATE:	12/12/84
SNOW DEPTH:	5 inches
TEMPERATURE:	-6 degrees F
DATE:	3/7/85
SNOW DEPTH:	33 inches
TEMPERATURE:	21 degrees F
VEGETATION TYPE-FORAGE COVER CLASSIFICATION:	SLo:w / 420

SPECIES COLLECTED: diamondleaf willow, feltleaf willow

SITE:	12
ELEVATION:	2,030
SLOPE:	17 degrees
ASPECT:	West
DATE:	12/13/84
SNOW DEPTH:	4 inches
TEMPERATURE:	-12 degrees F
DATE:	3/7/85
SNOW DEPTH:	28 inches
TEMPERATURE:	21 degrees F
VEGETATION TYPE-FORAGE COVER CLASSIFICATION:	Mc:sb / 031

SPECIES COLLECTED: paper birch

SITE:	9
ELEVATION:	1,580 feet
SLOPE:	1 degree
ASPECT:	South
DATE:	12/12/84
SNOW DEPTH:	4 inches
TEMPERATURE:	-22 degrees F
DATE:	3/7/85
SNOW DEPTH:	24 inches
TEMPERATURE:	21 degrees F
VEGETATION TYPE-FORAGE COVER CLASSIFICATION:	STo:w / 401

SPECIES COLLECTED: feltleaf willow

SITE:	10
ELEVATION:	2,200 feet
SLOPE:	4 degrees
ASPECT:	Northwest
DATE:	12/13/84
SNOW DEPTH:	8 inches
TEMPERATURE:	-18 degrees F
DATE:	3/7/85
SNOW DEPTH:	41 inches
TEMPERATURE:	21 degrees F
VEGETATION TYPE-FORAGE COVER CLASSIFICATION:	SLc:w / 410

SPECIES COLLECTED: diamondleaf willow, resin birch

SITE:	16
ELEVATION:	2,350 feet
SLOPE:	20 degrees
ASPECT:	South
DATE:	12/12/84
SNOW DEPTH:	--
TEMPERATURE:	-5 degrees F
DATE:	3/5/85
SNOW DEPTH:	22 inches
TEMPERATURE:	12 degrees F
VEGETATION TYPE-FORAGE COVER CLASSIFICATION:	Dc:b / 131 & SLo:b / 131

SPECIES COLLECTED: paper birch, mountain cranberry

SITE:	14
ELEVATION:	2,160 feet
SLOPE:	30 degrees
ASPECT:	Southeast
DATE:	12/13/84
SNOW DEPTH:	5 inches
TEMPERATURE:	-7 degrees F
DATE:	3/7/85
SNOW DEPTH:	30 inches
TEMPERATURE:	21 degrees F
VEGETATION TYPE-FORAGE COVER CLASSIFICATION:	Cc:mw / 121

SPECIES COLLECTED: paper birch

SITE:	15
ELEVATION:	1,620 feet
SLOPE:	25 degrees
ASPECT:	South
DATE:	12/12/84
SNOW DEPTH:	4 inches
TEMPERATURE:	-15 degrees F
DATE:	3/7/85
SNOW DEPTH:	24 inches
TEMPERATURE:	21 degrees F
VEGETATION TYPE-FORAGE COVER CLASSIFICATION:	Do:b / 020

SPECIES COLLECTED: paper birch, mountain cranberry