ALASKA POWER AUTHORITY

SUSITNA HYDROELECTRIC PROJECT

ENVIRONMENTAL STUDIES - SUBTASK 7.12

1982 PLANT ECOLOGY STUDIES

FINAL REPORT

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By

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Habitat Assessment Plans on the Kenai Peninsula

Background

The Alaska Department of Fish and Game has been working since 1978 to develop a method to measure the carrying capacity of different habitats for moose. Greatly simplified, the method matches animal requirements for protein and energy with the amount and quality of forage on an area.

We have completed studies that measured moose energy and protein requirements throughout the year. These data, together with several other physiological values that we measured at the MRC, were incorporated into a mathematical model that calculates the daily nitrogen and energy requirements and food intake of moose. We are presently testing this simulation model to determine if it accurately predicts daily forage intake rates and changes in body composition. These tests are being conducted at the MRC and will be completed in June 1985.

From 1977 to 1981, Regelin collected data on forage quantity and quality from numerous vegetation types on the Kenai National Wildlife Refuge (KNWR). The amount of forage biomass produced in all vegetation types that are important to moose has been determined. Forage quality of the 7 forage species most important to moose were measured at 2-month intervals during an annual cycle.

Original research plans written in 1977 called for mapping the vegetation types on the KNWR so the carrying capacity concept could be applied to the Refuge. We intended to use 1:24000 scale color aerial photographs to map the vegetation types. Funding was never available to accomplish this job.

Current Status

The opportunity to test the utility of the carrying capacity model as a tool for area planning and mitigation may be available through the Regional Guides CIP. Habitat Division is interested in the carrying capacity concept and may be able to provide some financial assistance for applying it to a large area. The large-scale mapping (1:24,000) is expensive and not feasible for large planning areas like the Susitna Planning Area or Copper River Planning Area. Small-scale photographs (1:63,360) and Land Satellite imagery (1:250,000) is available for the KNWR. The opportunity exists to map the refuge at 3 scales using 3 types of imagery. The goal would be to determine if the carrying capacity concept is useful using small-scale photographs. The model was developed using data from the KNWR so it is the best place for the test. We are planning to use the model on the Susitna-Hydro Project as a mitigations tool if funds are available from the APA. However, we will not test different scales of photographs on the Susitna Project and the vegetation sampling has not been completed. Vegetation sampling will not be as intensive in the Su-Hydro area as it was on the KNWR, if it occurs at all.

Future Plans

I recommend a 2-phase approach for a study to evaluate the carrying capacity concept on the KNWR. First, map the study area using the 3 scales of imagery and check the accuracy of the maps through extensive ground truth sampling. Second, use the vegetation data collected by Regelin and the simulation model of moose requirements to predict carrying capacity for the study area. Independent estimates of carrying capacity would be made using each scale of map. Using the 1:24,000 scale map as the best estimate, we could determine the usefulness of the smaller scale maps.

The study area would be in GMU 15A, that portion north of the Sterling Highway and the Kenai Spur Highway, and west of longitude 150.05, a north-south line through Fuller Lake. All areas over 1,500 feet in elevation would be omitted. Size of this area is 140 sq mi approximately 600,000 acres. It contains all vegetation types that are important to moose on the KNWR.

Steps in the process are outlined below along with crudely estimated costs and manpower requirements.

Phase I

1. Begin project July 1, 1984. Spend about 2 months during summer becoming familiar with vegetation type: and photographs.

2. During fall and winter, prepare maps at each scale. The 1:24,000 scale maps should be able to identify vegetation types to level 4 of Viereck's classificat: system. Classification levels for the smaller scales are unknown.

3. Digitize all vegetation maps.

4. During late spring, check accuracy of maps and make corrections. ? difficult timing for phenology

5. Complete maps by June 30, 1985.

Manpower requirements for Phase 1 are:

GB or HB II or III for 1 year	$38,000
Tech III for 6 months	16,000
	$54,000

Operating costs:

Travel/per diem	$ 4,000
Computer time	10,000
Miscellaneous	2,000
	$16,000
Total	$70,000

The biologist's position requires knowledge of vegetation classification and mapping, preferably with a background in computer science.

Phase II.

1. Begin July 1, 1985. Put all Regelin's data on comput and match with appropriate vegetation types from maps

2. Calculate standing crop, biomass of each vegetation type and the entire study area.

3. Apply the carrying capacity model to the study area using the 3 scales of maps.

4. Write final report, complete by June 30, 1986.

Manpower

GB III for 1 year	$40,000
Operating costs & miscellaneous	10,000
	$50,000
Total cost of Project	$120,000

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1 - SUMMARY

The range ecology group of the University of Alaska, Agricultural Experiment Station, was responsible for conducting browse inventory and plant phenology studies in the middle Susitna River Basin and a pre-burn inventory and assessment study in the Alphabet Hills of southcentral Alaska.

A total of 47 sites were sampled from 27 July to 20 August, 1982, to measure canopy cover, shrub stem density, browse utilization, browse availability, and current annual growth biomass in the browse inventory study. The 47 sites were classified and grouped into 10 Level IV vegetation types based on Viereck et al.'s (1982) vegetation classification system. Five of the sampled vegetation types were forest: Open White Spruce, Open Black Spruce, Woodland Spruce, Open Birch Forest, and Open Spruce-Birch Forest. Five of the sampled vegetation types were scrub: Dwarf Birch, Dwarf Birch-Willow, Open Ericaceous Shrub Tundra, Ericaceous Shrub-Sphagnum Bog, and Low Willow Tundra.

Picea glauca was the dominant overstory tree in the Open White Spruce and Woodland Spruce vegetation types while *Picea mariana* dominated the tree canopy in the Open Black Spruce vegetation type. In these 3 needleleaf forest types, *Alnus sinuata* was the only tall shrub, *Betula glandulosa* and *Salix pulchra* were the dominant low shrubs, and *Vaccinium uliginosum*, *V. vitis-idaea*, and *Empetrum nigrum* were the dwarf shrubs with the highest average canopy cover. *Petasites frigidus* and *Cornus canadensis* were the predominant forbs. Moss cover averaged 46% in the needleleaf forest types. *Alnus sinuata*, *B. glandulosa*, and *S. pulchra* were the dominant shrubs producing leaf and twig current annual growth biomass and gross available twig biomass in the 3 needleleaf forest vegetation types. Percent utilization of these shrub species ranged from 2% to 30% in the needleleaf forest. *Betula papyrifera*

and mixed Picea glauca - B. papyrifera stands were the dominant overstory cover in the Open Birch Forest and Open Spruce-Birch forest vegetation types, respectively. Alnus sinuata was the dominant tall shrub in these deciduous forest types. Dryopteris spp., Epilobium angustifolium, and Linnaea borealis were the predominant forbs.

Betula glandulosa had both the highest canopy cover, stem density, current annual growth biomass, and gross available twig biomass in the Dwarf Birch vegetation type of all vegetation types sampled. Percent utilization of twigs, however, was only 3%. Salix pulchra had low canopy cover and scattered distribution in the Dwarf Birch Type, but still averaged 14 kg/ha current annual twig growth biomass with 9% utilization. The Dwarf Birch-Willow vegetation type was only 1 of 2 types sampled where the low shrub S. pulchra had canopy cover estimates approximately equal to or greater than B. glandulosa, although stem density estimates remained lower. Current annual growth biomass of both leaves and twigs of B. glandulosa remained much higher than for S. pulchra. The ericaceous shrubs Vaccinium uliginosum, V. vitis-idaea, Empetrum nigrum, and Ledum groenlandicum were dominant low-growing shrubs in the Open Ericaceous Shrub Tundra and Ericaceous Shrub-Sphagnum Bog vegetation types. Salix pulchra in the Low Willow Tundra vegetation type had both the greatest canopy cover and stem density in the vegetation types sampled.

The phenology study was initiated to evaluate forage availability for cow moose during parturition along the canyon slopes above the middle Susitna River. If critical spring forage were found only in the potential impoundment area, then moose survival and reproduction may be impacted by the reservoir. Exclosures were erected in late May at 4 elevations along 4 transects (3 at 1 transect) on south-facing slopes to protect plants from grazing. The exclosures were sampled and the corresponding north-facing slopes were observed at 7-day intervals for phenological development of the vegetation and evidence of utilization by moose. These observations were made from 31 May to 2 July 1982. Some general observations were made on a reconnaissance survey on 15 and 16 May. Samples were also obtained at the end of the growing season from 31 August to 3 September 1982.

Elevation within transect and transect location had a significant effect on soil temperature, plant canopy cover, and current growth biomass during the spring period. However, the effects of elevation were not consistent among transects. On some transects vegetation matured faster at the bottom-elevation site while on others it matured faster at the middle-slope or at the highest elevations. Vegetation along one of the transects matured much later than along any other transect. Timing of vegetation development resulted from an interaction of climate, topography, and site history. Some plant maturation differed among species at the same site. Most early-developing sites that were studied were above the level of the potential impoundment, but could be influenced by mesoclimatic changes created by the reservoir.

Twenty-five sites were sampled for cover of shrubs, herbaceous plants, lichens, and bryophytes in the Alphabet Hills study area. The density of trees as well as tall and low shrubs was estimated at each site. Biomass and utilization of major tall and low shrub twigs were also estimated. The sites examined were classified into 5 vegetation types: Open White Spruce, Open Black Spruce, Woodland White Spruce, Dwarf Birch, and Dwarf Birch-Willow. *Picea glauca* and *P. mariana* were the major tree species present in the study area. *Betula glandulosa*, *Salix pulchra*, and *Salix glauca* were the most abundant low shrubs. Utilization was greatest for *S. pulchra* twigs.

Vaccinium spp. and *Empetrum nigrum* were the most abundant dwarf shrubs. *Equisetum* spp., *Cornus canadensis*, and *Petasites frigidus* were the most abundant forbs. *Carex* spp. were also abundant, as well as bryophytes and lichens.

Vegetation type names were indicative of the relative abundance of trees and/or shrubs in each type. Cover of herbaceous vascular plants was inversely related to shrub density in the study area. Fire may increase the potential of Open White Spruce, Open Black Spruce, and Woodland White Spruce types as moose habitat. Shrubs that are major foods of moose in Alaska exist in these types. In addition, the Dwarf Birch-Willow sites had the greatest density of those important shrub species, presumably due to a relatively recent history of fire.

2 - INTRODUCTION

During spring, summer, and fall 1982 (15 May through 20 September) the range ecology group at the Agricultural Experiment Station, University of Alaska, Palmer Research Center was involved in 3 studies that were designed to examine specific parameters of vegetation types to address information gaps concerning habitat requirements for moose (Alces alces gigas) in the middle Susitna River Basin of southcentral Alaska (Fig. 1). The 3 studies were: 1) an inventory of available browse and its utilization by large herbivores (primarily moose) in the middle Susitna River Basin, 2) a plant phenology study, also in the middle Susitna River Basin, and 3) a pre-burn inventory and assessment of the vegetation in the nearby Alphabet Hills in cooperation with the Bureau of Land Management (BLM) and the U.S. Forest Service Institute of Northern Forestry (INF), Fairbanks.

Utilization as determined in the browse study could possibly be attributed to a number of animal species, ranging from herbivorous insects to large ungulates. However, utilization was determined only for shrubs that are major foods of moose in Alaska (Peek 1974). In addition, utilization was based on observations of browsed and unbrowsed twigs on these plants, which by the very nature of the methods used excluded all animals but the large herbivores. We have assumed that moose are the dominant large herbivore in the middle Susitna River Basin and that the majority of utilizaton that these plants received was due to moose browsing.

2.1 - Browse Inventory

Browse abundance and utilization in different habitat types (plant communities) are key components for assessing the impacts and developing mitigation procedures required for the proposed dam impoundments. Until now, this data has been lacking for the middle Susitna River Basin. The implementation and design of a mitigation plan for many species of wildlife will be greatly enhanced by this information.

The objectives of the browse inventory were to measure canopy cover and standing crop biomass of shrubs, graminoids, and forbs. Utilization of shrubs that are presumably the major foods of moose in the middle Susitna River Basin was also estimated. These data were collected from some of the 16 vegetation types described by McKendrick et al. (1982). Only vegetation types that were considered to be important as moose habitat were examined.

2.2 - Plant Phenology

The plant phenology - moose utilization study was initiated because it was suspected that pregnant cow moose concentrated along south-facing slopes and some north-facing slopes of the Susitna River valley during calving (Ballard et al. 1982) to take advantage of any late winter - early spring growth by herbaceous plants. The original objective was to determine if early spring growth of forbs on the slopes of the impoundment areas were providing forage for cow moose prior to parturition. Since the possibility existed that the moose could completely remove the forbs, exclosures were built to protect the vegetation and provide an area of "intensive" sampling. Hence, the study had to be rather qualitative to cover the area needed to explore this hypothesis. As actually implemented, the objective was broadened to monitor vegetation development during early spring to determine if early forage availability occurred in some areas before others and why these differences occurred. It had been hypothesized that herbaceous vegetation development would occur first on the south-facing slopes and would be affected by elevation. Hence, field effort were concentrated on south-facing slopes. Energy reserves of moose are probably near depletion by late winter. Parturition and lactation further increase energy demands of cow moose.

Graminoids and forbs that are breaking quiescense and actively photosynthesizing immediately prior to and during moose calving would have relatively greater energy content than many of the shrubs present (Cook 1971). Shrubs, graminoids, and forbs all have high energy content when in vegetative stages, far beyond what is needed for gestation and lactation in domestic large ungulates (Cook 1971). Archer and Tieszen (1980) have shown that at Atkasook, Alaska, 2 graminoid species initiated growth sooner than the shrub species *Salix pulchra* and *Ledum decumbens*. Graminoids and forbs do not produce any nonphotosynthetic support tissue while these 2 shrub species may allocate 75-84% of their total nonreproductive, aboveground biomass to stems (Archer and Tieszen 1980). Thus, herbaceous plant production in late winter-early spring could be critical to moose reproductive success.

2.3 - Alphabet Hills Pre-burn Inventory and Assessment

The purpose of the Alphabet Hills study was to obtain pre-burn inventory and assessment data on composition, distribution, utilization, and abundance of the vegetation, as well as litter depths, and chemical composition of soils in the proposed burn area. The long term objectives of the study are to monitor changes in the vegetation, litter, and soils following the burn and the subsequent response of moose to documented vegetation dynamics.

The Bureau of Land Management (BLM) proposed the controlled burn in the Alphabet Hills area (Fig. 1) to improve moose habitat. Several starved moose found in the area after the 1982 winter (W. B. Ballard, ADF&G, *personal communication*). Habitat improvement in the Alphabet Hills could possibly decrease moose mortality due to starvation. The fire team of the BLM and INF cooperated throughout all phases of planning and sampling. The management goal was a discontinuous burn that would create more area of favorable habitat for moose and could be easily controlled. The area was surrounded by natural water boundaries in most sections which eliminated the need for fire lines. Several points had been selected for ignition by heli-torch. A heli-torch exudes a discontinuous stream of jelled gasoline which is ignited by a striker. This burning mass then ignites the vegetation where it falls. Because of the natural boundaries, little, if any, ground support would be required to control the fire. If the fire did not spread as intended, the fire boss would have the option of starting additional ignition points. Fluorescent pink panels were placed near our study sites so that ignition could be made near them and insure that some study plots would be burned. The panels also insured that fuel would not be dumped directly on the permanent plots.

Initially, a secondary burn area was defined by the BLM-INF fire team. This area was also surrounded by natural boundaries. Any part of it could conceivably be burned. Later, the fire boss defined the primary burn area. This was the area expected to carry the fire. Study sites within this area would have a high probability of impact if the fire burned as expected. Based on similarities in vegetation as determined from color infrared U-2 imagery, the range ecology group defined a control area that was outside the burn areas. Sites placed here had little probability of burning and were used as controls. Most study sites were positioned within the primary burn area because it had the highest probability of being burned. Fewer sites were located in the secondary burn area because it had a lower probability of being burned.

Spencer and Hakala (1964) noted that moose responded positively to fire on the Kenai Peninsula. They estimated that the productive life of a burn as good moose range was about 20 years. Oldemeyer et al. (1977) found that within 30 years after the 1947 Kenai burn the range was deficient in browse quality. Although different plant communities are involved, the same results could be expected in the Alphabet Hills area. Our personal observation of areas with a past history of fire in the middle Susitna River Basin support this contention.

3 - ACKNOWLEDGEMENTS

We would like to thank Dr. Wayne L. Regelin and Mr. Warren B. Ballard who provided needed information on moose ecology and assisted in determining the objectives of these studies. Luke Werner and Robert Crane assisted in summer field sampling. Granville Couey and Onnalie Logsdon organized logistic support for field operations while at Watana Base Camp. Helicopter pilots James Connor, Jerry Abshire, and Jerry Dickson are acknowledged for their exceptional service during the course of these investigations. Maintenance personnel at Watana base camp provided needed tools and shop support.

We would also like to thank Dr. David F. Murray of the University of Alaska for his help with plant species identification and verification of range extension specimens. Gary and Carol Gustafson provided clerical services for preparation of this manuscript. Dave Lanneville prepared the maps and illustrations.

4 - STUDY AREAS

4.1 - Middle Susitna River Basin

The middle Susitna River Basin in the northern Talkeetna Mountains was the primary study area for the 1982 range ecology studies (Fig. 1). The browse inventory and plant phenology studies were both conducted within this 46,644 km^2 area (Fig. 1). The middle Basin was bounded on the west by Devil Canyon and on the east by the Maclaren River, and extended approximately 16 km on either side of the Susitna River. Elevations ranged from about 333 m on the river at Devil Canyon to 2085 m at the top of Mt. Watana. The river elevation rises to approximately 800 m at the confluence with the Maclaren River.

Topography of the middle Basin has been strongly influenced by past glacial action and associated creek and river erosion. Generally, the middle Basin is a broad U-shaped valley. Presumably, the west and east fork glaciers united and extended into the middle Basin. The Susitna River has carved a steep, relatively narrow V-shaped channel through the valley as the glaciers receeded. Numerous creeks and rivers drain into the Susitna River along its course in the middle Basin. The channel slopes are extremely steep near Devil Canyon, rising approximately 333 m vertically in about 1 km horizontal distance. The benches above the river channel are approximately 666 - 833 m in elevation and make up a majority of the study area. At the eastern end of the middle Basin, the river channel is relatively less steep and much wider.

Various plant communities are found in the middle Basin study area. McKendrick et al. (1982) mapped 16 vegetation types in the middle basin at Levels III or IV of Viereck et al. (1982). 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 forest and various open to closed coniferous forests on both sides of the river. The benches above the river contain primarily shrub communities on the drier sites, followed by white spruce (<u>Picea glauca</u>) forests on well-drained slopes, and black spruce (<u>Picea mariana</u>) forests at the wettest sites. Alpine tundra exists at the highest elevations.

4.2 - Alphabet Hills

The Alphabet Hills study area encompassed approximately 276 km^2 and elevations ranged from 833 m to 1137 m. This study area was approximately 38 km north of Lake Louise and 19 km southeast of the confluence of the

Maclaren and Susitna Rivers (Fig. 1). The Alphabet Hills are a gently sloping, elevated ridge (1137 m) surrounded by lowland areas with numerous lakes and ponds. Major vegetation types are scrub and coniferous forest communities.

5 - METHODS

5.1 - Browse Inventory

A total of 47 sites were sampled from 27 July through 20 August, 1982, to estimate the availability of woody browse and herbaceous plants for large herbivores in the middle Susitna River Basin (Fig. 2). Thirty-nine sites were randomly selected by overlaying a grid on a vegetation map (from McKendrick et al. 1982) of the area. Selection of sites was limited to areas within home ranges of radio-collared moose that use the potential impoundment areas as delineated by ADF&G biologists. This was within approximately 16 km (10 miles) of the proposed dam impoundments and the Coal Creek area. However, because the planar of the proposed impoundment was relatively small in relation to that portion of the middle Basin under consideration, 8 of the 47 sites were sampled near the locations of the 4 1982 phenology transects within the area to be inundated (see Fig. 3). Near the lower elevations of each of these transects, a browse inventory site was situated on each opposing slope at approximately mid-slope of the canyon in the representative vegetation type.

In the field, browse inventory sites were visually classified to Level V of Viereck et al. (1982). Several sites were later adjusted to different, or new, Level V classifications based on results of preliminary analysis of canopy cover data. Some vegetation types were sampled more intensively than others. Sampling intensity was based on land area occupied by a vegetation type and also on suspected importance to moose. Several prospective sites originally selected using the grid overlay were omitted from the final selection of sites. Vegetation types that were considered of lesser importance to moose such as mat and cushion tundra, sedge grass tundra, mat and cushion-sedge grass tundra and alpine herbaceous tundra vegetation types were not sampled.

At each browse inventory site, 3 parallel 50-m line transects were established from a randomly chosen point. The transects were spaced 10 to 20 m apart; the distance between transects was adjusted from site to site in an effort to keep all transects within the particular vegetation type being sampled. Temporary plots were located at 10 m intervals along each transect; 5 plots per transect, totalling 15 plots per site.

5.1.1 - Canopy Cover

At each plot location a 0.5-m^2 (1 x 0.5 m) rectangular quadrat was sampled for percent canopy cover of plant species within the vertical projection of the boundaries of the quadrat. The quadrat was oriented such that the left-rear corner was touching the center-point of the plot location and the long axis of the quadrat was parallel to the direction of travel. Percent canopy cover of understory plant species and trees $\leq$1.13 m in height (breast height) was ocularly estimated using 5% cover increments if plant cover was between 10 to 90% (10, 15, 20,...,90%) and 1% cover increments in the 1 to 9% and the 91 to 100% ranges. A precision of 1% for low and high cover values was used for all studies since an observer can differentiate between 1% and 2% cover (or open space in the case of 98% and 99% cover); however, differentiation between 20% and 21% is difficult. Use of 5% intervals at the low and high ends would lead to overestimates of uncommon species which would usually cover only 1% of the quadrat in any particular area. These precision levels are frequently used in vegetation inventories. Percent canopy cover of forbs, graminoids and shrubs was estimated by species and life form totals. Percent cover for several graminoids and lichens was estimated by genus as well as life form totals. Percent cover of bryophytes was estimated as a life form total.

Additionally, at each plot location along each transect line a 4-m^2 circular quadrat was delineated by rotating a rope, 1.13 m in length, around a metal rod placed at the center of the plot location. Percent canopy cover of tall shrubs, low shrubs, and crown canopy and basal stem cover of trees > 1.13 m in height within the vertical projection of the boundaries of the quadrat were occularly estimated using the same cover increments as for the 0.5-m^2 quadrat. For all canopy cover estimates, the actual vertical projection of the vegetation upon the area enclosed by the quadrat boundaries was used rather than methods employing connection of outer points of plant crowns into polygons for cover estimates based on area of vegetation influence. Neither 0.5-m^2 or 4-m^2 quadrat sizes were adequate to estimate tree canopy coverage. Tree canopy estimates were taken from a combination of ocular estimations using aerial photographs, aircraft over-flight, and on-the-ground site descriptions.

5.1.2 - Shrub Stem Density

Within each 4-m^2 quadrat at each plot location, the number of live stems of each tall and low shrub species were counted by diameter class. Diameter classes were in 1-cm increments: 0-1 cm; 1-2 cm; 2-3 cm; and 3-4 cm. The total number of live stems was obtained by summing over all diameter classes for each species.

5.1.3 - Browse Utilization

At each plot location along each transect line a circular quadrat with a 5-m radius was established. This quadrat was divided into 4 even-sized quadrants (point-centered quarter) with its center at the plot location. Within each quadrant, the distance to the nearest stem 40 cm or taller of each tall and low shrub species represented within the quadrant was measured. The maximum distance measured to a shrub was 5 m. This arbitrary limit was established to prevent overlap between quadrats that were spaced at 10 m intervals along the line transect and to expedite sampling and decrease search time for shrubs with low densities.

Only shrubs with stems 40 cm or taller were considered for measurement. Our observations indicated that 40 cm was the approximate lower limit of much of the browsing of low shrubs during winter. This height limitation approximated "typical" snow cover during winter when most of the twigs below 40 cm would be covered by snow. In effect, this particular limitation on the selection of the nearest individual shrub of each species in each quadrant biased the sampling effort toward taller plants. This eliminated sampling of small seedlings or root-sprouts that did not meet the minimum height of 40 cm. We determined, however, that for 2 reasons this bias was supportive of our goal to estimate available browse for large herbivores such as moose: 1) sampling for available browse conducted during the summer was to be used to estimate the availability of that same browse during the winter, thus sampling very small individuals (e.g. 10 cm in height) with high probability of being covered with snow during winter was not desirable; and 2) most browsing pressure was observed to be on shrubs 40-50 cm or taller in height. Additionally, the establishment of some minimum shrub size was necessary to defining a browsable shrub; inclusion of small seedlings or root-sprouts was not considered a good estimate of browse available to moose during the winter.

The basal diameter at approximately 5 cm from ground level of each nearest shrub stem was also measured to the nearest millimeter. Average height of the stem was measured to the nearest 10-cm increment. The number of unbrowsed and "recently" browsed twigs extending above 40 cm on the stem were counted. A twig was defined as a branch that had a basal diameter approximately equal to the estimated diameter at point-of-browsing (DPB) for that shrub species. The average DPB for each shrub species was estimated for the middle Susitna River Basin by randomly measuring "recently" browsed twigs at a number of sites and locations over the study area.

Basal diameters of intact twigs were estimated rather than measured when counting unbrowsed twigs. Twigs on branches were counted in such a way that the basal diameter of any twig did not exceed the average DPB for that shrub species. Thus, in cases where several lateral twigs were produced due to previous browsing of the terminal bud and/or stem, individual lateral twigs would be counted as unbrowsed twigs rather than counting the large main stem below the point-of-browsing and below the base of the lateral twigs. Every attempt was made to count twigs at the average DPB; however, smaller twigs would be counted as unbrowsed twigs before a single large stem containing ≥ 1 smaller twigs would be counted as a single large unbrowsed twig. Due to the low growth stature of all shrubs except Alnus sinuata and the open branching habit of both A. sinuata and Betula glandulosa, no arbitrary distinction other than minimum height of the twigs (40 cm) was placed on availability of twigs to browsing large herbivores. Few individuals shrubs of any species were hedged to the degree that would directly inhibit acquisition of new growth twigs by browsing animals. In extremely few and in only local instances would hedging have been severe enough to produce "broom-stick-like" stems of dead twigs that would directly inhibit browsing of new twig growth. For these reasons, all twigs above 40 cm in height on the shrub in question were counted and considered available to a browsing animal.

To be considered a "recently" browsed twig, the remaining portion of the stem immediately below the point-of-browsing either had to be alive or appear as if browsing had occurred within the previous 2 years. Twigs that had been browsed in the less recent past, leaving only dead stubs where the bark was separating from the xylem and/or the twigs were shrunken in diameter, were not counted as browsed twigs. Utilization (by browsing) of browsable twigs by large ungulates was expressed as a percent by dividing the number of browsed twigs by the total number of browsed and unbrowsed twigs for each stem.

5.1.4 - Browse Availability

At each site, 25 twigs from each tall and low shrub species were randomly harvested at the average DPB. These twigs were oven-dried at 60°C for 48 hrs., separated into their respective leaf and woody stem components, and weighed to the nearest tenth gram. The average dry weight per twig of leaves and woody stems provided estimates of standing crop biomass removed when twigs were browsed by moose. Dry weight standing crop biomass is referred to as biomass in this report. Average weight per twig and its associated leaves for each shrub species was multiplied by the mean number of unbrowsed twigs/stem in each vegetation type. This total was then multiplied by the average number of stems/ha for each species to produce estimates of total kg/ha of unbrowsed forage. Estimates of total kg/ha of utilized forage was calculated in the same manner using average number of browsed twigs/stem. Available and utilized leaf biomass apply to summer use only.

5.1.5 - Current Annual Growth Biomass

All current annual growth (CAG) of forbs and graminoids as life form totals and shrubs by species were clipped from the 0.5-m^2 quadrats used to estimate canopy cover. Samples were oven-dried, the leaves and woody stems of shrubs separated, and then weighed to the nearest 0.01 gram.

Estimates of dry weight biomass were for all current forb and graminoid growth to ground (or moss) level was calculated by life form totals. The dry weight biomass estimates of shrubs was derived from CAG of woody stems, and CAG of leaves that were attached to the stems. CAG of leaves attached to previous years' woody stems were not collected. CAG for shrubs was collected over the entire height of the plant within the vertical projection of the boundaries of the quadrat.

5.1.6 - Statistical Analysis

Analysis consisted of descriptive statistics ($\bar{x}$, SE, N) and comparisons among vegetation types of the variables measured. The number of plots that were needed to adequately sample each variable to within 20% of the mean with 67% confidence (except for small means) in each vegetation type was also calculated. Only individual plant species or life form total average measurements with a mean $\geq$ 1 were presented. Life form totals (e.g. total tall shrub, total forb) were either estimated or computed additive measurements across all individual species occurring within each life form.

The reported standard error and the variance used for the sample size estimates were based on the total variance calculated from plots within sites within Level IV (Viereck et al. 1982) vegetation types. This was the total variance from "between" sites (within type) and within sites. This represented the variance resulting from plots within sites and sites within a vegetation type. Hence, the estimated sample size represents the number of plots needed if they were located randomly within a vegetation type. It does not indicate the number of sites per type or the number of plots per site needed for adequate sampling.

As noted earlier, sample sizes were calculated to estimate the number of plots needed to adequately sample the parameter to within 20% of the mean with 67% confidence for means that were not considered "too small". The formula is:

$$n = \frac{s^2 t^2}{d^2}$$

where n = estimated sample size,

s = standard deviation,

t = t value for 67% confidence (1.0), and

d = half-width of confidence interval.

The 67% confidence level was chosen since it was decided that being right 2 out of 3 times was ecologically acceptable. Sampling to within 20% of the mean for small averages meant that if the calculated mean was 1% cover, the confidence interval ranged from 0.8 to 1.2%. Realistically, if the cover were 1%, results of a repeated experiment would probably be acceptable if the cover were estimated to be less than 5%. Hence, absolute differences (rather than a percentage of the mean) were selected for small values. If cover was less than 25%, then an absolute difference of 5% cover was used rather than 20% of the mean. Criteria used for all studies are shown in Table 1.

5.1.7 - Soils

In order to gain an understanding of the difference or similarities in chemical composition of soils between the proposed Susitna impoundment area and Alphabet Hills burn area, soil samples were collected during the browse inventory study. In this study, 3 parallel transects of 5 plots each, totalling 15 plots per site, were used to estimate vegetation parameters. At each site, soil samples were collected from plots 2, 6, and 13. The soil sample was taken approximately 1.13 m distance from plot center and perpendicular to the line of travel. A cylindrical coring device approximately 15 cm in diameter and 45 cm deep was used to take soil samples. The coring device was pushed into the soil and a built-in plunger was used to push the soil and litter core out of the cylinder after extraction.

Each of the soil profiles were sampled to a depth of 15 cm, where possible. Depth of the organic matter was measured, removed from the core, and placed in a cloth bag. Soil samples from extracted cores were divided into 0-5 cm, 5-10 cm, and 10-15 cm depths which were separated and stored in labelled plastic bags. Soil samples were submitted to the Alaska Agricultural Experiment Station Plant and Soil Analysis Laboratory, Palmer. The analysis performed consisted of:

1) pH (1:1 water-soil method),
2) available potassium, calcium, and magnesium measured in parts per million (neutral 1 normal ammonium acetate extraction method),
3) total nitrogen and phosphorus measured in parts per million (modified Kjeldahl method, than autoanalyzed),
4) sand, silt, and clay measured by percent (hydrometer method),
5) organic matter measured by percent (Walkley-Black method), and
6) copper, zinc, manganese, and iron measured in milligrams per gram (DPTA extraction method).

Analysis consisted of descriptive statistics ($\bar{x}$, standard deviation, N) and comparisons of the soils among depths and among vegetation types of the variables measured. Analysis of variance incorporating a nested design was used to test differences in soil parameters among vegetation types. Sites were nested within vegetation types and depths nested within sites.

5.2 - Plant Phenology

5.2.1 - Site Selection

Transect locations were selected based on concentrations of radio-collared moose in the impoundment zone during parturition periods (Fig. 3). Locations were chosen to represent areas of use and non-use by radio-collared moose during April-June, the usual period of parturition (Ballard et al. 1982). It was recognized that nonradio-collared moose were probably using areas that were not being used by radio-collared moose. However, this was the best approximation available for an experimental design. Areas of "use" and "non-use" were included in the design to attempt to identify differences in vegetation that were attractive to cow moose. The study transect near the switchback of the Susitna River (near the Oshetna

River) represented sites with usage on both south- and north-facing slopes. The transect east of Jay Creek represented areas of little or no usage by radio-collared moose during parturition. The transect east of Watana Creek was used by radio-collared moose on the south-facing slope but not on the north-facing slope. These areas were all in the potential Watana impoundment area. One transect was chosen west of Tsusena Creek in an area used by radio-collared moose on both north- and south-facing slopes in the potential Devil Canyon impoundment area. Exact locations of transects were determined using aerial and ground reconnaissance during May, 1982.

Transects were generally about 1.5 km long, although one was 2 km. The "transects" were lines used for qualitative, non-structured observations, especially on the north-facing slopes. Exclosures were constructed at discrete points along the transects on the south-facing slopes.

Four elevations for each study area were selected along each of the 4 transects, except Tsusena Creek transect where only 3 elevations were examined. The highest elevation was on the bench above the river, the second elevation was at the top of the slope, and the third and fourth elevations were mid-slope and bottom of the slope, respectively. Exact ground locations at each elevation were based on slope position, vegetation, and helicopter access. Tree cover at the mid-slope elevation on the Tsusena Creek transect prevented helicopter access either by landing or by dropping a sling load. Terrain was too rough and vegetation too dense to reasonably hand-carry the materials to an appropriate location, therefore no exclosures were constructed at the site.

Exclosures were constructed in vegetation representative of each elevation and transect. Some exclosures were located within a single vegetation type, such as low shrub scrub, while others were located along ecotones because moose frequently use "edges" of vegetation types. The exclosures were always constructed away from the helicopter access point.

Pairs of 2.1 x 2.1-m (7 x 7 ft) exclosures were constructed in late May at each location using 1.5-m (5 ft) woven wire with a single strand of barbed wire at the top, and 2.1-m metal fence posts. Transects were sampled at 7-day intervals beginning 31 May and ending 2 July, 1982. The south-facing slope exclosures were sampled in the morning for all transects except Watana Creek. The corresponding north-facing slope without exclosures was examined in the afternoon for general observations on vegetation composition and phenological development as well as utilization by wildlife. The north-slope at Watana Creek was visited at the end of each week for logistical reasons. Sampling was not begun until after snowmelt because of project delays.

5.2.1.1 - Plant Phenology Transects, Specific Site Descriptions

5.2.1.1.1 - Watana Creek Transect

The bench location upstream from the Watana Creek transect (Fig. 3) was in a low birch shrub scrub inclusion in an open spruce type. It was at an elevation of 774 m (2440 ft) with 2° slope and 185° average aspect. Betula glandulosa (resin birch) dominated the low shrub layer while Ledum groenlandicum (Labrador tea), Vaccinium uliginosum (bog blueberry), and V. vitis-idaea (mountain cranberry) dominated the dwarf shrub layer. Moss covered almost 90% of the ground. The average age of 4 large trees in the area was 94 years, making it a relatively old site. Methodology describing the aging technique used for tree cores is contained in the Methods section.

The exclosure at the top of the slope was in an ecotone between low birch shrub scrub and woodland spruce. It was at an elevation of 683 m (2240 ft) with a 5° slope and 150° aspect. This would be 17 m above the potential impoundment water surface. Vegetation consisted of B. glandulosa in a low shrub layer with a dwarf shrub layer of L. groenlandicum, V. vitis-idaea, and Empetrum nigrum (crowberry). Moss provided about 65% ground cover. The mean age of 3 Picea glauca individuals was 82 years.

The middle-slope location along the Watana Creek transect was an open white spruce site located on the sides of a small knoll. Poorly drained black spruce areas existed just uphill from the site in a relatively level area. This site had an elevation of 610 m (2000 ft) with an average aspect of 173° on an 8° slope. This site would be inundated by the Watana impoundment. One exclosure faced westward on a 13° slope while the other had a southerly exposure. Vegetation consisted of a B. glandulosa low shrub layer with L. groenlandicum. V. uliginosum, and V. vitis-idaea in the dwarf shrub layer. Vaccinium uliginosum was more abundant on the south-facing exclosure while B. glandulosa was more abundant on the west-facing exclosure. Moss formed 90% of the ground cover. Trees averaged 62 years (N=4) making it a medium-aged site. Old snags were present but not aged.

The bottom location was in an open mixed spruce-birch site just above the floodplain with a 12° slope and 192° aspect. Its low elevation of 549 m (1000 ft) placed it in the potential impoundment zone. The most important understory vegetation included L. groenlandicum and V. vitis-idaea, but Rosa acicularis (prickly rose) was also present. Moss was less important in this site because of the litter layer in some places. The average age of 3 trees was 99 years. As a general observation, bottom elevations had older trees than the other elevations for all transects. The bottom location on the Watana transect was about 35 years younger than any other bottom site on the other transects. The Watana transect bottom-elevation site was the only bottom site positioned on a slope, and it had the warmest soil temperatures of any bottom-slope site for any transect. These three facts (younger, greater degree of slope, and warmer) are related to disturbance due to fire at this site that was not a factor at bottom sites on other transects.

5.2.1.1.2 - Jay Creek Transect

The Jay Creek transect began at a higher elevation than any other transects at 884 m (2900 ft) (Fig. 3). The bench location was on a slope below an almost barren outcropping. The highest elevation site was a low birch shrub scrub type with a 10° slope and 176° aspect. The low shrub layer was composed of B. glandulosa and the dwarf shrub layer of L. decumbens (northern Labrador tea) and V. vitis-idaea. Trees in this area were of mixed age with 1 tree being 89 years old and 2 others averaging 27 years. This was a relatively dry area.

The second elevation, top position, was another low birch shrub scrub type located on a gentle break in the 15° slope. Elevation was 792 m (2600 ft) on a 5° slope with 144° aspect. The low shrub layer was composed of B. glandulosa and a dwarf shrub layer of L. decumbens and V. vitis-idaea. Betula glandulosa usually occurred on mounds with other lower growing species growing beneath the shrub layer. Most trees at this site averaged 31 years of age although 1 was 100 years old and a dead tree was 157 years old.

The middle slope position was in an open mixed spruce-birch forest at an elevation of 701 m (2300 ft) with 14° slope and 157° aspect. It was located about 35 m above the potential impoundment area and might be affected by mesoclimatic changes associated with the reservoir. The exclosures were placed on either side of an open, grassy area in the forest type. Understory vegetation in 1 exclosure was dominated by V. vitis-idaea with some Cornus canadensis and Mertensia paniculata (tall bluebell). The other exclosure was dominated by Calamagrostis canadensis, Equisetum silvaticum (woodland horsetail), and M. paniculata. Average age for 6 trees at this site was 37 years, making it one of the youngest sites. It also appeared to be the warmest site, as indicated by plant species composition, the time at which plant growth was initiated, and soil temperatures.

The bottom location was a woodland black spruce type with exclosures on either side of a wet sedge-grass-shrub meadow. The slope was <1° and aspect averaged 119° although 1 exclosure faced south-southeast and the other faced east-northeast. At an elevation of 610 m (2000 ft), this site would be in the potential impoundment zone. Important vegetation consisted of B. glandulosa, L. groenlandicum, Empetrum nigrum, and graminoids. Mean age of 4 trees was 146 years, the oldest average of any site.

5.2.1.1.3 - Switchhback Transect

The bench location at the Switchback transect (Fig. 3) was in a low birch shrub scrub type. The site was at an elevation of 762 m (2500 ft) with average slope of 6° and aspect of 250°. Vegetation consisted of a B. glandulosa low shrub layer and a dwarf shrub layer of L. decumbens, V. vitis-idaea, and lichens. The average age of 3 trees was 35 years, although 1 tree was 91 years old.

The top-slope elevation was located on the bench as it broke toward the river at an elevation of 762 m (2500 ft), 96 m above the potential Watana impoundment. This site was in an ecotone between low birch shrub scrub and woodland white spruce with an average slope of 1° and aspect of 275°. Important species included B. glandulosa, V. uliginosum, and lichens. Average age of 3 trees was 56 years while a fourth individual was 163 years old. Fire scarred snags were present.

The middle slope location was just upstream from a dry knoll. Vegetation was an open spruce type at an elevation of 701 m (2300 ft) with 16° slope and 189° aspect. The site was 35 m above the potential impoundment zone. Important plant species included B. glandulosa, L. groenlandicum, and S. pulchra. Moss covered over half the area. The average age of 3 trees was 41 years while 1 was estimated to be 210 years old. This supported the contention that a relatively recent fire had occurred at this site.

The bottom elevation at the Switchback location was in an alder-spruce type with 3° slope and 210° aspect at an elevation of 640 m (2100 ft). This site would be flooded by the impoundment. The most abundant plants at this site were Alnus sinuata, Ribes triste, and several forb species. This was a relatively moist site. Mean age of 5 trees was 143 years, making it one of the oldest sites sampled.

5.2.1.1.4 - Tsusena Creek Transect

The transect downstream from Tsusena Creek was the only one in the potential Devil Canyon impoundment area (Fig. 3). The bench location was a low birch shrub scrub type at an elevation of 758 m (2486 ft) on a mean slope of 3°. Aspects of the 2 exclosures were 232° and 86° at this site which was on top of a knoll. Abundant vegetation consisted of Betula glandulosa over a layer of L. groenlandicum, and E. nigrum. Betula glandulosa was much taller at this site than at other sites. Moss covered about 85% of the area and was about 8 cm deep, which was much deeper than at sites on other transects. Average age of 3 trees was 114 years while 1 individual was 56 years old. This site had not been disturbed as recently as other sites and was well above timber line.

The top-slope position on the Tsusena Creek transect was another low birch shrub scrub type at an elevation of 635 m (2086 feet) on a 7° slope with aspects of 110° and 20°. Vegetation consisted of a low shrub layer of B.

glandulosa and a dwarf shrub layer of L. groenlandicum and E. nigrum. Moss covered about three-fourths of the ground and was about 8 cm deep. Average age of 4 trees was 87 years.

The bottom location was in an open spruce type with 2° slope and aspects of 5° and 140° at an elevation of 512 m (1680 ft). This site was on a level, forested area by the Susitna River. Vegetation consisted of B. glandulosa, L. groenlandicum, and V. vitis-idaea. Moss covered 90% of the ground. Mean age of 4 trees was 135 years.

5.2.2 - Photographic Points

Photographic points inside and outside each exclosure were permanently marked with 30 to 45-cm long rebar painted fluorescent orange which were driven into the ground. Photographs of the vegetation were taken each time the site was sampled to document phenological development of plant species. Photographs were taken looking uphill from a height of 1.6 m using a Fujica ST605 camera with 28 mm lens. The rear 2 fence posts were located in the upper corner of the photograph. Sometimes 2 photographs had to be taken to include some of the taller vegetation. Individual twigs of shrubs were flagged and photographed each week outside some exclosures to record development of individual twigs. Species selected for individual tagging were Betula glandulosa, Ledum groenlandicum, and Rosa acicularis. Selection of individuals was random.

5.2.3 - Soil Temperature

Soil temperature at the 10-cm depth was taken inside each exclosure using a bimetallic thermometer with a dial scale. The temperature was always measured in a "typical" location in the shade to avoid daily heating effects of the sun. Hence, the thermometer location varied slightly from week to week because the sun angle as well as our arrival time would vary. The thermometer was allowed to equilibrate in the ground while plant canopy cover was estimated. Soil temperatures were used to monitor the warming of sites because daily ambient temperatures were extremely variable.

5.2.4 - Canopy Cover

Percent canopy cover was ocularly estimated in 0.5 x 1-m (0.5-m^2) quadrats using 5% intervals (1% if < 10% or > 90%). Two quadrats were randomly located outside the exclosure by pacing a random number of steps from a randomly selected corner of the exclosure. Quadrats outside the exclosure were independent of each other across weeks. Two quadrats were randomly located inside each exclosure but were not independent across weeks because of the limited size of exclosures. Cover was the vertical projection of living vegetation and did not include canopy gaps. Canopy cover was estimated by species for most vascular plants, by genus for sedges, and by life form for bryophytes, lichens, and unidentified forbs and grasses.

5.2.5 - Height and Phenological State of Growth/Maturation

Average height (cm) and most advanced phenological state were recorded for each plant species in each quadrat inside and outside the exclosures. Phenological stages were as follows:

vegetative	(1) just emerging or first signs of new growth or dormant for evergreens
	(2) leaf buds visible
	(3) leaves expanded
anthesis	(4) flower buds
	(5) flowers
fruiting	(6) seeds
	(7) decadent.

In some evergreen species, such as _Vaccinium vitis-idaea_, it was extremely difficult to tell when the plant initiated new growth in the spring. New leaves were the same color as old leaves. Thus, unless a leaf was only partially emerged, new growth could not be easily determined. Hence, some phenological states for some species were not as precise as for others.

5.2.6 - Biomass Estimations

Standing crop biomass (current annual growth) of forbs and graminoids, and current annual growth biomass of 4 individual twigs with associated leaves of *Betula* spp., *Salix* spp., and *Alnus* spp. was estimated within each 0.5-m^2 plot. Forbs and graminoids were clipped at ground or moss level. The current growth (leaves and stems) of each designated shrub species occurring within a plot was clipped from 4 representative twigs. This permitted an analysis of total mass per 4 twigs, but not mass/unit area. During the first 5 weeks (31 May through 2 July) only plots located outside the exclosures were clipped. During week 6 (31 August through 3 September) plots inside and outside the exclosures were clipped. This information makes up the phenology current annual growth data set.

The scope of biomass estimations for the phenology study was changed for week 6 sampling. In addition to the data collected as described above, all of the current annual growth of shrubs was clipped in the plots both inside and outside the exclosures. From those clipped samples 4 twigs of the designated shrubs were subsampled from each plot to complete the phenology current annual growth data set. Furthermore, all *Vaccinium vitis-idaea* was clipped in each plot because of its potential importance as moose forage (Oldemeyer 1977, W. L. Regelin, ADF&G, *personal communication*). The information on total current annual growth of shrubs sampled during week 6 makes up the phenology total current annual growth data set.

All clipped samples were oven-dried for 48 hours at 60°C and weighed to the nearest 0.01 g. Twigs of shrubs were stripped of leaves, and both components weighed separately.

Statistical analysis of the plant current growth biomass data for the phenology study consisted of analysis of variance using a nested design for both current annual growth and total current annual growth data sets. Transect location was treated as the main effect. Elevation was nested within transect, and exclosure and week were nested within elevation. This design applied to the current annual growth data, weeks 1 through 6 outside the exclosures. For data collected during week 6 (current annual growth and total current annual growth inside and outside) the nested design was similar as described above, except that inside/outside exclosure comparisons were nested within elevation. Tukey's test was used as a mean separation procedure. Statistical significance was accepted at $P \leq 0.05$.

5.2.7 - Current Annual Growth Twig Diameter - Length Relationships

Four twigs of each shrub species were clipped from within the 0.5-m^2 plots of the phenology study. The twigs were clipped at the leaf bud scale to remove only the current annual growth. Shrubs were clipped from plots located outside the exclosures during weeks 1 through 5 and from plots both inside and outside the exclosures during the last week (week 6) of sampling. The basal diameter and total length of each twig was measured to the nearest 0.1 mm with calipers.

A mean diameter and length was calculated for each species and tested for significant differences among species with paired t-tests. Simple linear regression equations were developed for each species, examining the relationship between basal diameter of the twig and its total length. Statistical significance was accepted at $P \leq 0.05$. The number of twigs needed to adequately estimate within 20% of the mean with 67% confidence in that measurement was also calculated for each measurement taken on each species.

5.2.8 - Tree Ring Analysis

Two tree cores were taken as close to the ground as practical from 2 trees or snags near each exclosure when possible. These data were collected to age the present plant community at each site in an effort to determine fire history. Ages of living trees were determined by counting rings after the cores had been sanded smooth on one side. The cores of dead snags were in such poor condition that the rings could not be counted.

This study was included in the original proposed methodology. During the early phases of the phenological study, it was noted that the sites with the earliest maturing forage appeared to have a relatively recent burn history whereas the latest maturing sites had a deep moss layer and little evidence of fire. Cores of living and dead trees were obtained in an attempt to determine the fire history of each site. Field time did not permit an intensive collection of cores. The intention of coring snags was to match tree ring patterns of living and dead trees in an attempt to determine how long since the trees had died and hence when the fire occurred, assuming the trees died during the fire. Limited laboratory time and poor quality cores did not permit this analysis.

If all the tree ages at one site were approximately the same, then the mean age was taken as the age of the stand. If the trees were of uneven age, the older individuals were assumed to be survivors of a fire (they usually had fire scars) while the younger trees were considered to be reproduction since the fire. Both sets of ages were reported as well as the number of trees. This was a qualitative study intended to determine if the hypothesis relating recent burn history to early forage availability was reasonable.

5.2.9 - Statistical Analysis - Cover

Cover were analyzed using an analysis of variance model with nested mixed effects. The model consisted of transect, elevation, inside/outside exclosure, exclosure, and plot. Transect, elevation, and inside/outside were fixed effects since each level was unique, rather than a random sample of a population. Each transect also represented either documented presence or absence of radio-collared moose. Each elevation was a particular location with respect to slope. Exclosures and plots represented random locations from the population of exclosures and plots.

The model was nested since the levels (bench, top, middle, bottom) of the nested factor (elevation within transect) were different for each level (Watana, Jay, Switchback, Tsusena) of the main factor (transect). Even though the bottom elevations of the Watana and Jay Creek transects were both the lowest elevation on those transects, geographical considerations dictated that they were different and hence nested within their respective transects (as opposed to being cross-classified). Cover data for each week were analyzed using this model since we were primarily interested in spatial differences at a given point in time rather than changes over time. Additionally, computer core limitations would not permit analysis over time.

5.3 - Alphabet Hills Pre-burn Inventory and Assessment

To facilitate the vegetation inventory of the burn area, the Alphabet Hills area was mapped at the scale of 1:24,000 (Fig. 4, back pocket) by vegetation type to Level III of Viereck et al. (1982) during June, 1982. From this map, sites to be sampled were selected based on known locations of moose (W. B. Ballard, ADF&G, personal communication). Sites were then randomly assigned within each vegetation type. The number of sites sampled in each vegetation type were based on the amount of area occupied by that type and the perceived variability of that type within the study area.

Twenty-five sites in the Alphabet Hills were sampled from 13-21 July 1982. At each site, 2 parallel 50-m line transects were established, spaced 10 m apart. Plots were located every 10 m along each transect. In addition, 1 site in each vegetation type contained 20 plots, spaced at 5-m intervals along each transect line. A number of steps were taken to permanently mark each site. At the center of each plot location, a 76 cm (2.5 ft) long, 1.3 cm (0.5 inch) diameter conduit was driven into the ground so it protruded approximately 30 cm (1 ft) above ground level. A numbered metal tag was wired to the top of each conduit stake for identifying purposes. A 120-cm (4-ft) conduit tripod was placed in an open area near plot location #1 and a metal tag identifying the site was wired to the top of the tripod.

Photographs were taken of 1) each 1-m^2 quadrat lying in position at each plot location, 2) each 50-m line transect from both ends and 3) of the general site from the tripod near plot location #1. At each plot location a number of measurements were taken.

5.3.1 - Canopy Cover

At each permanent plot location a 1-m^2 (1 x 1 m) quadrat was sampled for canopy cover of plant species within the vertical projection of the boundaries of the quadrat. The quadrat was oriented such that the left-rear corner was touching the conduit stake in the center of the plot location. Percent canopy cover of life form totals, dwarf shrubs, forbs, graminoids, bryophytes, and lichens as well as litter, dead wood, bare ground, and water were ocularly estimated within each 1-m^2 quadrat. Percent canopy cover was estimated using 5% cover increments if plant cover was between 10 to 90% (10, 15, 20,..., 90%) and 1% cover increments in the 1 to 9% and the 91 to 99% ranges. Percent canopy cover of forbs, graminoids, and shrubs was estimated by species and life form totals. Percent cover for several graminoids and lichens was estimated by genus and life form totals. Percent cover of bryophytes was estimated as a life form total and in some cases by genus.

At each permanent plot location along each transect line, a 4-m^2 circular quadrat was also delineated by rotating a rope, 1.13 m in length, around the metal stake in the plot center. Percent canopy cover of trees, tree saplings, tree seedlings, tall shrubs, and low shrubs was ocularly estimated using the same cover increments as for the 1-m^2 quadrat. Trees were > 1.13 m in height and had diameter-at-breast-height (dbh) measurements exceeding 2.5 cm. Saplings were > 1.13 m in height with < 2.5 cm dbh's and seedlings were < 1.13 m in height.

5.3.2 - Shrub and Tree Stem Density

Density of tall shrubs was estimated by counting the number of stems rooted within the 4-m^2 circular quadrat. A distinction was made between live and dead plants. Shrubs were also tallied by 1-cm basal diameter classes: 0-1 cm; 1-2 cm; 2-3 cm; and 3-4 cm.

Tree density was estimated using the point-centered quarter method (Mueller-Dombois and Ellenberg 1974). At each location along the transect lines, the center of a circular plot with a radius of 33.3 m (3485 m^2) was established. Within each quarter of the circle, the distance to the nearest individual of each species present within the quadrant was measured. The total height and dbh of these trees was also estimated. Both live and dead trees were examined. Tree seedlings and saplings were also tallied.

5.3.3 - Browse Utilization

The point-centered quarter method was also used to estimate utilization of <u>Salix</u> spp., <u>Alnus</u> spp., and <u>Betula</u> spp.. Plots had a radius of 5 m (79-m^2). The closest shrub of each species in each quadrant was measured for distance from the plot center and basal diameter by size class (0-1 cm, 1-2 cm, 2-3 cm, and 3-4 cm). Shrubs had to be at least 40 cm in height (average snow depth) to be sampled. The number of unbrowsed and "recently" browsed twigs above 40 cm were counted on the shrubs.

A twig was defined as a branch that had a basal diameter equal to the estimated diameter at point-of-browsing (DPB) for that shrub species. The average DPB for each shrub species was estimated for the Alphabet Hills by randomly measuring twigs that had been "recently' browsed at a number of sites over the study area. Utilization of browsable twigs was expressed as a percent by dividing the number of browsed twigs by the total number of browsed and unbrowsed twigs for each stem.

5.3.4 - Browse Availability

Biomass estimates based on the diameter at point-of-browsing (DPB) were made by clipping, at random, approximately 25 twigs from a number of individuals of every species examined. These twigs were trimmed to the average DPB (mm), oven-dried at 60°C for 48 hrs, and weighed to the nearest tenth gram. Stems and leaves were weighed separately.

Average weight per twig and its associated leaves by shrub species was multiplied by the mean number of unbrowsed twigs/stem in each vegetation type. This total was then multiplied by the average number of stems/ha for each species to produce estimates of total kg/ha of unbrowsed forage biomass. Estimates of total kg/ha of forage already utilized was calculated in the same manner using average number of browsed twigs/stem. Available and utilized leaf biomass were estimated for summer use only.

5.3.5 - Statistical Analysis

Analysis consisted of descriptive statistics ($\bar{x}$, SE, N) and comparisons among similar vegetation types. In addition, the number of plots that needed to be sampled to estimate within 20% of the mean of each plant species, with 67% confidence in those estimates, was determined for cover and twig count data. Spearman's rank-order correlation (r_s) was used to compare relationships in cover among vegetation categories (shrub, graminoid, forbs, lichens) across vegetation types. Only individual plant species or life form total average measurements with a mean ≥ 1 are presented in the tables.

5.3.6 - Soils

To assess the chemical composition of soils found within the Alphabet Hills study area, samples were taken at each site where vegetation sampling occurred. At each site where vegetation was examined in 10 plots, soils were taken at plots 2, 5, and 7. At each site where 20 vegetation plots were examined soils were sampled at plots 1, 7, 13, and 17. At each plot location, the soil was cored at a distance of 1.13 m from the plot center, perpendicular and to the right of the line of travel.

A cylindrical coring device, approximately 15 cm in diameter and 45 cm deep, was used to take soil samples. The coring device was pushed into the soil and a built-in plunger was used to push the soil and litter core out of the cylinder after extraction.

Each of the soil cores were sampled to a depth of 15 cm, where possible. Depth of the organic matter layer was measured, removed from the core, and placed in a cloth bag. The soil profile was divided into 0-5 cm, 5-10 cm, and 10-15 cm depths which were separated and stored in labelled plastic bags. Soil samples were submitted to the Alaska Agricultural Experiment Station Plant and Soil Analysis Laboratory, Palmer. The analysis performed consisted of:

1) pH (1:1 water-soil method)
2) available potassium, calcium, and magnesium measured in parts per

million (neutral 1 normal, ammonium acetate extraction method),

3) total nitrogen and phosphorus measured in parts per million (modified Kjeldahl method, then autoanalyzed),

4) sand, silt, and clay measured by percent (hydrometer method),

5) organic matter measured by percent (Walkley-Black method),

6) copper, zinc, manganese, and iron measured in milligrams per gram (DPTA extraction method).

At each plot where soils were sampled, depth to permafrost was recorded. These readings were derived by using a frost probe measuring 110 cm in length that was pushed into the soil profile until permafrost was reached. Six readings were taken at each of the plots where soil samples were taken at various points radiating not more than 5 m from plot center. These readings were then pooled in order to derive an average depth to permafrost at each of these plots.

Analysis consisted of descriptive statistics ($\bar{x}$, standard deviation, N) and comparisons of the soils among depths and among vegetation types of the variables measured. Analysis of variance incorporating a nested design was used to test differences in soil parameters among vegetation types. Sites were nested within vegetation types and depths nested within sites.

5.4 - Species List and Range Extensions

Identification and verification of plant species not previously reported with ranges extending into the Susitna River Basin was undertaken to document their presence and range extensions. Unknown species on the various studies were collected and identified. If the species had not been identified previously, it was added to the list of species for the study area. If the occurrence was outside the range indicated by Hulten (1968), then it was added to the range extension list. No special attempt was made to find new species as an end in itself, although several new species were found in the phenology study because we were looking for forbs and this was the earliest that plant ecology studies had been initiated.

6 - RESULTS AND DISCUSSION

Results and discussion of the 3 studies are presented in the same sequence as in the Methods section; browse inventory, plant phenology, and Alphabet Hills pre-burn inventory and assessment. Results for the browse inventory and Alphabet Hills studies are presented by vegetation type. A comparison of the browse inventory and Alphabet Hills vegetation types follows the discussion of the Alphabet Hills results. Plant phenology results are presented by week of study and for individual species through time and by study site location.

6.1 - Browse Inventory

During the browse inventory and plant phenology studies in the Susitna River Basin, 14 new vascular plant species (Table 2) were added to the species list compiled by McKendrick et al. (1982) and are found in Appendix A. Eight new species were located upstream during the plant phenology study while 1 new species was found during the browse inventory study. Another species, Ribes hudsonianum (northern black currant), had been previously found downstream, but has now also been identified upstream. A total of 294 vascular plant species have been found during vegetation studies on the Susitna River project. This includes a total of 58 families and 146 genera. Two hundred sixty-eight species in 57 families and 138 genera have been identified upstream. Several of these species were not found before because field work had not started in early as May in the past.

Range extensions for 2 species were made. Primula egaliksensis (Greenland primrose) and Ribes hudsonianum were found upstream. Ribes hudsonianum was previously reported as a downstream extension, but its location upstream was also a range extension Additionally, 4 genera of mosses were identified, and 2 species of lichens were identified for a previously reported genus.

A list of the scientific and common names of species appearing in this report are tabulated by life form in Appendix B. For simplification, *Salix planifolia* subsp. *pulchra* is referred to as *Salix pulchra* in this report.

Average DPB measurements for shrub species in the middle Susitna River Basin are shown in Table 3. *Alnus sinuata*, *Betula papyrifera*, and *Salix glauca* DPB measurements all averaged 3.5 mm. Individual DPB measurements often exceeded these average values. This was particularly evident for some *Salix* spp. when they occurred in low densities scattered among less preferred browse species, e.g. *B. glandulosa*. Individual DPB measurements were smaller than the average measurement when smaller twigs adjacent to a dominant terminal twig were taken in the same bite. From our observations it appeared that no attempt was made to browse secondary twigs beyond the initial bite.

The average weight per twig and for the attached leaves was greatest for *A. sinuata* (Table 3). Mean weight of attached leaves was similar among *S. pulchra*, *S. glauca* and *A. sinuata*. Leaves attached to twigs would only be available as forage either during the summer growing period or after leaf drop in the fall when leaves accumulated on the ground. Some leaves probably remained on some twigs during at least part of the winter.

The 47 browse inventory sites were grouped at Level IV of Viereck et al. (1982) for presentation of results. A much more intensive sampling effort would be required to produce adequate mean and variance estimates for vegetation types at Level V. Level IV and the associated Level V vegetation types sampled in the middle Susitna River Basin during summer, 1982 are shown in Table 4.

Ten vegetation types defined at Level IV of Viereck et al. (1982) were sampled in the middle Susitna River Basin during summer, 1982. These 10 vegetation types were classified under 2 broad Level I (Viereck et al. 1982) vegetation classifications; forest and scrub. Within the forest classification are those types with trees 3 m or more in height at maturity and totaling at least 10% crown canopy cover. The scrub classification includes vegetation types with < 10% tree cover and with low and dwarf shrub categories comprising ≥ 25% absolute cover.

6.1.1 - Forest

The forest classification was subdivided according to: 1) the dominant tree types (i.e. needleleaf, broadleaf and mixed), 2) by dominant tree species, and 3) by tree crown cover percentage. Needleleaf and broadleaf types had at least 75% of the tree cover provided by needleleaf or broadleaf trees, respectively. The open types contained 25-50% tree cover. The division between open and closed forest was retained at 50%, rather than the 60% that Viereck et al. (1982) used, to maintain continuity with the studies conducted by McKendrick et al. (1982). No closed forest types were sampled. The woodland types had 10-25% tree crown canopy cover.

6.1.1.1. - Needleleaf Forest

Needleleaf forests were dominated by Picea glauca (white spruce) or Picea mariana (black spruce).

6.1.1.1.1. - Open White Spruce Vegetation Type

Seven sites were sampled in the Open White Spruce vegetation type. The Open White Spruce type contained P. glauca as the dominant overstory tree, although P. mariana was often present. The tall shrub (shrubs over 1.5 m in height) layer was composed entirely of Alnus sinuata (Sitka alder) while the low shrub (shrubs 20 cm - 1.5 m in height) layer had small cover percentages of Betula glandulosa (resin birch), Salix pulchra (diamond leaf willow) and S. glauca (glaucous willow) (Tables 5 and 6). Canopy cover percentages for both tall and low shrubs were very similar between the 0.5-m^2 quadrat (Table 5) and the larger 4-m^2 quadrat (Table 6). The dwarf shrub (shrubs < 20 cm in height) layer totaled 31% cover, dominated by Vaccinium uliginosum (bog blueberry) and V. vitis-idaea (mountain cranberry) (Table 5). As noted by McKendrick et al. (1982:39) and Viereck (1970:12), the forb Linnaea borealis (twinflower) was observed in this study only in vegetation types dominated by P. glauca overstory. Average percent cover for individual forbs was low, but they were relatively consistent from plot-to-plot as evidenced by low standard errors and low estimated sample sizes (Table 5). The Open White Spruce vegetation type had low canopy cover of both graminoids and lichens.

The average density of stems (#/ha) for S. glauca and S. lanata was greater in the Open White Spruce vegetation type than in the other needleleat forest types sampled in the middle Susitna River Basin (Table 7). Approximately 94% of B. glandulosa stems were ≤ 1 cm in basal diameter. The greatest density of Salix lanata (Richardson willow) and S. glauca in the needleleaf forest types was found in the Open White Spruce vegetation type.

The average basal diameter, height, and percent utilization of tall and low shrub species in the Open White Spruce vegetation type is shown in Table 8. The average basal diameter of all shrubs was less than 2 cm, which corresponded closely with results from density estimates based on size classes (Table 7). Percent utilization of twigs in the Open White Spruce type averaged 5% for all shrub species. Alnus sinuata was utilized in about the same percentages as the Salix spp. and B. glandulosa shrubs in this vegetation type (Table 8).

Total available biomass of twigs and leaves for shrub species in the Open White Spruce vegetation type is shown in Table 9. Total available woody twig biomass totaled 208 kg/ha. Thirty-seven percent of available woody twig biomass was A. sinuata, which, presumably, is not a preferred browse species of moose in the study area. Utilization estimates show slightly higher utilization for A. sinuata (6%) than for S. pulchra (4%) (Table 8), which was probably the most heavily hedged browse species measured in the Open White Spruce type. The 3 Salix spp. composed 54% of the total available twig biomass and 58% of the total available leaf biomass (Table 9). Salix pulchra had higher estimates of both available and utilized biomass than S. glauca.

Average current annual growth (CAG) of forbs for the 6 sites in the Open White Spruce vegetation type was 159 kg/ha (Table 10). Leaf CAG of shrubs ranged from 1 to 9 times higher in weight than the twig CAG to which they were attached. Alnus sinuata, R. acicularis, and S. glauca produced from 9 to 20 kg/ha of leaf CAG biomass. Alnus sinuata also produced the greatest twig CAG biomass (12 kg/ha), while 7, 4, and 9 kg/ha of twig CAG biomass were produced by S. glauca, B. glandulosa, and S. pulchra, respectively (Table 10). Approximately 36 kg/ha of twig CAG and 79 kg/ha of leaf CAG were produced by tall and low shrubs in the Open White Spruce vegetation type.

6.1.1.1.2 - Open Black Spruce Vegetation Type

Ten sites were sampled in the Open Black Spruce vegetation type. The Open Black Spruce type contained P. mariana as the dominant tree in the overstory layer, although P. glauca was also often present. The understory of the Open Black Spruce vegetation type (Tables 11 and 12) was similar to the understory of the Open White Spruce vegetation type (Tables 5 and 6) for both species composition and percent canopy cover. Alnus sinuata was the only tall shrub sampled in the Open Black Spruce vegetation type (Tables 11 and 12). Betula glandulosa and S. pulchra had the greatest canopy cover in the low shrub layer while V. uliginosum and E. nigrum had the greatest average canopy cover in the dwarf shrub layer. Viereck (1970:10) showed increasingly greater cover percentages of V. vitis-idaea as the overstory changed from P. glauca to P. mariana - dominated stands along the Chena River in interior Alaska. Although the difference in this study was between the Open Black Spruce and Open White Spruce vegetation types, our data show the opposite trend in changing cover of V. vitis-idaea (Tables 11 and 5).

Total average moss cover was greater in the Open Black Spruce type than in the Open White Spruce vegetation type (Tables 11 and 5). Sphagnum girgensohnii and Hylocomium splendens were dominant mosses in a climax P. mariana/Sphagnum spp. stand on the Chena River in interior Alaska (Viereck 1970:11). The Open Black Spruce vegetation type in the Susitna River Basin had low canopy cover of both graminoids and lichens (Table 11).

The average density of stems/ha for B. glandulosa and S. pulchra was greater in the Open Black Spruce vegetation type than for any other type in the needleleaf forest (Table 13). Over 97% of B. glandulosa stems and 62% of S. pulchra stems were ≤ 1 cm in basal diameter. Betula glandulosa stem densities in this size class averaged approximately 4 stems/m^2 in the 10 sites sampled in the Open Black Spruce vegetation type. The average density of A. sinuata in the Open Black Spruce vegetation type was comparable in both size class distribution and density estimates to the Open White Spruce vegetation type (Tables 13 and 7).

The average basal diameter of B. glandulosa shrubs was smaller in the Open Black Spruce vegetation type (Table 14) than in the Open White Spruce vegetation type (Table 8). This was partially explained by the high density of 0-1 cm diameter stems in the Open Black Spruce vegetation type (Table 13). Both S. glauca and S. pulchra twigs were utilized in the Open Black Spruce type to a greater extent by browsing animals than in the Open White Spruce vegetation type. Only 2% of B. glandulosa and A. sinuata twigs were utilized.

Forty percent of the total available twig biomass in the Open Black Spruce vegetation type was B. glandulosa while 30% was S. pulchra (Table 15). Available woody biomass of S. pulchra was almost 2 times greater in the Open Black Spruce than in the Open White Spruce vegetation type. In contrast to the Open White Spruce type, S. pulchra had substantially higher utilized biomass estimates in the Open Black Spruce vegetation type (Table 15). This difference was due largely to greater stem densities and higher percent utilization of S. pulchra in the Open Black Spruce type (Tables 13 and 14). Betula glandulosa and S. pulchra had the greatest available biomass, together comprising 67% of the total available biomass.

Total forb CAG was approximately 35% lower in the Open Black Spruce type than the Open White Spruce type (Table 16). However, total graminoid CAG was 10% greater in the Open Black Spruce type (Tables 16 and 10). Salix pulchra and B. glandulosa had the highest leaf CAG production (Table 16). Total leaf CAG for tall and low shrubs was 64 kg/ha and twig CAG totaled 32 kg/ha. Although the bulk of leaf and twig CAG produced in the Open Black Spruce vegetation type was mainly by S. pulchra, B. glandulosa, and A. sinuata, the total leaf and twig CAG estimates were comparable to total CAG estimates for the Open White Spruce vegetation type.

6.1.1.1.3 - Woodland Spruce Vegetation Type

Three sites were sampled in the Woodland Spruce vegetation type, which contained both P. mariana and P. glauca in the overstory (Tables 17 and 18). The average percent cover of B. glandulosa ranged from 1 to 19% over the 3 sites. The dwarf shrub layer was the major contributor to shrub canopy cover in the Woodland Spruce vegetation type (Table 17). Vaccinium uliginosum, V. vitis-idaea and E. nigrum were the dominant dwarf shrubs. Total moss cover was similar to moss canopy cover in the Open Black Spruce vegetation type (Tables 17 and 11). Canopy cover of lichens, particularly Cladonia spp., was greater in the Woodland Spruce vegetation type than in the other needleleaf forest types that were sampled.

Average density of S. pulchra and S. glauca stems was lower in the Woodland Spruce vegetation type than in other needleleaf forest types (Table 19). Approximately 67% and 96% of S. pulchra and S. glauca stems, respectively, were ≤ 1 cm in basal diameter. Approximately 93% of the B. glandulosa stems were in the smallest basal stem size class (Table 19).

Percent utilization of S. pulchra, S. glauca, and A. sinuata twigs was substantially greater in the Woodland Spruce vegetation type (Table 20) than either the Open White Spruce (Table 8) or Open Black Spruce (Table 14) types. It should be noted, however, that the number of plants actually sampled for those shrub species in the Woodland Spruce vegetation type was low. Generally, palatable shrub species were observed to be heavily browsed when densities were low or when they had a scattered distribution. Individual shrubs often received heavier browsing pressure when growing at low density than when stem density was relatively greater.

Betula glandulosa made up approximately 78% of the total available biomass in the Woodland Spruce vegetation type (Table 21). Salix pulchra had only 27 kg/ha of woody twig biomass which would be available as winter browse. Low stem densities (Table 19) and 30% utilization of S. pulchra twigs (Table 20) contributed to only 14 kg/ha estimated for twig biomass already utilized.

Total forb CAG biomass estimates were lower in the Woodland Spruce vegetation type than for any other forest type sampled. Mean forb CAG biomass was 54 kg/ha and total graminoid CAG was 65 kg/ha (Table 22). Total tall and low shrub leaf CAG was 20 kg/ha and twig CAG was only 10 kg/ha.

6.1.1.2 - Broadleaf Forest

Broadleaf forest types were restricted to the steep canyon walls along the Susitna River and tributary drainages. Betula papyrifera (paper birch) dominated the overstory of the broadleaf forest type sampled for the browse inventory study.

6.1.1.2.1 - Open Birch Forest Vegetation Type

Alnus sinuata was the principal shrub species in the understory of the single site sampled in the Open Birch Forest vegetation type (Tables 23 and 24). Below a B. papyrifera overstory, nearly 50% of the understory vegetation was composed of forbs (Table 23). Dryopteris spp. (shield fern) was the dominant forb, making up approximately 72% of the total forb cover. Moss canopy cover was about one-third less than in needleleaf forest types. Nearly 50% of the ground layer was covered by litter, primarily leaves of B. papyrifera.

Species of Salix were essentially absent in the Open Birch Forest vegetation type (Tables 23, 24, and 25). Very low densities of B. glandulosa, all with small basal diameters, were found in this type. Alnus sinuata, growing in the understory of B. papyrifera in this vegetation type, had the highest stem densities ($0.5/m^2$) of all vegetation types sampled (Table 25). Alnus sinuata growing in the Open Birch Forest vegetation type also had the largest average basal stem diameter and height measured in any of the vegetation types sampled (Table 26). Percent utilization of both B. glandulosa and A. sinuata twigs was very low in this type.

About 99% of available browse for moose in the Open Birch Forest was A. sinuata (Table 27). However, utilization of A. sinuata was almost non-existent for the 48 stems sampled in this type (Table 26), thus biomass estimates for utilized A. sinuata leaves and twigs were also very low.

The Open Birch Forest type had by far the largest canopy cover of forbs of all vegetation types sampled (Table 23), averaging 578 kg/ha CAG biomass (Table 28). The forb CAG was composed primarily of Dryopteris spp., however Linnaea borealis, Lycopodium spp., Cornus canadensis, and Rubus chamaemorus were consistently found in plots sampled in this type (Table 23). *Alnus sinuata* was the only tall shrub that occurred in plots sampled in the Open Birch Forest vegetation type, averaging only 2 kg/ha woody CAG biomass (Table 28).

6.1.1.3 - Mixed Forest

The mixed forest types had overstory cover that was intermediate between that of needleleaf forests and broadleaf forests. The mixed forest type is typical of interior Alaska and is dominated by a *P. glauca* and *B. papyrifera* overstory. McKendrick et al. (1982:43) suggested that mixed forests were probably successional stands which developed as needleleaf forest replaced broadleaf forests.

6.1.1.3.1 - Open Spruce-Birch Forest Vegetation Type

The *P. glauca* - *B. papyrifera* dominated overstory of the single site sampled in the Open Spruce-Birch Forest vegetation type was located on a south-facing slope of the Susitna River canyon. The low shrub *Ribes triste* (red currant) and dwarf shrubs *V. vitis-idaea*, *V. uliginosum*, and *Ledum groenlandicum* were common understory shrub species (Table 29). *Betula glandulosa* was the only low shrub species sampled in the 4-m^2 quadrats (Table 30). *Epilobium angustifolium*, *Mertensia paniculata*, and *C. canadensis* were the dominant forbs (Table 29). *Linnaea borealis* was found in the Open Spruce-Birch Forest vegetation type in approximately the same cover percentages as in the Open White Spruce vegetation type; both have *P. glauca* trees in the overstory. Similar to the Open Birch Forest vegetation type, litter cover was high (59%). However, moss cover was low (6%) in relation to the Open Birch Forest (Tables 29 and 23). Low density and a clumped distribution pattern in this vegetation type resulted in no shrubs being rooted in the 4-m^2 quadrats. Thus, stem densities could not be calculated for shrub species.

Where B. glandulosa and A. sinuata shrubs were present in the Open Spruce-Birch Forest vegetation type, they were utilized relatively more heavily than in other vegetation types (Table 31).

Total forb CAG biomass in the Open Spruce Birch Forest vegetation type was approximately half as abundant in the Open Spruce Forest, averaging 284 kg/ha (Table 32). Populus balsamifera (balsam poplar) had 6 kg/ha and Rosa acicularis had 5 kg/ha of twig CAG biomass. Sixty-nine percent (42 kg/ha) of the total leaf CAG biomass (61 kg/ha) was R. acicularis. Woody twig CAG totaled 13 kg/ha in this type (Table 32).

6.1.2 - Scrub

6.1.2.1 - Low Shrub Scrub

Low shrub scrub vegetation was composed of vegetation types dominated by shrubs between 20 cm and 1.5 m in height and with ≥ 25% canopy cover of shrubs in this height range. Total canopy cover of tall shrubs such as A. sinuata was < 25%.

6.1.2.1.1 - Dwarf Birch Vegetation Type

The low shrub B. glandulosa dominated the 19 sites sampled in the Dwarf Birch vegetation type (Tables 33 and 34). Salix pulchra, a preferred item in moose diets (Milke 1969, Peek 1970), was scattered in distribution in this vegetation type. Other predominant shrub species included the dwarf shrubs V. uliginosum, E. nigrum and L. groenlandicum (Table 33). Total lichen cover was 20%, which was the second largest mean total lichen cover for all vegetation types sampled. Cladonia spp. and Stereocaulaon paschale were the prevalent lichen species in the Dwarf Birch vegetation type (Table 33).

The greatest density of B. glandulosa stems of all vegetation types sampled was in the Dwarf Birch vegetation type (Table 35). Approximately 88% of the stems had basal diameters ≤ 1 cm in size. Many small seedlings and root sprouts of B. glandulosa occurred in the Dwarf Birch type. The average density of 74,677 stems/ha for all size classes combined yielded over 7 stems/m^2, most of which were about 70 cm in height (Table 34). Salix pulchra had a scattered distribution and was subdominant to B. glandulosa.

Betula glandulosa occurred in 81% of 1,140 quadrants used to sample utilization at 19 sites in the Dwarf Birch vegetation type, but received only very light utilization (Table 36). Approximately 23% of the quadrants for the 19 sites in this vegetation type contained S. pulchra. Where present, S. lanata was utilized to a greater extent than other Salix spp. shrubs in the Dwarf Birch type. However, very low densities of S. lanata precluded an accurate assessment of the importance of that species as forage.

By far the dominant shrub species in terms of browsable forage for moose in Dwarf Birch vegetation types was B. glandulosa, totaling 535 kg/ha in available twig biomass alone (Table 37). However, only an average of 3% of B. glandulosa twigs were utilized over the 19 sites sampled in this type (Table 36). This low utilization of B. glandulosa as forage was probably due to the relatively large amount of area dominated by this species (33,549 ha) (McKendrick et al. 1982) and low palatability of the species. However, B. glandulosa might be eaten by moose when snow covers the lower-growing Salix spp. or when more palatable forage species become limited.

Betula glandulosa and S. pulchra were the major shrubs in terms of leaf and twig CAG in the Dwarf Birch vegetation type (Table 38). Total leaf CAG for the 2 low shrub species was 64 kg/ha while total twig CAG biomass was 35 kg/ha. Forb CAG (12 kg/ha) was lower in the Dwarf Birch type than any other vegetation type sampled.

6.1.2.1.2 - Dwarf Birch-Willow Vegetation Type

The single site sampled in the Dwarf Birch-Willow type was in a wetter area than sites in the Dwarf Birch type. Salix pulchra was the dominant willow species (Tables 39 and 40). Low-growing B. glandulosa was also present in the Dwarf Birch-Willow vegetation type. Vaccinium uliginosum was the most abundant dwarf shrub, averaging 13% canopy cover (Table 39). Forbs and graminoids had greater cover percentages in this type than the Dwarf Birch vegetation type, probably due primarily to the moisture regimes found in association with the Dwarf Birch-Willow vegetation type. Total moss cover was lower than the total moss cover in the Dwarf Birch vegetation type (Tables 39 and 33).

Betula glandulosa had greater stem densities than S. pulchra in the Dwarf Birch-Willow vegetation type (Table 41). All B. glandulosa stems were ≤ 1 cm in basal diameter. Approximately 67% of the S. pulchra stems were ≤ 1 cm in basal diameter.

Percent utilization of B. glandulosa was very low in the Dwarf Birch-Willow vegetation type (Table 42). Stem densities of S. pulchra were low (Table 41), but utilization was higher than for B. glandulosa (Table 42). Browsing of shrubs with low densities might inadvertently suggest that S. glauca was a major forage items in the diet of moose. However, heavily browsed shrub species with low densities may not necessarily be preferred forage species. Animals may browse plants that, in low densities, sustain higher utilization per plant than do the same plants when they occur at greater densities. Utilization data alone cannot determine forage preference. Information on animal diets is also necessary, as well as information on the ecology of the animal (Johnson 1980).

The number of unbrowsed twigs of B. glandulosa was nearly 8 times greater than for S. pulchra, reflecting calculated available leaf, twig, and total biomass of the 2 species in the Dwarf Birch-Willow vegetation type (Table 43). Total available biomass in the Dwarf Birch-Willow vegetation type was 451 kg/ha, of which approximately half was twig and half was leaf biomass (Table 43).

Betula glandulosa and S. pulchra were the 2 major shrub species in terms of twig and leaf CAG in the Dwarf Birch-Willow vegetation type (Table 44). Salix pulchra had 3.7 times as much leaf CAG as B. glandulosa but only twice as much twig CAG biomass. In contrast to the Dwarf Birch vegetation type, the wetter soil moisture conditions predominating in the Dwarf Birch-Willow type averaged 88 kg/ha of forb CAG biomass (Table 44). The forb CAG biomass was composed of Petasites frigidus, Cornus canadensis, and Rubus chamaemorus (Table 39). Graminoid CAG was composed primarily of Calamagrostis canadensis and Carex spp. (Table 39). Total leaf and twig CAG biomass for tall and low shrubs was 56 kg/ha and 24 kg/ha, respectively, in the Dwarf Birch-Willow vegetation type.

6.1.2.1.3 - Open Ericaceous Shrub Tundra Vegetation Type

The Open Ericaceous Shrub Tundra had low-growing dwarf shrubs and the largest canopy cover of lichens of all vegetation types sampled (Tables 45 and 46). The predominant shrubs in this type were the ericaceous dwarf shrubs V. uliginosum, E. nigrum, L. groenlandicum and V. vitis-idaea (Table 45). Cladonia spp. and Stereocaulon paschale were the most important components of the lichen canopy cover.

Betula glandulosa was the only low shrub which occurred in plots sampled in the Open Ericaceous Shrub Tundra (Table 47). Stem densities of B. glandulosa were similar to those found in the Woodland Spruce (Table 19) and Dwarf Birch-Willow (Table 41) vegetation types. Percent utilization of shrubs in the Open Ericaceous Shrub Tundra vegetation type was very low (Table 48).

Betula glandulosa averaged 84 kg/ha leaf biomass and 111 kg/ha twig biomass (Table 49). Shrubs in this vegetation type were low-growing, and would be covered when snow exceeded 0.5 m in depth.

The Open Ericaceous Shrub Tundra vegetation type had 51 kg/ha and 17 kg/ha CAG biomass of forbs and graminoids, respectively (Table 50). Betula glandulosa was the only shrub with CAG biomass estimates.

6.1.2.1.4 - Ericaceous Shrub-Sphagnum Bog Vegetation Type

The Ericaceous Shrub-Sphagnum Bog vegetation type is common on ridges, lowlands, depressions, and poorly drained flats (McKendrick et al. 1982). Scattered P. mariana were in the overstory layer (Tables 51 and 52). Betula glandulosa was the only low shrub species with > 1% cover in the 1 site sampled in this vegetation type. The ericaceous shrubs E. nigrum, V. uliginosum, and L. groenlandicum were common plants in this type (Table 51). Rubus chamaemorus and Carex spp. were also present. Sphagnum spp. moss made up a large proportion of the total moss cover in the Ericaceous Shrub-Sphagnum Bog vegetation type (Table 51). Seven percent of the area sampled was covered by standing water.

Stem densities of B. glandulosa in the Ericaceous Shrub-Sphagnum Bog vegetation type (Table 53) approximated those found in the Open Black Spruce vegetation type (Table 13). Utilization of low-growing B. glandulosa shrubs was very low (Table 54).

Similar to the Open Ericaceous Shrub Tundra type, B. glandulosa was the only low shrub which occurred in quadrats sampled in the Ericaceous Shrub-Sphagnum Bog vegetation type. Betula glandulosa averaged only 40 cm in height (Table 54), so snow depths exceeding 0.4 m would inhibit utilization of these shrubs by browsing moose. Twig biomass available above 40 cm was 67 kg/ha for B. glandulosa (Table 55). Utilization of B. glandulosa for forage in the Ericaceous Shrub-Sphagnum Bog vegetation type was almost non-existent (Tables 55 and 54). Forb CAG biomass totaled 154 kg/ha in the Ericaceous

Shrub-Sphagnum Bog vegetation type (Table 56). Leaf and twig CAG biomass of B. glandulosa was very low in relation to stem densities totaling 45,550 stems/ha (Table 53) and 67 kg/ha available twig biomass (Table 55).

6.1.2.2 - Dwarf Shrub Scrub

Dwarf shrub scrub vegetation types are composed of scrub vegetation that is < 20 cm in height and has ≥ 25% canopy cover of dwarf shrubs.

6.1.2.2.1 - Low Willow Tundra Vegetation Type

The Low Willow Tundra vegetation type was composed of low-growing (< 20 cm) S. pulchra in the shrub layer (Tables 57 and 58). The single site sampled in this higher elevation vegetation type was dominated by E. nigrum and V. uliginosum in the dwarf shrub layer. A total of 12 forbs were sampled in this type, of which Artemisia spp. (wormwood), Leutkea pectinata (leutkea) and Viola spp. (violet) had the largest average canopy cover (Table 57).

The greatest density of S. pulchra stems in the vegetation types sampled was found in the Low Willow Tundra vegetation type (Table 59). These low growing shrubs were relatively random in their distribution as noted by the small estimated sample size. Density of S. pulchra stems averaged over 5 stems/m^2 in this vegetation type. All stems of S. pulchra were < 1 cm in basal diameter.

Total graminoid and forb CAG biomass was 86 kg/ha and 132 kg/ha in the Low Willow Tundra vegetation type (Table 60). Salix pulchra had 145 kg/ha of leaf CAG biomass and 24 kg/ha of twig CAG biomass.

A summary of current annual growth leaf and twig biomass, density, gross available twig biomass, and percent utilization of twigs for the 10 Level IV vegetation types in the Susitna browse inventory study is shown in Table 61.

6.1.3 - Discussion

The 47 sites sampled for the browse inventory study encompassed approximately 27 vegetation types classified at Level V of Viereck et al. (1982) (Table 4). These 27 Level V vegetation types combined into 10 vegetation types classified at Level IV of Viereck et al. (1982). Level IV vegetation types, whose classification was based on canopy cover percentages of trees and shrubs by species, were used for this report because most Level V vegetation types were represented by only 1 sample site.

In an inventory of browse quantity, it would not be practical to subdivide vegetation types to the lowest common denominator, particularly if that denominator is not a plant species keyed in some way to moose. Subdividing vegetation communities requires that discriminating criteria be established to identify and distinguish between those vegetation communities. Level V vegetation types, as described by Viereck et al. (1982), enlist a number of dominant plant species as descriptive criteria. For Level V vegetation types in the middle Susitna River Basin these include: 1) dominant overstory trees such as P. glauca, P. mariana, Populus balsamifera, and B. papyrifera; 2) the tall shrub A. sinuata; 3) low shrubs such as B. glandulosa, S. pulchra, and S. glauca; 4) dwarf shrubs like V. uliginosum, V. vitis-idaea, E. nigrum, and L. groenlandicum; and 5) ground layer species such as mosses (e.g. Sphagnum spp.), lichens (Peltigeraspp., Nephroma spp., Cetraria spp., Cladonia spp), forbs (Rubus chamaemorus, Petasites frigidus, Cornus canadensis), and graminoids (Calamagrostis canadensis, Carex spp.). Both individual species and complexes of species are used in the classification scheme.

Although a vegetation type is composed of many plant species, certain species are more important to moose than other plant species. Trees are useful descriptive criteria for defining vegetation types for moose because they are important components of moose habitat. Trees provide escape as well as thermal cover, and also forage in some instances. The relative abundance of trees is often indicative of the understory plant species composition; an important attribute when classifying and mapping vegetation. Shrubs are also useful descriptive criteria for defining vegetation types as they relate to the habitat requirements of moose. Woody browse may supply over 95% of the winter diet of moose (Spencer and Chatelain 1953). Shrub species composition is particularly important because moose are known to exhibit a preference for some shrub species over others (Milke 1969, Peek 1970, Machida 1979). Thus the identification of important shrub species in a vegetation association is also a useful criterion in defining a vegetation type as it relates to moose habitat requirements.

Dwarf shrubs, forbs, graminoids, and lichens are probably most useful as criteria for defining vegetation types as they may relate to moose spring and summer food habits. Murie (1944) stated that grasses, sedges, various herbs, and submerged vegetation were eaten by moose in summer. Summer diet of 3 semi-tame moose on the Kenai Peninsula was composed of one-fourth forbs including _Rubus chamaemorus_, _Epilobium angustifolium_, and _E. latifolium_ (Le Resche and Davis 1973). Le Resche and Davis (1973) reported that mushrooms (_Basidiomycetes_) were eaten whenever found, and that grasses, sedges, and aquatic plants constituted about 10% of the observed diet. During winter when snow depths exceeded 30 cm the dwarf shrub _V. vitis-idaea_ was reported to comprise 26% of moose diets (Le Resche and Davis 1973). Under poor range conditions on the Kenai Peninsula, Le Resche and Davis (1973) reported lichens (_Peltigera_ spp.) as 24% of the diet. Species of moss are important in characterization of vegetation types, especially successional areas (Viereck 1970, L. A. Viereck, INF, _personal communication_), but they have limited value as moose forage.

Classification of vegetation types to Level IV for the shrub scrub types of Viereck et al. (1982) represents a more useful scheme for identifying moose habitat than Level V. However, Level V would be more appropriate for the forest and dwarf tree scrub types since the dominant shrub species in the understory would be included. Restructuring of Level V vegetation types to include only dominant tall and low shrubs used by moose for forage might also benefit the evaluation of moose habitat. Vegetation types within Level V could be distinguished by changes in percent cover of dominant tall and low shrub species.

The Open White Spruce vegetation type occurred on gentle to steep slopes where drainage was adequate for growth of P. glauca. Picea mariana also occurred in the Open White Spruce type where gentle slopes intergraded with relatively level, wet areas. Species composition and canopy cover percentages among the Open White Spruce, Open Black Spruce, and Woodland Spruce vegetation types were similar. Two of the 3 sites in the Woodland Spruce vegetation type were dominated by P. glauca overstory. Total low shrub and dwarf shrub canopy cover in the 0.5-m^2 quadrats averaged 12% and 35%, respectively, among the 3 needleleaf forest vegetation types. Total moss cover averaged 46%.

Canopy cover of A. sinuata was higher in the Open Birch Forest vegetation type than any other type sampled. Alnus sinuata grew in narrow, vertical bands extending from the upper elevational limits of the Open Birch Forest in the Susitna River canyon down the steep slopes to the edge of the river floodplain. These vertical bands of A. sinuata were discontinuous, but generally followed drainage courses down hillsides. Dryopteris spp. was the predominant forb in the Open Birch Forest vegetation type. Total forb and litter cover together accounted for 92% of the ground surface area sampled in this vegetation type.

Betula glandulosa averaged 22% canopy cover in the Dwarf Birch vegetation type. Important dwarf shrubs were *E. nigrum* and *V. uliginosum*. In contrast to the Dwarf Birch-Willow vegetation type, the Dwarf Birch type had little forb cover. The Dwarf Birch vegetation type was situated on ridge-tops or slopes with good soil moisture drainage. Forb cover and biomass was greater in the Dwarf Birch-Willow vegetation type. Many areas of standing water were evidence of the relatively wet site conditions in this vegetation type.

The Open Ericaceous Shrub Tundra and Ericaceous Shrub-Sphagnum Bog vegetation types had low-growing ericaceous (Ericaceae) shrubs as the main shrub component. Lichen cover, notably *Cladonia* spp. and *Stereocaulon paschale*, was greater in the Open Ericaceous Shrub Tundra type while moss cover was 1.9 times greater in the Ericaceous Shrub-Sphagnum Bog vegetation type.

Percent canopy cover of *S. pulchra* was greater in the Low Willow Tundra vegetation type than in any other type, averaging 18% in the 0.5-m^2 quadrats. Most of the *S. pulchra* was shorter than 40 cm in height. Thus it would be less available as winter forage for moose when snows exceeded 40 cm in depth unless cleared by wind or moose digging into the snow.

In a study designed to determine the relative preference by moose for various species of *Salix* in interior Alaska near Fairbanks, Milke (1969) found that *S. pulchra* was generally browsed more intensively than other species of *Salix* when it and other species were growing together. In each of 4 study areas where both *S. pulchra* and *S. glauca* occurred together, Milke (1969) ranked *S. pulchra* as the preferred species. *Salix lanata* was preferred over *S. pulchra* at 2 of 3 study areas where both species occurred (Milke 1969). Milke (1969) stated that *S. glauca* was almost without exception one of the most lightly browsed species of *Salix* studied. It was a common occurrence on the Interior Alaska study plots to see "substantially browsed" _S. pulchra_ plants adjacent to a stand of unbrowsed _S. glauca_. Milke (1969) found this trend to be consistent over all 7 of the study areas he investigated, leading to the conclusion that _S. pulchra_ was preferred by moose over most other _Salix_ spp. at those sites. Extrapolating to important moose range throughout Interior Alaska, Milke (1969) ranked in order of decreasing preference by moose the species of _Salix_ which were studied. For the species of _Salix_ referenced by Milke (1969) that were measured in the middle Susitna River Basin browse inventory study, the order of decreasing preference was as follows: 1) _S. pulchra_, 2) _S. lanata_, and 3) _S. glauca_. Murie (1961) indicated that of the more than 20 species of _Salix_ in Mt. McKinley National Park, _S. pulchra_ was 1 of 3 species preferred by moose.

In the Susitna Basin vegetation types where both _S. pulchra_ and _S. glauca_ occurred together, and percent utilization estimates were made for each species, utilization estimates of _S. glauca_ exceeded those for _S. pulchra_ in 4 out of 5 vegetation types. Also average percent utilization of _S. glauca_ was greater than _S. lanata_ in 1 of 2 vegetation types.

The reasons for the apparent contradiction in the preference or use of _S. glauca_ between the Susitna study and those reported for Milke's (1969) data in Interior Alaska could possibly be related to the relative availability of species of _Salix_ in different vegetation types. Stem densities of _S. pulchra_, _S. lanata_, and _S. glauca_ were all approximately equal (4667 to 8548 stems/ha) in the Open White Spruce vegetation type, where percent utilization ranged from 4 to 6%. Similarly, _S. glauca_ and _S. pulchra_ stem densities ranged from 1278 to 2167 stems/ha, respectively, in the Woodland Spruce vegetation type where utilization was 22% and 30%, respectively. In the Open White Spruce and Woodland Spruce vegetation types, stem densities of any species of _Salix_ ranged from 5% to 74% of the total stem density of B. glandulosa. In the Open Black Spruce, Dwarf Birch and Dwarf Birch-Willow vegetation types, stem densities of both S. pulchra and the much less utilized B. glandulosa (Spencer and Hakala 1964) far exceeded those for S. glauca and/or S. lanata. However, percent utilization of the species of Salix with low stem densities was greater than those with higher stem densities. Observations of browsed shrubs for this study suggested that, although in most areas the intensity of browsing within the previous 2 years had been relatively light, almost every S. pulchra shrub had been browsed to some degree. In a given locality, most S. pulchra shrubs were consistently lightly to moderately hedged and exhibited the growth form of shrubs which had been moderately to heavily hedged in the past. Salix glauca and S. lanata shrubs were usually more scattered in distribution than S. pulchra, but, although they received a higher degree of recent utilization than S. pulchra in most cases, they were less consistently browsed. Standard errors for percent utilization estimates were higher for both S. glauca and S. lanata than for S. pulchra in all vegetation types sampled where these species occurred together.

Milke (1969), however, observed that the relative rarity or abundance of a species of Salix in interior Alaska did not affect its degree of utilization to an extent greater than did the species' inherent palatability. Milke (1969) found that certain species of Salix including S. glauca were poorly utilized by moose, regardless of its relative abundance, on all the study areas on which the species occurred. Milke (1969) reported that S. glauca was poorly utilized on study areas where it was abundant as well as on study areas where it was scarce. Conversely, Milke (1969) noted that S. pulchra was heavily browsed by moose whether it was very abundant or relatively uncommon. For Salix spp. occurring in interior Alaska, species utilization by moose was not correlated with species density (Milke 1969). Milke (1969) also concluded that neither relative abundance nor density of Salix spp. observably affected the degree to which moose utilized the plants. Rather, the inherent palatability of a species tends to override the effects of relative abundance or density on browsing intensity.

One other reason why S. glauca is browsed more heavily than S. pulchra in the middle Susitna River Basin study may be the physical proximity of S. glauca stems to nearby S. pulchra stems. Milke (1969) observed moose feeding on S. pulchra that, while standing in place, would briefly browse nearby S. glauca or S. lanata plants that were within reach. This type of feeding behavior suggests a possible explanation for the abnormal degree of utilization on the lower preference Salix spp. shrubs that occur in low density or with scattered distribution in the immediate vicinity of a more highly preferred forage species. In addition, other herbivores such as caribou (Rangifer tarandus), rodents, leporids, and insects may be selectively browsing S. glauca. Information on the food habits of moose in the middle Susitna River Basin is essential to determine forge preferences of this animal.

Average DPB measurements for all shrub species sampled in the middle Susitna River Basin study area were larger than the average measurements of basal diameter of current annual growth of twigs. The mean DPB was: 1) 121% for A. sinuata; 2) 133% for B. glandulosa; 3) 152% for B. papyrifera; 4) 184% for S. glauca, and 5) 147% for S. pulchra greater than the basal diameter of current year's growth for each respective shrub species. Peek et al. (1976) described a similar situation in northeastern Minnesota where mean DPB's averaged 111% greater than the basal diameter of current year's growth for all shrub species. The DPB increase over basal diameter of current annual growth twigs for the 5 shrub species in the middle Susitna River Basin averaged 147%. Peek et al. (1976) suggested that their estimates of utilization based on percentages of current annual growth leaders probably underestimated actual utilization of twigs on a weight basis. This conclusion was based on the premise that either more than the current year's growth was browsed or that only larger twigs were eaten (Peek et al. 1976). The available and utilized leaf biomass estimates for the Susitna study do not have the same inherent calculation error as Peek et al. (1976). Our utilization estimates for available and utilized twig and leaf biomass were calculated from twigs clipped at an average point-of-browsing calculated for each shrub species rather than at the basal diameter of current annual growth. Except for occasional cases where S. glauca and S. lanata current annual growth of twigs was stimulated by past browsing and were long and robust, DPB's extended below the current year's growth.

Removal of 100% of the available twig biomass back to the DPB we have used would concurrently remove 100% of the previous summer's current annual growth as well as a portion of the plants 2-yr, and/or 3-yr-old stem growth. In species of Salix, 96% of the lateral dormant buds were located on 1-yr-old stems (Archer and Tieszen 1980). Lateral dormant buds were those which would respond by initiating leaf or twig growth following removal of the terminal bud. Three percent of the bud production in Salix spp. was located on 2-yr-old stems and about 1% was on 3-yr-old stems (Archer and Tieszen 1980). The average Salix plant initiated growth of leaves and lateral twigs from less than 20% of its visible buds during spring and summer growth. Archer and Tieszen (1980) concluded that a Salix shrub experiencing partial defoliation of leaves during the growing season had great potential to replace photosynthetic tissue lost to herbivores because buds were still intact.

However, if terminal 1- and 2-yr-old stems were removed along with current growth, particularly if it occurred late in the growing season, shrubs could not regenerate photosynthetic tissue in time to recover the energy investment before the end of the growing season (Archer and Tieszen 1980).

Archer and Tieszen's (1980) work on _S. pulchra_ demonstrated that removal of terminal growth back to 5- to 7-yr-old growth stimulated the development of terminal long-shoots from suppressed lateral buds buried in the cambium. This growth far exceeded growth of terminal long-shoots under non-defoliation conditions (Archer and Tieszen 1980). However, the energy reserves of a plant may become depleted if all terminal stem growth back to 3-yr-old stems were removed over a number of consecutive years during the growing season.

Wolff (1978) found that browsed branches of _S. scouleriana_ (Scouler willow) produced more than unbrowsed branches during subsequent growing seasons over a 3-yr period. However, continuous browsing during the growing season over several years may eventually deplete plant or soil reserves, causing eventual decline in productivity (Menke 1973). Aldous (1952) reported that _B. papyrifera_ could withstand clipping of 50% of the current year's growth over a 6-year period without loss of production. Several authors have suggested that 50% browse utilization may give maximum sustained production of hardwood browse (Spencer and Chatelain 1953, Krefting et al. 1966, Wolff 1976, Wolff 1978).

Based on this argument, available and utilized leaf and twig biomass as well as current annual growth biomass estimates reported here should be reduced by at least 50%. This reduction would provide more reasonable estimates of the actual amount of forage available when calculating carrying capacities of vegetation types for moose. More information is needed on shrub response to the degree of utilization by moose and its season of use.

Assuming the daily consumption rate of forage for adult moose was 13 kg/day (C. C. Schwartz, ADF&G, personal communication), and 50% of available twig biomass of all shrub species was consumed, the Open White Spruce vegetation type (104 kg/ha) would support 8 moose/ha for 1 day. It follows that 1 moose could survive for 8 days on each hectare, or 8 moose days/ha. Using vegetation type area estimates for the portion of the middle Susitna River Basin 16 km on either side of the Susitna River from Gold Creek to the Maclaren River reported by McKendrick et al. (1982), the Open White Spruce vegetation type could support 414 moose-days for a winter 210 days long. These estimates are probably too high. Certain broad assumptions must be made in order to use the foregoing technique:

Assumption #1: Moose occupy all geographical areas and vegetation types equally.

However, moose will not make full use of a large geographical area such as the Open White Spruce vegetation type unless populations are extremely large. Variables such as snow depth, slope, aspect, wind speed and direction, general movements, behavioral patterns, and proximity to a localized source of forage all interact to influence the use of a vegetation type by moose. Moose in the middle Susitna River Basin were not randomly distributed throughout all vegetation types during all times of year (Ballard et al. 1982).

Assumption #2: All shrub species are equally preferred, equally palatable, and equally utilized by moose.

Although preference and/or browsing intensity on different species of shrubs varies by locality, association with more preferred shrub species, and animal behavior, some shrub species such as *A. sinuata* and *B. glandulosa* presumably do not make up a large proportion of the diet of moose on ranges where *Salix* spp. are abundant. However, without specific food habits information on moose in the middle Susitna River Basin, accurate estimates of the relative importance of shrub species cannot be determined. A 55% reduction in moose-days for a 210 day winter was calculated if a maximum of 10% of the winter diet were composed of available *A. sinuata* and *B. glandulosa* twigs and the remainder of the diet were composed of *Salix* spp. twigs in the Open White Spruce vegetation type.

Assumption #3: Moose consume woody browse only during the winter months.

However, utilization of woody browse is not restricted to the winter months. Moose were observed to browse current annual growth of twigs and leaves, particularly of *S. pulchra*, throughout the summer growing season. Summer diet of moose are dominated by *S. pulchra* in Denali National Park (V. Van Ballenberghe, INF, *personal communication*).

Therefore, the actual calculation of carrying capacity for vegetation types, and subsequently for the middle Susitna River Basin as a whole, rests on assumptions whose accuracy cannot be addressed within the scope of this study. Periodicity, timing, and season of use of various vegetation types by moose are valuable information in assigning the relative importance of various shrub species. Activity patterns (e.g. feeding, resting, hiding) of moose within vegetation types is needed to determine the reasons why those vegetation types are used. Food habits must be determined to rank shrub species and to ascertain the composition of food items in moose diets. Of course, the presence and abundance of preferred forage species will weigh heavily in determining the relative importance for moose of the vegetation types sampled in this study. Ballard et al. (1982:70) commented that the distribution of species of *Salix* preferred by moose probably strongly influenced seasonal distribution of moose in the middle Susitna River Basin. However, presence or absence of plant species, or even abundance of forage based on canopy cover, stem densities, and biomass estimates alone do not provide the complete picture when assessing the importance of the various vegetation types to moose in the middle Susitna River Basin.

6.1.4 - Susitna Basin Soils

Soils information in this study was collected for comparison between the proposed Alphabet Hills burn and those locations sampled within and near the proposed Susitna dam impoundment areas. Similar sampling techniques and analysis were employed for that purpose. Unless otherwise stated, means presented in the text reflect the average for the entire soil profile sampled (0-15 cm).

6.1.4.1 - Open White Spruce Vegetation Type

Within the Open White Spruce vegetation type, pH averaged 5.97±0.71 ($\bar{x}$± standard deviation). Averages for each depth (Table 62) within this vegetation type ranged from 5.93 to 6.05 (moderately to slightly acidic). Individual readings within the Open White Spruce vegetation type varied from 4.90 to 6.71 for depths 0-5 cm, 5-10 cm, and 10-15 cm, indicating that soils ranged from strongly acidic to neutral.

Macronutrient concentrations were greatest for calcium at 1680.94±1506.11 ppm (parts per million), followed by magnesium (245.62±252.06 ppm), and potassium (52.09±23.06 ppm). Average concentrations of macronutrients were always greater in the 0-5 cm depth than either the 5-10 or 10-15 cm depths. Viereck (1970) noted that greater levels of potassium, mognesium, and calcium were often found in association with the greatest concentrations of organic matter in study areas adjacent to the Chena River in interior Alaska.

Micronutrient concentrations were greatest for iron (300.51±133.90 mg/g), followed by manganese (23.19±27.29 mg/g), copper (2.30±2.21 mg/g), and zinc

(1.44±1.41 mg/g).

Average percent organic matter of sampled soils was 9.24±7.50 in the Open White Spruce vegetation type. Organic matter decreased (Table 62) from the 0-5 cm depth through the 10-15 cm depth.

Total nitrogen and phosphorus averaged 0.28±0.23% and 0.07±0.03%, respectively. Total nitrogen and phosphorus are usually correlated with organic matter content of soils (Hausenbuiller 1978). Associated decreases in total nitrogen and phosphorus content with increasing soil depth are not uncommon.

Texture classification would be loamy with 37.47±10.27% sand, 46.35±8.26% silt, and 16.18±6.28% clay in the Open White Spruce vegetation type.

6.1.4.2 - Open Black Spruce Vegetation Type

In the Open Black Spruce vegetation type, pH averaged 6.09±0.54. Average pH for each depth in this vegetation type (Table 63) ranged from 5.88 to 6.29. Individual readings in the Open Black Spruce vegetation type varied from 5.36 to 6.51 for depths 0-5 cm, 5-10 cm, and 10-15 cm, reflecting a moderately to slightly acidic soil pH range.

Macronutrient concentrations were greatest for calcium (2537.25±2315.91 ppm), followed by magnesium (310.20±268.06 ppm), and potassium (61.10±42.56 pmm). High concentrations of calcium would be expected since calcium is often a more abundant element than either magnesium or potassium (Hausenbuiller 1978).

Micronutrient concentrations were greatest for iron (456.37±287.36 mg/g), followed by manganese (86.36±121.59 mg/g), copper (9.50±11.50 mg/g), and zinc (2.75±3.13 mg/g).

Organic matter content averaged 13.54±10.64%. Total nitrogen and total phosphorus averaged 0.50±0.41% and 0.09±0.02%, respectively.

Soil texture classification indicated a loamy soil with 33.78±10.84% sand, 49.08±8.17% silt, and 17.15±9.12% clay.

6.1.4.3 - Woodland Spruce Vegetation Type

In the Woodland Spruce vegetation type, pH averaged 4.21±0.06. Average pH for each depth in this vegetation type ranged from 4.15 to 4.26, or strongly acidic (Table 64). The soil samples taken in this vegetation type were more acidic than soils in any other vegetation type sampled. Large amounts of coniferous leaf litter and a thick moss layer could have contributed to the low pH.

The greatest macronutrient concentration was found for calcium with 99.00±23.52 ppm, followed by 46.67±4.16 ppm for potassium, and 30.00±5.57 ppm for magnesium.

Micronutrient concentrations were greatest for iron with 482.50±7.78 mg/g, followed by 23.90±0.85 mg/g for manganese, 0.92±0.08 mg/g for zinc, and 0.37±0.08 mg/g for copper.

Organic matter averaged 10.45±1.76%. Total nitrogen averaged 0.38±0.07% and total phosphorus averaged 0.09±0%.

Soil texture indicated a loamy classification with 33.87±4.67% sand, 43.13±2.04% silt, and 23.00±3.64% clay.

6.1.4.4 - Dwarf Birch Vegetation Type

In the Dwarf Birch vegetation type, pH averaged 6.01±0.48. Average pH for each depth within this vegetation type ranged from 5.70 to 6.26, or moderately to slightly acidic (Table 65). Individual pH readings within the Dwarf Birch vegetation type ranged from 5.70 to 6.51 for depths 0-5 cm, 5-10 cm, and 10-15 cm.

The greatest macronutrient concentrations were found for calcium with 1992.40±2692.70 ppm, followed by magnesium with 127.00±118.37 ppm and potassium with 40.20±19.83 ppm.

Micronutrient concentrations were greatest for iron at 253.80±236.69 mg/g, followed by 14.76±16.80 mg/g for manganese, 5.41±10.38 mg/g for copper, and 0.90±1.06 mg/g for zinc.

Organic matter content averaged 8.19±9.40%. Total nitrogen measured 0.24±0.24% and total phosphorus was 0.06±0%.

Texture classification was loamy with 33.92±6.13% sand, 43.32±3.58% silt, and 22.76±4.88% clay for soils sampled within the Dwarf Birch vegetation type.

6.1.4.5 - Conclusions

Comparisons of soil variables were made using analysis of variance. Significance was set at $P \leq 0.10$. No significant differences were found among depths within a vegetation type for any of the soil variables measured. No significant differences in variables measured were found among all vegetation types. It appeared that there was a substantial amount of variability between soils at each site within a given vegetation type as shown by the high standard errors (Tables 62, 63, 64, and 65). Organic matter decreased with decreasing depths as did total nitrogen and phosphorus in most instances. Soils were grouped based on vegetation type rather than on soil type. High variability in soil chemical analysis within a given vegetation type is an indication of the variability inherent in the vegetation composition itself within the Level IV vegetation types of Viereck et al. (1982).

6.2 - Plant Phenology

6.2.1 - Reconnaissance Observations

Some general observations on late winter snow conditions were made on a reconnaissance trip on 15 and 16 May, 1982. The Watana and Jay Creek transects were almost snow-free at that time, although the Watana area contained some snow patches in depressions between shrubs, and _Vaccinium_ uliginosum was partly snow-covered. The Switchback and Tsusena Creek sites still had substantial snow cover on the slopes at this time, although snow cover at the base of trees had already decreased. Vaccinium vitis-idaea was abundant at the base of trees in the area between Devil and Tsusena Creeks. Snow was melting around Ledum groenlandicum at the highest elevations of the Switchback transect.

General observations between Watana Base Camp and Talkeetna River on 15 and 16 May indicated that snow cover had been reduced by approximately 50% on forested south-facing slopes while it had only decreased around trees on north-facing slopes. The immediate area around shrub stem bases was relatively snow-free on the benches. Snow depths were greatest between shrubs and contained many animal tracks. Apparently these areas of less snow cover surrounding shrub stems are important to wildlife at this time of year. Snow depths were least in wet, boggy sites as well as the dry, windy areas that had no trees.

6.2.2 - Soil Temperature

Temperatures varied significantly by transect, elevation within transect, and date within elevation within transect (Table 66). However, trends for elevations within transects varied at each location. The bottom location at the Watana transect was usually the warmest in that area (3.5 - 4.0°C). It was a mixed spruce-birch stand on a well-drained slope (12°) whereas other bottom elevations were flat (<2°) and poorly drained.

The warmest location on the Jay Creek transect, and the warmest overall, was mid-slope in an open spruce-birch type adjacent to a grassy opening. Soil temperatures ranged from 3.5 to 7.0°C. This area had different vegetation from any other site, including large individuals of Rosa acicularis (1 m or taller) as well as abundant Calamagrostis canadensis (bluejoint), Equisetum silvaticum (woodland horsetail), and Mertensia paniculata (tall bluebell). Evidence of an old burn and extensive browsing by moose was present. This was the youngest site in terms of tree ages: 36 years (5 trees) although 1 other tree was 124 years old. Several individuals of B. papyrifera had been hedged so that they resembled large B. glandulosa - B. papyrifera hybrids and caused species identification problems through the early weeks of the study.

Bench and top-slope elevations were the warmest (2.0 - 6.5°C) at the Switchback transect. These sites had gentle, west-facing slopes and were not shaded by higher ridges to the north as were the other south-facing slopes. Vegetation here was more open than on the lower slopes.

The top-slope location at Tsusena Creek was somewhat warmer (average across weeks 2.6° versus 2.0°C) than the other elevations at this transect (Table 66). The bench location was well above the current forest line although a few surviving old trees were present.

The coldest transect was Tsusena Creek. Minimum temperature separation from the other transects was 0.9°C lower than the average transect temperature during the first and fourth weeks. The maximum temperature difference was 1.5°C colder than any other transect during the last week. Colder temperatures delayed phenological development by at least a week, and almost 2 weeks, for some plants at this site. Betula glandulosa did not develop leaves until the week of 14 June. During the previous week, 7 to 11 June, B. glandulosa had already developed leaves at most of the other sites. Colder temperatures were probably caused by the thick insulating layer of moss as well as colder mesoclimatic conditions. The soil temperatures at the top-slope location at Tsusena Creek were 3.5 to 4.5°C lower than the middle slope temperatures at Jay Creek even though the former site (730 m) was 75 m lower than the latter (805 m). Consultation with a project hydrologist indicated that climatic conditions along that transect might be cooler and moister than along the 3 transects in the potential Watana impoundment zone.

The Tsusena Creek transect appeared less recently disturbed by fire than the other transects. The average age of trees at the bottom elevation on Tsusena Creek was 135 years. Large trees on the bench location averaged 114 years old (although there was a smaller tree 56 years old) while top-slope tree ages averaged 87 years. The only other sites with average large tree age greater than 100 years were the bottom positions. Hence, the Tsusena Creek sites appeared to be more mature than other sites. Whether the lower soil temperatures along the Tsusena Creek site resulted from a different mesoclimatic regime or the deeper moss layer is a matter of conjecture, but it seems likely that the delayed phenological development resulted from an interaction of mesoclimate, burn history, and deeper moss layer.

The middle elevation on the Jay Creek site was consistently the warmest. Vegetation there not only initiated growth earlier but was dominated by the mixed birch-spruce forest, which was generally found on warmer sites than spruce forests or low shrubland types. Each week this site had the warmest soil temperatures which ranged from 3.5 to 7.0°C. The middle elevation was also the youngest site in terms of tree ages: 37 years (N=6 trees) although 1 other tree was 124 years old.

6.2.3 - Canopy Cover, Height, and Phenological State of Growth/Maturation

6.2.3.1 - General

Results and discussion of the statistical analysis of phenological development of the vegetation were confined to dominant species. Because some species only occurred at 1 or a few sites, they frequently showed significant differences ($P < 0.10$) among elevations and transects. This was primarily because of differences in vegetation type rather than a difference related to phenological development. Only species that consistently occurred in most sites would give reasonable statistical results when comparing elevations and transects. The major species were B. glandulosa, V. vitis-idaea, V. uliginosum, and Empetrum nigrum.

6.2.3.2 - Week 1; 31 May - 4 June

During the first week of 31 May to 4 June, no differences (P < 0.1) between inside and outside exclosures were observed for the major species. Vaccinium vitis-idaea had significantly different cover values for elevation within transect (P < 0.1) and for transects (P < 0.01). Cover values for B. glandulosa (P < 0.01) and V. uliginosum (P < 0.02) varied among elevations within transect while E. nigrum (P < 0.02) differed among transects (Table 67).

Most plant species were either dormant or had just initiated leaf buds during the first week. Vaccinium uliginosum on the Watana transect was generally dormant or had some leaf bud development whereas most B. glandulosa plants had developed at least to the bud stage. Vaccinium vitis-idaea appeared dormant; however, it was sometimes difficult to identify new growth. The bottom elevation at Watana Creek contained an individual of R. acicularis with leaves and V. vitis-idaea with flower buds. Some individuals of V. uliginosum were in leaf bud stage whereas individuals of the same species were still dormant at the higher elevations.

The Jay Creek transect had several species already leafed out on 1 June (Table 68). At the bench and top-slope positions on V. vitis-idaea exhibited leaf emergence while more individuals of V. uliginosum had leaf buds than on the Watana transect. Some B. glandulosa individuals were starting to leaf out at the Jay Creek transect, although most were still in the bud stage. Arctostaphylos alpina (alpine bearberry) already had leaves and flowers.

Betula papyrifera on the middle position of the Jay Creek transect had begun leaf expansion, but had been severely hedged in the past. There was a substantial amount of Equisetum silvaticum and Calamagrostis canadensis (standing dead from the previous year's growth), but little growth (< 1% cover) had started this year by week 1. Ground cover might inhibit initial soil warm-up in the spring. Mertensia paniculata had flower buds on a few individuals.

Most species at the bottom elevation of Jay Creek during the first week were in the leaf bud stage. This site had some of the few species of Salix observed on the south-facing slopes.

The corresponding north-facing slope at the highest point had more dense, but smaller, B. glandulosa individuals. Leaf buds did not appear to be as far advanced on this slope. More Salix spp. was present here than on the south-facing slope. Farther down the slope (about midway), last year's standing dead growth of Equisetum silvaticum was abundant but no current growth was observed. Two species of Salix were found in a woodland black spruce scrub site. Salix pulchra generally occurred along small runoff rills while S. glauca grew on the small ridges between these drainages. One lower elevation area had a 13° north-facing slope with 4°C soil temperature. This was warmer than most of the south-facing transects, except the middle position. Equisetum silvaticum was just emerging from the soil and Betula nana (dwarf arctic birth) was leafed out. A wet sedge grass tussock vegetation type existed at the bottom and contained partially leafed-out B. nana. This area was more advanced phenologically than at a similar site on the south-facing slope, but since different species were present an actual comparison could not be made.

The Switchback transect had several species already in the leaf stage by

2 June: S. pulchra, Ribes triste, Ledum groenlandicum, and L. decumbens (Table 69). Most V. vitis-idaea was still dormant while some V. uliginosum had entered leaf bud stage.

Individuals of Carex spp. on the bench position were beginning to emerge while most other species, except B. glandulosa, were dormant. The top elevation was similar during this time period. The middle location contained V. uliginosum in leaf bud while Equisetum silvaticum was just emerging. Betula glandulosa was in the advanced bud stage with many starting to break open. Salix pulchra already had exerted some leaves. Potentilla fruticosa (shrubby cinquefoil) and V. vitis-idaea had leaves at the lowest elevation. Ribes triste had leaves and flower buds. Most Alnus sinuata were in the bud stage, but some had started to leaf out.

The corresponding north-facing slope across from the Switchback transect contained very hedged Salix, with DPB's of 10 mm. Alnus sinuata had been noticeably browsed. This area contained the only V. uliginosum which had been observed as browsed.

The Tsusena Creek transect contained V. uliginosum in leaf on 3 June, but most other species were dormant or entering leaf bud state (Table 70). The two highest elevations were similar with B. glandulosa just starting to form leaf buds. Observations between the top and bottom positions indicated that graminoids were greening up sooner here than on some other transects. Rosa acicularis also was more developed. Ledum groenlandicum had new leaves at the bottom location whereas Cornus canadensis was dormant and B. glandulosa had leaf buds.

6.2.3.3 - Week 2; 7 June - 11 June

The second week of 7 to 11 June had no significant differences ($P > 0.10$) for major species cover values between inside and outside the exclosures. All major species had significant (P < 0.03) differences with respect to elevation while only V. vitis-idaea and Empetrum nigrum had different cover values among transects (P < 0.01). The previous week, E. nigrum cover varied only with transect, and B. glandulosa and V. uliginosum varied with elevation.

Several changes occurred along the Watana Creek transect by the second week. Betula glandulosa and V. uliginosum had leafed out in many places and Rosa acicularis had leaf buds (Table 71). Vaccinium uliginosum tended to have leaf buds at the 2 highest elevations while at the lower 2 elevations plants were leafed out. Changes in leaf area like this could account for elevational differences in cover for this species. There were no major differences in phenological development at different elevations at this time at this site.

Plant species on the Jay Creek transect had also advanced phenologically by 8 June (Table 72). Betula glandulosa and R. acicularis were in leaf as were V. uliginosum, Salix reticulata (netleaf willow), and Arctostaphylos alpina (alpine bearberry). As in week 1, the top 2 elevations were similar. At the middle elevation Mertensia paniculata was still in the flower bud stage but had grown from 8 to 13 cm, while Epilobium angustifolium (fireweed) had acquired leaves. Equisetum silvaticum had strobili on many individuals and had almost doubled in height. Carex spp. and Empetrum nigrum had acquired leaves at the bottom location.

Phenological development of plants on the north-facing slope opposite the Jay Creek transect was equal to that on the south-facing slope and was even more advanced in some cases. Observations made from this slope while looking at the south-facing slope indicated that deciduous trees in mixed evergreen-deciduous forests were leafed out while pure stands of deciduous trees were only in bud stage or just starting to expand leaves. The deciduous trees in the mixed stands, which were relatively common, were B. papyrifera while those in pure stands were probably Populus tremuloides (quaking aspen), although this was never ground-truthed. These stands were assumed to be P. tremuloides because of the different appearance of the individuals relative to those in B. papyrifera - P. glauca sites. The other deciduous tree species, Populus balsamifera, generally does not grow on those types of slopes. Populus tremuloides appeared to develop later than B. papyrifera. If this was true for stems in the shrub and understory layers, then B. papyrifera might provide moose forage earlier than P. tremuloides. Lack of leaves on P. tremuloides overstory might allow the ground layer and herbaceous understory species to emerge earlier.

Almost all major plant species on the Switchback site advanced a full phenological state from 2 June to 9 June (Table 73). Alnus sinuata, B. glandulosa, R. acicularis, and V. uliginosum had leaves at this time. Average height of Equisetum silvaticum had increased from 2 to 10 cm (Tables 69 and 73). Ribes triste was in flower at the bottom elevation. Vaccinium vitis-idaea had flower buds at the middle-slope location. No new differences in phenological development were noted on the north-facing slope.

The Tsusena Creek transect sampled on 10 June was almost identical to the previous week with most species in the leaf bud stage or still dormant (Tables 70 and 74). On the north-facing slope B. glandulosa buds were more advanced but were still immature.

6.2.3.4 - Week 3; 14 June - 18 June

Cover values of all major species including B. glandulosa ($P < 0.001$), V. vitis-idaea ($P < 0.08$), V. uliginosum ($P < 0.02$), and Empetrum nigrum ($P < 0.02$) were different across elevations within transects during week 3. Only V. vitis-idaea ($P < .04$), V. uliginosum ($P < 0.06$), and E. nigrum ($P < 0.06$) were different among transects.

Vegetation on the Watana Creek transect exhibited no major plant phenological advances between the second and third week (14 June) except that Rosa acicularis was now in leaf and E. nigrum had some terminal buds at the bottom and top transect elevations, respectively (Table 75). Vaccinium uliginosum had flower buds at the top-slope elevation, where flower buds of L. decumbens were starting to break. The north-facing slope at this transect had flowers on Diapensia lapponica (diapensia) and Cassiope tetragona (four-angle mountain-heather) at the higher elevations on 17 June.

The Jay Creek transect showed no major phenological advancement for shrubs during the third week 15 June (Table 76). However, Cornus canadensis acquired new leaves and Epilobium angustifolium and Mertensia paniculata had flower buds. The average height of M. paniculata increased 10 cm while that of Equisetum silvaticum increased 8 cm (Tables 72 and 76). Epilobium angustifolium did not significantly increase in height. Mertensia paniculata, a perennial, appeared to initiate growth earlier than E. angustifolium, an annual. However, it appeared to grow slower. Epilobium angustifolium started growth later but grew more rapidly, reaching its maximum height a week earlier than M. paniculata. Mertensia paniculata would be available earlier as forage.

Few plant species progressed phenologically along the Switchback transect by 16 June (Table 77). Vaccinium uliginosum had flower buds, Empetrum nigrum had only terminal buds, and many Ribes triste had lost their flowers. Equisetum silvaticum was more abundant since 6 observations on height were made this time, as opposed to 1 previously. The average height, however, did not increase. Moose were observed feeding between top and middle-slope elevations. Several small forbs appeared at the bottom elevation: Valeriana capitata (capitate valerian), Chrysosplenium tetrandrum (northern watercarpet), and Astragalus spp. (milk-vetch).

Many plant species had not leafed out until 17 June on the Tsusena Creek transect (Table 78). Betula glandulosa, V. uliginosum, and Empetrum nigrum all developed leaves by this time. Cornus canadensis at the bottom elevation was dormant.

6.2.3.5 - Week 4; 21 June - 25 June

Betula glandulosa ($P < 0.03$), V. uliginosum ($P < 0.01$), and E. nigrum ($P < .01$) had significant cover differences during the fourth week with respect to elevations within transects. Vaccinium vitis-idaea ($P < 0.02$), V. uliginosum ($P < 0.01$), and E. nigrum ($P < 0.01$) cover values were different among transects at this time. Vaccinium vitis-idaea did show trends with respect to elevation ($P < 0.14$) and B. glandulosa with respect to transects ($P < 0.18$). Most ubiquitous species had different cover values among transects and elevations within a transect.

The only new development on the Watana Creek transect in the fourth week was that V. vitis-idaea and V. uliginosum had developed flower buds (Table 79). Some L. decumbens had flowered at the top-slope elevation although most were still in bud.

Developments along the Jay Creek transect during week 4 (22 June) included flower buds on V. vitis-idaea and V. uliginosum and flowers on Cornus canadensis (Table 80). Most of the forbs slowed their growth although the average height of Equisetum silvaticum increased slightly.

Several phenological advances occurred on the Switchback transect during the fourth week. Empetrum nigrum, Arctostaphylos uva-ursi (bearberry), and grasses entered the leaf stage (Table 81). Although most V. vitis-idaea were in the leaf stage, some had acquired flower buds. Valeriana capitata was flowering at the bottom elevation while M. paniculata had leaves. Phenological development on this site was delayed relative to the Jay Creek site.

Only minor changes were evidenced on the Tsusena Creek transect during the fourth week. Cornus canadensis leafed out while grass expanded leaves (Table 82). Rubus chamaemorus and Vaccinium uliginosum were flowering at the top-slope location.

6.2.3.6 - Week 5; 28 June - 2 July

Cover values of B. glandulosa ($P < 0.001$), $P < 0.04$) V. uliginosum ($P < 0.01$, $P < 0.02$), and E. nigrum ($P < 0.01$, $P < 0.01$) during the fifth week differed with both elevation and transect. Vaccinium vitis-idaea cover did not differ with either elevation or transect ($P > 0.10$).

The last week of 28 June to 2 July had few changes as most species had at least expanded leaves at all sites by this time. Watana Creek transect had only minor changes during the last week. Rosa acicularis and Spiraea beauverdiana (beauverd spiraea) developed flower buds (Table 83) and some C. canadensis and V. vitis-idaea started flowering.

Several changes occurred on the Jay Creek transect by the last week (Table 84). Ledum groenlandicum and L. decumbens had flowered. Most Mertensia paniculata was in flower, rather than being restricted to the most advanced individuals. Epilobium angustifolium, M. paniculata, and Equisetum silvaticum all increased their average height. Empetrum nigrum at the top-slope elevation had set fruit.

Changes along the Switchback transect during week 5 (30 June) included some V. vitis-idaea flowering at the middle slope location as well as L. decumbens flowering at higher elevations (Table 85). The average height of Equisetum silvaticum increased by 10 cm while the mean grass height remained the same.

During the fifth week (1 July) some V. vitis-idaea and C. canadensis flowered along the Tsusena Creek transect (Table 86). Average height of grasses increased slightly. *Ledum groenlandicum* and *L. decumbens* had flowered at this time.

6.2.4 - Spatial Variation in Phenological State of *Betula glandulosa*

An evaluation of the effect of transect and elevation might be better accomplished by discussing a single ubiquitous species during 1 week. The average cover, height, and phenological state for *B. glandulosa* are reported in Table 87. This species was more abundant at the higher elevations than at the 2 lower elevations, but did not vary significantly by transect. This trend was consistent with the fact that higher elevations were generally low birch shrub scrub vegetation types while the lower elevations contained several different vegetation types, depending on the transect.

Generally, *B. glandulosa* grew taller at the higher elevations except along the Switchback transect where heights were similar among elevations (Table 87). The higher elevations, especially the bench position, along Tsusena Creek had much taller shrubs (86 cm versus overall mean of 55 cm). Whether this was related to edaphic, climatic, topographic, or site history factors or a combination of factors was not known.

Phenological state was not different for the Watana Creek, Jay Creek, and Switchback transects (Table 87). However, *B. glandulosa* along the Tsusena Creek transect was in the leaf bud stage while plants along the other transects had already developed leaves. Watana and Jay Creek transects had some variation in phenological state with respect to elevation. The bench location appeared to lag behind the other elevations in plant development (2.4 versus mean 2.7 and 2.6 versus mean 2.9). The Switchback and Tsusena Creek transects were not different in phenological state with respect to elevation.

6.2.5 - Phenological Development of a Species Over Time

Height growth from a phenological point of view was important only for herbaceous plant species, which did not occur at many sites. Table 88 presents cover, height, and phenological development of *M. paniculata* over time for the middle slope elevation of the Jay Creek transect. Cover increased slowly during the first 2 weeks, then increased at a faster rate during the third week and remained the same during the fourth week. Cover values almost doubled (9 versus 14%) between 22 June and 29 June. Height followed a similar pattern with rapid growth through the first 3 weeks, slowing in the fourth week, and almost doubling in the fifth. The phenological state of *M. paniculata* exhibited a similar pattern. Most individuals were in a leaf state on 1 June but had progressed to the flower bud stage by 8 June. A few had begun flowering on 15 June. Phenological development slowed on 22 June but advanced to the flowering state for many plants by 29 June. All parameters showed a slowing of growth during the fourth week. This could have resulted from colder air temperatures and snow flurries that occurred at the higher elevations the previous week or could have been an artifact of sampling. However, *M. paniculata* may normally exhibit a slowing of growth at this stage, as resources are directed toward flower development.

6.2.6 - Transect Effects

The effect of transect location on phenological development of 4 common species can be seen graphically by maintaining the elevation approximately constant and comparing observations through time (Figure 5). Since plots were not repositioned in the same place each week, the phenological development sometimes appeared to regress. In addition, in evergreen species (*Ledum groenlandicum* and *V. vitis-idaea*) it was sometimes difficult to distinguish between old and new growth because of similar coloring. If a leaf was party emerged, it was obvious that the leaf was a result of new growth. Otherwise an actively growing plant could be listed as dormant. For comparison, the bench elevation on the 2 transects farthest downstream and the top slope elevation was selected on the upstream transects so that mean sea level elevations would be similar between transects.

Betula glandulosa was at the leaf bud stage on the selected transects during the first week (Figure 5). During the second week, most leaves had expanded on the Jay Creek transect while most were still in the bud stage on the Tsusena Creek transect. The other 2 transects were intermediate in development of *B. glandulosa*. By the third week, plants along all transects except Tsusena Creek had leafed out. Plants on the Tsusena Creek site developed leaves during the fourth week.

Vaccinium uliginosum developed earlier than *B. glandulosa* under some conditions, as evidenced by the presence of leaves during the first week at the Switchback site (Figure 5). During the second week *V. uliginosum* plants on the Jay Creek site had developed leaves. By the third week *V. uliginosum* had developed leaves at the elevation on all transects. Differences in leaf development of *V. uliginosum* after the third week were probably not significant.

Ledum groenlandicum initiated early growth at this elevation on the Swithback and Jay Creek transects, with the leaves having been expanded by the first week (Figure 5). By the second week *L. groenlandicum* on all the transects were in the flower bud stage. These plants on the Jay Creek transect were in flower by the fifth week. The flower bud stage appeared to last longer in this species than in other species. The retrogression between weeks 3 and 4 on the Switchback transect was unexplained, unless flowers had fallen off.

Vaccinium vitis-idaea initiated growth later than other species since the first new leaves did not appear on the plants until the third week, and then only at the Jay Creek site (Figure 5). *Vaccinium vitis-idaea* on most other transects did not show development of leaves until week 5, by which time the plants on the Jay Creek transect were already in flower. The apparent retrogression probably resulted from difficulty in determining phenological state on this species.

6.2.7 - Elevation Effects

The effect of elevation on phenological development of 4 common species was examined by selecting a single transect and examining its 4 elevations. The Watana Creek transect was selected because the vegetation was the least patchy and had a relatively continuous gradient along the entire slope. The other transects all had level areas at the bottom slope site. The Watana Creek transect was the only transect where elevation would not be excessively confounded with burns or other disturbance.

Betula glandulosa showed slightly earlier development at the mid-slope elevation than at higher elevations during the second week (Figure 6). During the third and fourth weeks the differences in development of *B. glandulosa* along the elevational gradient were minor or nonexistent. *Betula glandulosa* did not occur in an open birch-spruce site at the bottom-slope elevation.

Vaccinium uliginosum exhibited slight differences in development during week 2 (Figure 6). Plants on the lower 2 elevations were slightly earlier in leaf development than the higher 2 elevations on this transect. Following week 2 the pattern of leaf development of *V. uliginosum* appeared random.

Ledum groenlandicum showed differences in phenological development at different elevations during week 1 (Figure 6). Plants at the lowest elevation were in the flower bud stage during week 1 while *L. groenlandicum* at the highest elevation still was dormant. Differences in phenological development during and after the second week were minor, although the bottom-slope elevation was slightly more advanced since it had a number of individual plants in the flower stage. It should be noted, however, that the top slope elevation for Jay Creek which was at a higher elevation than the same position on the Watana Creek transect, was even more advanced (full flower).

The bottom-slope elevation had the earliest development of V. vitis-idaea on the Watana Creek tansect and had some individuals in flower during the fifth week (Figure 6). The bench position was the last of the 4 elevations to develop leaves on V. vitis-idaea during week 4.

Slight overall trends with respect to elevation could be observed with bottom elevations developing first and plant phenological development proceeding up the slope. However, as results on other transects show, site burn history may modify the effects of elevation. Many areas have flat areas along the river that would have a different cold air drainage regime than the Watana Creek transect.

6.2.8 - Summary and Discussion of Plant Phenology

Early development of herbaceous plant species could be important for moose in the spring on south-facing slopes of the potential impoundment areas, however, numerical data for cover, height, and phenological state collected in this study did not support this hypothesis. In contrast, visual observations indicated that herbaceous species and possibly some shrubs such as Vaccinium vitis-idaea might provide early spring forage in localized areas. There does not appear to be a specific type of location, such as bottom-slope elevation, that was a consistently good source of early growth of vegetation. However, "younger" aged sites tended to greenup earlier regardless of vegetation type.

Areas that had vegetation that greened up earliest were the open birch-spruce vegetation type at the mid-slope elevation on the Jay Creek transect and at the bottom elevation on Watana Creek transect. The low birch shrub scrub vegetation at sites on the bench and top-slope elevations on the Switchback transect also initiated early spring greenup. However, the low birch shrub scrub sites at the bench and top-slope elevations on the Tsusena Creek transect had late development of green forage. The only common factor we were able to identify among early-developing sites was a relatively recent (within 50-75 years) burn history.

Availability of forage in the spring depended not only on elevation but also on the geographic location within the potential impact areas. Which elevations had early available forage depended on the transect location. Effects of elevation were probably confounded with vegetation type. Hence, disjunct patches of vegetation may become available for foraging at the same time. Forage availability appeared to be dependent on the mesoclimatic environment in a particular area as modified by elevation, aspect, surrounding topography, and site history especially with respect to fire.

Mesoclimate was important since the area within the Watena impoundment tended to be warmer than the area within the Devil Canyon impoundment area. Elevation played conflicting roles in plant development since higher altitudes generally had cooler ambient temperatures, but lower positions on the slope were shaded and were sometimes in cold air drainages. Aspect was important for angle of incidence of solar radiation. The surrounding topography could shade what would be an otherwise warm site, or an open area might provide more sunlight. For instance, neither south- nor north-facing slopes near the Switchback were shaded by mountains above the level of the benches. Disturbance, especially by fire, was important as it might remove the insulating moss layer. In fact, fire history may be an overriding effect on plant phenological development and should be investigated further.

It is possible that the late start in field observations may have led to results that showed no obvious differences in north- versus south-facing slopes. The early reconnaissance trip indicated differences in snow melt between the 2 aspects. However, by the time forage was actually appearing, the sun angle was very high. Slight variations in the aspect modify the environmental regime. For instance, the "south-facing" slope along the Switchback transect actually faced slightly west. The late snow melt during spring, 1982 may have modified the normal plant phenological development; e.g. if snow melted earlier, sun angle would be lower and aspect would have a greater effect.

Some species such as V. vitis-idaea may appear at the base of trees in the first snow-free areas in forest types. This species is known to be used as forage by moose on the Kenai Moose Range (Oldemeyer et al. 1977, W. L. Regelin, ADF&G, personal communication). Some species, such as Mertensia paniculata and Epilobium angustifolium, grow at different rates, possibly providing forage at different times. Mertensia paniculata started slowly and continued development over a longer period while E. angustifolium started later but developed more quickly. Thus, E. angustifolium could avoid grazing at the earliest times. Similarly Populus tremuloides appeared to develop leaves later than Betula papyrifera.

Equisetum silvaticum at the middle-slope Jay Creek site and Eriophorum spp. (cottongrass) at the bottom of the north-facing slope opposite the Switchback site had been grazed at a time when other forage was not abundant. Later in the spring we observed no evidence of grazing, presumably because there was an abundance of forage available at that time.

If one assumes a maximum resevoir elevation of 666 m for the potential Watana impoundment, then several of the "warmer" areas that developed early forage will be above the level of the impoundment while some will be inundated. The warmest and earliest developing areas of middle-slope Jay Creek and bench and top positions on the Switchback transect would not be flooded. However, the bottom 2 elevations along the Watana Creek transect would be flooded. The top location of Watana would be only 17 m above the surface of the impoundment, while the middle-slope elevations of Jay Creek and Switchback transect would be 35 m above the surface. If the water body were to create a mesoclimatic effect, it might modify the timing of spring growth on the Watana site. The other 2 areas may be far enough from the impoundment to avoid such effects. Regardless, sites that warmup relatively early would still be available in the Switchback area.

6.2.9 - Biomass Estimations

Forbs and graminoids were the most abundant plants measured in terms of current annual growth biomass (Table 89). Forbs averaged 29 kg/ha over all sites and graminoids averaged 33 kg/ha. Biomass of forbs ($P < 0.05$) and graminoids ($P < 0.05$) increased over the growing season. *Betula glandulosa* had the greatest current growth of twigs and leaves for all sites. Weights of paired leaves and twigs were closely correlated ($P < 0.01$) for all species measured. Shrub biomass remained relatively constant over the period of study, except for *B. glandulosa* leaves which increased slightly ($P > 0.05$) in biomass over time.

Graminoid biomass was greatest ($P < 0.05$) at Jay Creek and Switchback, bottom elevation when compared to all other locations (Table 89). Forb biomass was greatest ($P < 0.05$) at Jay Creek, mid-slope and Switchback, bottom elevation. Few significant trends in differences among transects and elevations were observed for any shrub species. However, *B. glandulosa* biomass of 100 twigs was different ($P < 0.05$) among all sites, depending on week and elevation. *Alnus sinuata* was most abundant ($P < 0.05$) at Switchback, bottom elevation averaging 24 g current growth of leaves and stems per 100 twigs. *Betula papyrifera* biomass was greatest ($P < 0.05$) at Jay Creek, mid-slope averaging 8 g current annual growth of leaves and twigs per 100 twigs (Table 89).

During week 1 (31 May - 3 June), *B. glandulosa* current twig biomass (per 100 twigs) was significantly greater ($P < 0.05$) at Watana Creek, bench location than any other location (Table 82). Current twig biomass per 100 twigs of *A. sinuata* was greatest ($P < 0.05$) at Switchback, bottom elevation. Jay Creek, mid-slope had the greatest ($P < 0.05$) biomass of *B. papyrifera* during week 1.

For week 2 (7-10 June), *B. glandulosa* leaf biomass per 100 twigs was greater ($P < 0.05$) at Jay Creek, mid-slope than any other location. Graminoid standing crop was greatest ($P < 0.05$) at Watana Creek and Jay Creek, bottom elevation.

Betula glandulosa average leaf and twig biomass per 100 twigs was greatest ($P < 0.05$) at Watana Creek, top-slope during week 3 (14-17 June). Graminoid biomass was greater ($P < 0.05$) at Switchback, bottom elevation, and *B. papyrifera* leaf biomass per 100 twigs at Jay Creek, mid-slope, than any other location.

During the 4th week (21-25 June), *B. glandulosa* leaf biomass per 100 twigs was greatest ($P < 0.05$) at Switchback and Tsusena Creek and *B. papyrifera* biomass at Jay Creek, mid-slope.

For week 5 (28 June - 1 July), *B. glandulosa* leaf biomass per 100 twigs was greatest ($P < 0.05$) at Jay Creek, bench location. Forb biomass was greater ($P < 0.05$) at Jay Creek, mid-slope, and graminoid biomass at Jay Creek, bottom elevation than any other location.

By week 6 (31 August - 3 September), forb biomass was greatest ($P < 0.05$) at Jay Creek, mid-slope and Switchback, bottom elevation, *A. sinuata* at Switchback, mid-slope and bottom, and *B. glandulosa* leaf biomass per 100 twigs at Watana Creek and Switchback, bench location (Table 89).

Comparisons inside and outside the exclosures during week 6 indicate that forb biomass was significantly greater ($P < 0.05$) inside the exclosures at Watana Creek, top- and mid-slope, and Switchback, bottom elevation (Table 89). Current growth biomass per 100 twigs of A. sinuata was greatest ($P < 0.05$) inside the exclosures at Switchback, bottom elevation. No other significant differences occurred between inside and outside the exclosures for the other plants measured.

General trends indicated that forb biomass was greater inside the exclosures, and grass biomass outside the exclosures (Table 89). Betula glandulosa leaf and twig biomass per 100 twigs was highly variable when comparisons between inside and outside the exclosures were made (Table 89).

Total current annual growth biomass of shrubs was similar ($P > 0.05$) inside and outside of the exclosures (Table 90). However, twig and leaf biomass of B. papyrifera was greater ($P < 0.05$) outside the exclosures at the Switchback bottom elevation.

Transect and elevation differences in total current annual growth biomass were similar to those in current annual growth data for all plants measured (Tables 89 and 90).

6.2.9.1 - Discussion of Biomass Estimations

Results of the phenology study addressing current annual growth biomass indicate that differences among sites and elevations in plant biomass exist, but few significant trends were apparent for any species. Generally, graminoid and forb biomass was greatest at mid-slope and bottom elevations at all transects (Table 89). Shrub current growth biomass per 100 twigs was greatest at bench and top-slope exclosures (Table 89). These results would be expected as the plant communities change with elevation going from low shrub scrub woodland and open spruce forest types on the bench above the river slopes, into a mixed deciduous-coniferous forest on the slope of the river channel, to various plant communities at the bottom of the slope, reflecting successional stage and environmental characteristics of the site. Generally, these bottom-slope sites were the oldest sites sampled. Moisture regimes and soil communities also played a part in these elevational trends. However, site fire history also provided an important modifying influence, overcoming the effects of elevation at some sites.

Over the period of this study, forb and graminoid biomass steadily increased at all sites (Fig. 7). However, shrub biomass per 100 twigs (leaves and twigs) tended to remain stable for most species. The only consistent increase in biomass over time for the shrubs sampled occurred for leaves of B. glandulosa. These data indicated that B. glandulosa directed more resources towards leaf development than stem growth as the growing season progressed. However, leaf biomass associated with a twig was generally less than twig biomass for B. glandulosa until the last 2 weeks of sampling (Table 89).

Comparisons of plant current growth biomass inside and outside the exclosures (week 6, both data sets) reveal few significant differences (Tables 89 and 90). Forb biomass was greater inside the exclosures, indicating possible utilization ot forbs by moose, caribou, or bears. The same trend was apparent for B. glandulosa leaves and twigs. Utilization of B. glandulosa was less than for species of Salix and Alnus at many of the sites sampled in the middle basin. Biomass of A. sinuata per 100 twigs was greater inside the exclosures than outside (Tables 89 and 90). This may also reflect utilization by large herbivores.

Total current annual growth biomass of plants sampled during week 6 outside the exclosures indicated the amount of new forage biomass available going into the winter at these sites. Presumably, peak biomass was reached by late August - early September. At this time and over all sites, total forb biomass averaged 42 kg/ha, total graminoid 75 kg/ha, V. vitis-idaea 346 kg/ha, B. glandulosa 49 kg/ha, B. papyrifera 32 kg/ha, S. pulchra 31 kg/ha, S. glauca

98 kg/ha, and *A. sinuata* 37 kg/ha. Biomass of these plants totaled approximately 710 kg/ha which would support 0.26 moose/ha/winter assuming that: 1) a moose eats about 13 kg of dry forage per day (C. C. Schwartz, ADF&G, *personal communication*), 2) all of the available biomass was utilized, and 3) winter lasts 210 days. However, this estimate must be qualified as it applies only to south-facing slopes of the river channel, and only if moose eat all the current annual growth of each species sampled. Defoliation experiments have shown that biomass replacement in arctic plants is highly variable and dependent on environmental conditions (Archer and Tieszen 1980). Deciduous shrubs replace growth after defoliation to a greater extent than evergreen shrubs, however, defoliation significantly decreased production in both shrub types the next year. Archer and Tieszen (1980) concluded that some arctic shrubs are highly intolerant to grazing. However, graminoids are much more tolerant of grazing because above ground biomass production can be actually stimulated (Mattheis et al. 1976, Archer and Tieszen 1980).

One of the primary purposes of the phenology study was to explore the hypothesis that moose eat herbaceous plants during spring, following snowmelt. These plants are presumably highly nutritious and palatable, and are crucial to survival of moose on the study area. Biomass sampling conducted during late spring did not lend itself to examination of this hypothesis. However, the greater biomass of forbs inside than outside the exclosures at week 6 supported the contention, that forbs were eaten at some time during the growing season. To provide a definitive answer as to the validity of the moose-forb relationship, forb biomass needs to be estimated inside and outside the exclosures on a weekly basis during early spring at snowmelt. The new location and size of exclosures will facilitate such a procedure. In addition, information on food habits of moose during spring at those sites is necessary to complete the analysis.

6.2.10 - Current Annual Growth Diameter - Length Relationships

Approximately 1,052 current annual growth twigs of B. glandulosa were sampled for the entire study. Fifty-eight twigs of S. pulchra and 91 twigs of S. glauca were examined. Sixty-five twigs were collected from A. sinuata and B. papyrifera. The number of twigs clipped were directly proportional to the abundance of these species at the sites sampled.

Mean basal diameters ranged from 1.8 to 2.9 mm (Table 91). Alnus sinuata had the largest diameters and B. glandulosa the smallest. Mean twig lengths ranged from 47.2 to 119.4 mm, with B. papyrifera having the longest twigs of current annual growth. Both Salix spp. were identical in mean basal diameter, and were similar in mean length.

The mean basal diameter of both A. sinuata and B. papyrifera were significantly larger ($P < 0.05$) than B. glandulosa. No other significant differences were found for basal diameters (Table 91).

The average length of B. papyrifera twigs was significantly greater ($P < 0.05$) than B. glandulosa twigs. Both A. sinuata and B. papyrifera twigs were longer ($P < 0.05$) than twigs of both Salix species. No other significant differences were detected (Table 91).

The observed differences in basal diameter and length of current annual growth of the shrubs examined was related to both the life form and growth pattern of these species, and the amount of browsing a particular species received. Betula glandulosa is generally a low growing and relatively open shrub. Utilization of B. glandulosa was less than on the other species examined. Both Salix species were also low growing, presumably because of higher utilization which was reflected in their greater basal diameter and twig length. Betula papyrifera is a tree, that was occasionally found to be kept in a tall shrub class by heavy browsing at some sites. Its large basal diameter and twig length were a reflection of the utilization as well as life form of that species. *Alnus sinuata* is a tall shrub that received only light to moderate utilization. Basal diameter and twig length were probably more a reflection of its life form than browsing pressure.

Correlations between basal diameter and length of the individual twigs sampled were significant ($P < 0.05$) for each species with correlation coefficients of 0.31 for *A. sinuata*, 0.33 for *S. glauca*, 0.41 for *B. glandulosa*, 0.42 for *S. pulchra*, and 0.48 for *B. papyrifera*. The slope of the regression line was very similar for each species (Fig. 8) and was generally flat. Only *A. sinata* differed noticeably from the other species along the y-axis. These data indicate a nearly 1:0 relationship between the basal diameter and length of the current annual growth of these shrubs. Such a relationship suggests that 1 measurement may be all that is needed to accurately predict biomass of current annual growth, and that no more than 33 twigs would be necessary to adequately estimate basal diameter and 223 twigs would be necessary to adequately estimate length for any shrub species (Table 91).

Basal diameter was the least variable of the two measurements (coefficients of variation ranging from 20% to 29% and 46% to 75% for diameters and lengths, respectively) and would be the best to use. Both Basile and Hutchings (1966) and Ferguson and Marsden (1977) found that the basal diameter of bitterbrush (*Purshia tridentata*) twigs was adequate to predict both current annual growth and biomass of twigs for that shrub species.

6.2.11 - Photographic Study

The sequence of photographs obtained during the phenology study graphically illustrated the spatial and temporal development of vegetation in the spring. The photographs illustrate many of the differences indicated by the data and supported the results already discussed. The photographs are on file at the Alaska Agricultural Experiment Station, Palmer.

6.2.12 - Larger Exclosures

Larger exclosures were constructed for the 1983 spring field season shortly after 1982 exclosures were disassembled. The new exclosures (5 x 5 m) were constructed of 2 layers of 1.2-m (4 ft) netted wire supported by 2.1-m metal fence posts guyed out with wire. These exclosures were approximately 2.1 m tall. The new exclosures were arranged in clusters of 2 to 4 in areas where moose were known to congregate during parturition (Fig. 9). W. B. Ballard (ADF&G) provided information on moose locations and assisted in the general positioning of the clusters of exclosures. Placement of the exclosures within these general areas was undertaken during September 1982, by Agricultural Experiment Station range ecology personnel.

6.3 - Alphabet Hills Pre-burn Inventory and Assessment

The 25 sites sampled in the Alphabet Hills pre-burn inventory and assessment were combined into Level IV vegetation types of Viereck et al. (1982). Pre-burn site descriptions will have greater meaning once a fire has taken place and pre- and post-burn comparisons are made. Subsequent changes in species composition and the responses of individual species to manipulation by fire are best undertaken on a site-by-site basis. Five vegetation types were sampled in the Alphabet Hills during summer 1982. These 5 vegetation types were classified under 2 Level I (Viereck et al. 1982) vegetation classifications; forest and scrub. The Open White Spruce, Open Black Spruce, and Woodland White Spruce vegetation types were all forest types. The Dwarf

Birch and Dwarf Birch-Willow vegetation types were classified as scrub type.

Area (ha) of each Level III Viereck et al. (1982) vegetation type, and the relative percentage of each, for the primary, secondary, and control burn areas in the Alphabet Hills is shown in Table 92. The outer boundary, surrounding the control burn area, was based primarily on the similarity of the vegetation in the burn and control areas (Fig. 10). The outer boundary of the secondary burn area followed the reasonable expected limits of the burn as formed by natural barriers. The primary burn site represented the area expected to burn. Most study sites were located in the primary burn and control areas. The primary and secondary burn areas were defined by INF and BLM fire specialists while the control area was defined by Agricultural Experiment Station range ecology personnel.

Average diameter at point-of-browsing (DPB) measurements for shrub species in the Alphabet Hills are shown in Table 93 . Salix glauca had the largest DPB measurements, averaging 3.5 mm. The smallest DPB's of the shrub species was for B. glandulosa, averaging 2.4 mm. All species of Salix had larger average DPS's than B. glandulosa.

Salix glauca had the greatest weight for leaves attached to twigs clipped at the average DPB (Table 93). Mean weight of leaves was 0.74 g for S. glauca while B. glandulosa averaged 0.30 gm. Salix pulchra had the greatest twig weights, averaging 0.51 g/twig (Table 93). Species of Salix had larger leaf and twig weights than B. glandulosa. This was due in part to the larger average DPB's for Salix spp.

6.3.1 - Open White Spruce Vegetation Type

Three sites were sampled within the Open White Spruce vegetation type. Tree cover averaged 10%, tall shrub canopy cover 1%, low shrub cover 19%, dwarf shrub cover 11%, forb cover 34%, graminoid cover 10%, moss cover 50%, and lichen cover 2%. Picea glauca, Alnus crispa, Salix pulchra, Vaccinium uliginosum, Equisetem spp., and Calamagrostis canadensis were the most abundant vascular plants in this vegetation type (Table 94).

Density of P. glauca averaged 455/ha, while A. crispa, B. glandulosa, and S. pulchra had the greatest density of the shrubs sampled (Table 95). The oldest-aged trees in each of the 3 sites averaged 183 yrs for P. glauca and 151 yrs for P. mariana.

Salix pulchra basal diameter was larger than B. glandulosa, and percent utilization based on twig counts was similar between the 2 species (Table 96). Total available biomass was greatest for S. pulchra and utilized biomass was also greatest for S. pulchra, averaging 24% of the total biomass produced (Table 97).

Adequate sample sizes needed for cover estimates ranged from 1 to 13 plots per vegetation type. For stem density estimates, only 1 plot was needed for both shrub species measured. Percent utilization estimates required from 54 to 77 plots in the Open White Spruce type (Tables 94 and 96).

6.3.2 - Open Black Spruce Vegetation Type

Seven sites were examined in the Open Black Spruce vegetation type. Basal tree averaged 13% canopy cover, low shrubs provided 12% cover, dwarf shrubs 31%, forbs 20%, graminoids 10%, moss 53%, and lichens 19% cover. Litter, dead wood, and bare ground combined to account for 12% cover (Table 98).

Stem densities were greatest for P. mariana, B. glandulosa, and S. pulchra. The oldest trees of the 7 sites sampled in the Open Black Spruce vegetation type averaged 155 yrs for P. mariana and 209 yrs for P. glauca. Live shrub stems were more abundant than dead stems (Table 99).

Basal diameter of shrubs fell within the <1 - 2 cm range, and utilization based on twig counts ranged from 3% to 27% (Table 100).

Available and utilized browse biomass in the Open Black Spruce type totaled 540 and 135 kg/ha, respectively (Table 101). This represents approximately 20% utilization of the total biomass of the shrubs sampled. Salix pulchra was the major species and received 22% utilization of the total biomass present. Betula glandulosa was second in biomass with 16% utilization. Salix glauca accounted for only 3 kg/ha, but received 25% utilization of the biomass present. (Table 101).

Adequate sample size for cover estimates ranged from 1 to 13 plots per site. To estimate basal diameters only 1 plot was needed, however, between 68 and 325 plots were needed to adequately estimate utilization using twig counts (Tables 98 and 100).

6.3.3 - Woodland White Spruce Vegetation Type

Five sites were sampled in the Woodland White Spruce vegetation type. Basal tree cover averaged 6%, low shrub cover 25%, dwarf birch 45%, forbs 8%, moss 46%, and lichens 21% (Table 102). Picea glauca was the most abundant tree, B. glandulosa, S. pulchra, V. uliginosum, Ledum groenlandicum, and Empetrum nigrum were the most abundant shrubs. Equisetum silvaticum was the most abundant forb, and Cladonia spp. were the most abundant lichens (Table 102).

Tree density totaled 448/ha, dominated by P. glauca. The oldest trees of P. glauca averaged 243 yrs while P. mariana averaged 211 yrs of age. Tree seedlings were numerous. Betula glandulosa, Rosa acicularis, and S. pulchra were the shrubs with the greatest density (Table 103).

Basal diameters of shrubs measured ranged from <1 to 2 cm. Percent utilization estimates based on twig counts were less than those based on biomass estimates, however, trends were similar between the 2 methods (Tables 104 and 105).

Total available biomass of shrub stems was 411 kg/ha (Table 105). Betula glandulosa and S. pulchra provided the greatest biomass and received 23% and

26% utilization of the biomass present, respectively. However, every individual of S. glauca and S. lanata that was sampled at these sites had been browsed. One individual S. pulchra shrub at site #23 in the Woodland White Spruce vegetation type had 208 browsed stems and 332 unbrowsed stems.

Adequate sample sizes followed the same pattern as for the 2 previous vegetation types (Tables 102 and 105.)

6.3.4 - Dwarf Birch Vegetation Type

Seven sites were examined in the Dwarf Birch vegetation type. Low shrub canopy cover averaged 49%, dwarf shrub cover 55%, forb cover 8%, graminoid cover 3%, moss 53%, and lichen cover 23% (Table 106). Betula glandulosa, V. uliginosum, E. nigrum, and L. groenlandicum were the most abundant shrub species. The only forb with >1% cover was Cornus canadensis. Cladonia spp. were the major lichens.

Tree density totaled 27/ha, most of which were saplings. Both Picea species were evenly represented (Table 107). The few trees present were younger in age than trees in the forested vegetation types. Picea mariana averaged 91 yrs of age while P. glauca trees had a mean age of 106 yrs. Betula glandulosa and S. pulchra had the greatest density of the shrubs sampled, and most individuals were alive.

Basal diameters of shrubs ranged from 1 to 2 cm. Percent utilization of twigs on these shrubs ranged from 5 to 15, and ranked similar to utilization based on biomass (Table 108).

Browse availability totaled 1,822 kg/ha with only 16% utilization of the total biomass. Betula glandulosa and S. pulchra provided the most biomass and 15% and 20% of the total biomass had been utilized, respectively (Table 109).

Adequate sample sizes needed for cover estimates and twig counts showed the same trends as for the other vegetation types discussed previously (Tables 106 and 108).

6.3.5 - Dwarf Birch - Willow Vegetation Type

Three sites were sampled in the Dwarf Birch-Willow vegetation type. Low shrub canopy cover averaged 37%, dwarf shrub canopy cover 68%, forb cover 12%, graminoid cover 9%, moss cover 53%, and lichen cover averaged 26% (Table 110). Abundant shrubs in terms of canopy cover were identical to those in the Dwarf Birch type. However, Salix spp. were abundant in the Dwarf Birch-Willow types (Tables 106 and 110). Equisetum silvaticum, carices, and Peltigera spp. were also abundant. Tree density was low and dominated by dead trees and seedlings of P. glauca. Picea mariana had nearly equal densities of dead and live trees (Table 111). Picea mariana trees had average ages of 55 yrs in this vegetation type. The oldest trees of P. glauca were 30 yrs of age. Shrub density was made up primarily by B. glandulosa and S. pulchra.

Basal diameters of shrubs were in the 1 - 2 cm size class (Table 112). Percent utilization of these shrubs, based on twig counts, ranged from 5 to 8.

Browse availability totaled 1,039 kg/ha with 18% of the total biomass utilized (Table 113). Betula glandulosa and S. pulchra were the most abundant shrubs sampled in terms of available biomass (Table 113). Leaf biomass was similar to twig biomass for each shrub species.

The number of plots needed to estimate canopy cover with the degree of precision as stated (Table 110) ranged from 1 to 21. Utilization estimated by counting twigs needed from 80 to 147 plots for an adequate sample in the Dwarf Birch-Willow type (Tables 110 and 112).

A summary of density, gross available twig biomass, and percent utilization of twigs for the 5 Level IV vegetation types sampled in the Alphabet Hills study is shown in Table 114.

6.3.6 - Discussion

Tree density in the Open White Spruce type was greater than any other type where P. glauca was present. P. mariana dominated the Open Black Spruce type where density of *Picea mariana* in this type was greater than density of *P. glauca* in any vegetation type. The Dwarf Birch and Dwarf Birch-Willow types supported very few trees. Most of the trees in the Dwarf Birch-Willow type were dead, but seedlings of *P. glauca* were abundant. This type appeared to have a history of relatively recent fire.

Shrub cover was inversely related to tree density ($r_s = -0.81$, $N=5$, $P < 0.05$) in the Alphabet Hills study area. Major shrubs at all sites included *B. glandulosa*, *S. pulchra*, and *V. uliginosum*. *Alnus crispa* was found only at Open White Spruce sites, and *S. lanata* only at Open White Spruce and Open Black Spruce sites.

Generally, forb and graminoid cover decreased as shrub cover increased ($r_s = -0.71, -0.23$, respectively, $N=5$, $P > 0.05$). Moss cover was consistent among all vegetation types, averaging 53%. Cover of lichens was greatest where forb and grass cover was the least ($r_s = -0.70, -0.08$, respectively, $N=5$, $P > 0.15$). Litter cover increased ($r_s = 0.98$, $N=5$, $P < 0.001$) in association with increasing shrub cover.

The Open White Spruce type was made up of stands with moderate tree density dominated by *P. glauca*. Shrub cover was relatively low, while forb and graminoid cover was abundant. Moss was the major ground cover, while lichens and litter were relatively less abundant.

The Open Black Spruce type had the greatest tree densities, dominated by *P. mariana*. Shrub cover was sparse, and forb and graminoid cover was relatively abundant. Moss and lichens were the major ground cover and litter cover was low.

The Woodland White Spruce type was moderate in tree density, yet less than the Open White Spruce type. Viereck et al. (1982) classified tree stands as forest (open, closed, and woodland) based on canopy cover of trees. Forests have > 10% tree cover. Shrub cover was higher in the Woodland White

Spruce type than in any other forest or woodland type sampled due to an increase in both low and dwarf shrub categories. Forb and graminoid cover was also low, but lichen cover was relatively great. Litter cover was also greater in this type than any other forest type.

The Dwarf Birch type had very few trees and P. glauca and P. mariana were equally abundant. Shrub cover was much more abundant than in the forested types due to an increase in both the low shrub and dwarf shrub components. Forb and graminoid cover was low. Moss provided the major ground cover, but lichens were also abundant. Litter cover was relatively greater than in other vegetation types, probably originating from the deciduous shrubs.

The Dwarf Birch-Willow type was very similar to the Dwarf Birch type, except that density of dead trees was higher, and S. pulchra and S. glauca were present.

The primary objective of the Alphabet Hills burn study was to monitor the response of the different vegetation types to fire, and the subsequent response of moose to changes in the plant communities. Until the burn has been completed and vegetation development has occurred, this objective cannot be fully met. The burn was attempted during September 1982, but environmental conditions prevented the fire from spreading beyond the ignition sites. Presumably, another attempt to burn the area will be made during fall, 1983.

However, some subjective evaluations can be made based on the present vegetative composition and knowledge of fire ecology. It appears that the potential to improve the study area as moose habitat exists, at least in terms of forage availability. Shrubs such as B. glandulosa, Salix spp., Alnus spp., and R. acicularis exist in almost every vegetation type present. The few post-fire successional studies that have been conducted in Alaska indicate that on most sites shrubs dominate the plant community after 6 years, and up to 25 years, of vegetation development (Lutz 1956, Van Cleve and Viereck 1981, Viereck 1982). *Picea mariana* forests generally revegetate at a faster rate than *P. glauca* forests (Van Cleve and Viereck 1981). Following disturbance by fire, plant communities dominated by shrubs experience quick revegetation with numerous stump sprouts and root suckers. However, it was noted by Lutz (1956) and Van Cleve and Viereck (1981) that some sites revegetate directly back to *Picea* spp. forest without development of a shrub-dominated stage. This is probably due to a lack of shrubs in the immediate area of the fire. Lutz (1956) stated that *Salix* spp., *B. papyrifera*, and *Populus tremuloides* produced seeds at a relatively young age, produced many seeds each year, and that seeds of these plants were morphologically adapted to be wind-blown great distances. The Alphabet Hills study area appears to have an adequate seed source for *Salix* spp., *B. glandulosa*, and *Alnus* spp. *Betula papyrifera* did not occur at any of the sites sampled in the Alphabet Hills. In addition, stump sprouts and root suckers from the shrubs present at the burn site will also contribute to revegetating the area following the fire.

Fire intensity also plays a role in post-fire vegetation succession in Alaska. Fire intensity is directly related to the burning of the organic layer covering the soil surface. Dyrness (1982) stated that fire effects on the environmental conditions of a site were directly related to how much of the organic layer, as well as vegetation, is removed. When the organic layer is consumed by fire, the active layer of the permafrost increases, soil temperatures increase, and seedling establishment by shrubs and trees is enhanced (Van Cleve and Viereck 1981, Dyrness 1982, Viereck 1982). The magnitude of these effects is directly related to how much of the organic layer is removed. Lutz (1956) stated that mineral soil exposed by fire provided an optimal seedbed for secondary plant succession.

Dyrness (1982) noted that fire effects are highly variable. Fire usually does not consume all of the surface organic layer in *P. mariana* forests due to the relatively wetter site conditions. However, most *P. mariana* sites do respond to fire in a way that would be desirable in the Alphabet Hills study. Furthermore, it would be desirable to provide areas of undisturbed forest communities in close juxtaposition to the fire, for use as escape and thermal cover by moose. To date, no published studies have examined vegetation response to fire in a quantitative manner for plant communities other than *P. mariana* forests.

The history of fire in Alaska is extensive. Most sites in interior Alaska burn every 50 to 100 years. Fire is a recurring and consistent phenomenon in Alaska, and the plant and animal communities have evolved around this ecologically important disturbance.

Further evidence of the potential for fire to improve moose habitat was provided by the Dwarf Birch-Willow type, which appeared to have a history of recent fire. Biomass of shrubs that could potentially be utilized by moose (primarily *Salix* spp.) was greatest in this type, followed by the Open White Spruce type. Utilization of available biomass was greatest in the Woodland White Spruce, but was also great for the Dwarf Birch type and moderate for the other vegetation types. Utilization is a function of forage availability and the number of moose. Utilization of available biomass in the Dwarf Birch-Willow type was low, presumably due to the greater availability of shrubs. *Salix pulchra* and *S. glauca* consistently received the greatest utilization (based on both twig counts and biomass estimations) in any vegetation type. These shrubs are major winter foods of moose in Alaska (Peek 1974). Information concerning use of each vegetation type by moose and food habits of moose before and after the burn would greatly increase our understanding of moose - fire relationships.

Sample sizes needed for cover estimates were well below the number ofplots actually read for most plant species. However, twig counts needed approximately twice the number of plots that were actually examined. Twig count data was variable with coefficients of variation (SD/$\bar{x}$) ranging from 20% to 30%, depending on the species.

6.3.7 - Alphabet Hills Soils

The information presented here is baseline data for the proposed Alphabet Hills burn. Pre- and post-burn should yield important information on changes in amounts and composition of the soil variables analyzed. Unless otherwise stated, means presented in the text reflect the average for the entire soil profile sampled (0-15 cm).

6.3.7.1 - Open White Spruce Vegetation Type

Average soil pH for the Open White Spruce vegetation type was 6.34±0.56($\bar{x}$± standard deviation). Overall averages for each depth within this vegetation type ranged from 6.28 to 6.45, or were slightly acidic (Table 115). Individual soil samples varied from 5.67 to 7.05 over all depths, indicating a pH ranging from moderately acidic to neutral.

Macronutrient concentrations were greatest for calcium with an average of 3690.40±3115.44 ppm (parts per million) followed by 483.68±289.44 ppm magnesium and 370.56±768.09 ppm potassium. Average concentrations for each of the macronutrients were usually greater at the 0-5 cm depth than either the 5-10 cm or 10-15 cm depths. Viereck (1970) found the greatest levels of potassium, magnesium, and calcium to be associated with areas of the profile containing the greatest concentrations of organic matter in study areas adjacent to the Chena River in interior Alaska. It is not apparent why an exceptionally high potassium content was found at the 5-10 cm depth.

Micronutrient concentrations were greatest for iron which had

189.08±81.54 mg/g (milligrams per gram), followed by 27.79±34.18 mg/g for manganese, 2.27±1.15 mg/g for copper, and 2.17±3.34 mg/g for zinc.

Average percent organic matter was 11.76±10.02 in the Open White Spruce vegetation type. As would be expected, organic matter decreased (Table 115) from the 0-5 cm depth to the 10-15 cm depth.

Total nitrogen averaged 0.41±0.35% and total phosphorus averaged 0.09±0.01%. Total soil nitrogen and phosphorus are often correlated with organic matter content of soils (Hausenbuiller 1978). This can be observed to some extent by decreases in concentration of total nitrogen and phosphorus with increasing depth (Table 115).

Texture analysis yielded 33.4±9.4% sand, 46.2±7.8% silt, and 20.4±4.5% clay, generally indicating a loamy texture classification for the soils within this vegetation type.

6.3.7.2 - Open Black Spruce Vegetation Type

Average soil pH for the Open Black Spruce vegetation type was 6.08±0.58. Averages at each depth within the Open Black Spruce vegetation type ranged from 5.82 to 6.31, indicating a moderately or slightly acidic soil (Table 116). Individual pH's over all depths for sites sampled in the Open Black Spruce vegetation type ranged from 4.81 to 6.78. A thick moss layer and coniferous tree litter probably accounted for the low pH of soils observed in this vegetation type (Viereck 1970).

Concentrations of calcium were the greatest at 2485.00±1795.90 ppm, followed by 410.20±245.02 ppm for magnesium and 104.41±94.83 ppm for potassium in the Open Black Spruce vegetation type. Of all the macronutrients examined, calcium always had the greatest concentration. Calcium is generally a more abundant element in the earth's crust than either magnesium or potassium (Hausenbuiller 1978).

Iron had the greatest average concentration of all micronutrients examined (300.63±215.18 mg/g), followed by manganese with 62.18±109.17 mg/g, copper with 2.97±1.40 mg/g, and zinc with 2.76±4.44 mg/g.

Percent organic matter averaged 11.21±11.14. Total nitrogen averaged 0.37±0.38% and total phosphorus averaged 0.09±0.02%.

Texture classification of soils in the Open Black Spruce type indicate a loamy soil with 31.5±9.6% sand, 42.8±7.3% silt, and 25.7±9.4% clay.

6.3.7.3 - Woodland White Spruce Vegetation Type

Average soil pH for the Woodland White Spruce vegetation type was 6.16±0.24. Averages for each depth ranged from 6.04 to 6.24, or slightly acidic (Table 117). Individual pH readings over all depths sampled within the Woodland White Spruce vegetation type varied from 5.76 to 6.43, indicating a range from moderately to slightly acidic.

Macronutrient concentrations were greatest for calcium with 2086.49±1358.77 ppm, followed by 406.81±235.70 ppm for magnesium, and 388.14±757.90 ppm for potassium.

Average micronutrient concentrations were greatest for iron at 225.70±120.94 mg/g, followed by 21.89±20.84 mg/g for manganese, 2.04±0.97 mg/g for copper, and 0.96±1.23 mg/g for zinc.

Organic matter content was low compared to other vegetation types, averaging 7.99±8.41%. Total nitrogen measured 0.26±0.25% and total phosphorus was 0.09±0.03%. This soil had have a loamy textural classification with 31.5±14.9% sand, 42.9±9.8% silt and 25.6±11.6% clay.

6.3.7.4 - Dwarf Birch Vegetation Type

Average soil pH for the Dwarf Birch vegetation type was 5.12±0.68, or moderately acidic. Averages for each depth varied from 4.66 to 5.52, ranging from strongly to moderately acidic (Table 118). Individual pH readings over all depths ranged from 3.99 to 6.51. A thick moss layer contributed to low pH. Viereck (1970) noted low soil pH in black spruce/sphagnum stands adjacent to the Chena River in Interior Alaska. The pH readings in the Dwarf Birch type were the lowest found in any of the vegetation types sampled in the Alphabet Hills study area (Table 118).

Macronutrient concentrations were greatest for calcium with 716.15±803.90 ppm, followed by magnesium (150.80±143.93 ppm) and potassium (105.38±179.28 ppm).

Micronutrient concentrations were greatest for iron with 231.26±99.73 mg/g, followed by 10.27±11.58 mg/g for manganese, 1.02±0.72 mg/g for copper, and 0.95±2.80 mg/g for zinc.

Organic matter averaged 10.54±9.10%. Total nitrogen averaged 0.28±0.23% and total phosphorus was 0.08±0.02%. Soil texture classification was loamy with 33.9±10.1% sand, 45.2±8.9% silt, and 20.9±8.6% clay.

6.3.7.5 - Dwarf Birch-Willow Vegetation Type

Average soil pH for the Dwarf Birch-Willow vegetation type was 5.86±0.42. Averages by depth ranged from a pH of 5.64 to 6.07, or moderately to slightly acidic (Table 119). Individual readings over all depths ranged from 5.50 to 6.70.

Macronutrient concentrations were greatest for calcium with 2090.94±1052.26 ppm, followed by magnesium (478.47±224.51 ppm) and potassium (103.56±51.31 ppm).

Micronutrient concentrations were greatest for iron with 275.65±90.56 mg/g, followed by 14.32±11.53 mg/g for manganese, 1.81±1.03 mg/g for copper, and 0.85±0.74 mg/g for zinc.

Organic matter content averaged 10.90±11.10%. Total nitrogen and total phosphorus averaged 0.37±0.32% and 0.09±0.02%, respectively. Soil texture classification for this vegetation type was loamy, with 31.8±9.2% sand, 43.5±4.8% silt, and 24.7±7.6% clay.

6.3.7.6 - Permafrost and Organic Matter

Average depth to permafrost within vegetation types was greatest in the Dwarf-Birch Willow type (Table 120). Lack of overstory and/or lack of an insulating moss layer in this vegetation type probably were major factors contributing to this characteristic. Open Black Spruce stands had the shallowest depth to permafrost. Dyrness (1982) reported shallow permafrost readings in undistrubed black spruce/feathermoss vegetation communities in the Yukon-Tanana Uplands of Alaska. Organic layer depth (Table 120) and depth to permafrost were negatively correlated ($r_s = -0.61$, N=5, $P > 0.05$), but the correlation was not significant.

6.3.7.7 - Total Tons Nitrogen and Phosphorus

Total metric tons of nitrogen and phosphorus were calculated by vegetation type within the Alphabet Hills primary and secondary burn areas (Table 121). The total metric tons per hectare were calculated for the entire 0-15 cm soil depth sampled using an average bulk density of 1.25 g/cm^3. Amounts of total nitrogen are expected to change after the burn is completed. Total nitrogen, including that in the organic layer, would decrease, much of it being lost to volatilization. However, more nitrogen would be available on site through release from organic matter (Martin 1981). Total phosphorus would also decrease following the burn. Slopes of sites sampled ranged from 1-25 percent. Slope steepness can have an effect on soil chemical composition due to the prospects of increased erosion following a burn. The aforementioned effects are highly variable due to differences in burn intensity, slope length, amount of ground cover, and precipitation. Resistance of soil particles to detachment, water infiltration rate, and rain intensity also play an important role in the severity of erosion (Boyer and Dell 1980). The Alphabet Hills burn will be attempted again during the late summer or fall of 1983. Post-burn studies should include soils analysis of each site burned to determine the extent of release of nutrients from burned vegetation and the organic matter layer. These post-burn soils will provide the baseline information necessary to document soil chemical composition changes through time for each site that was burned.

6.3.7.8 - Conclusions

Comparisons of soil components were made using multivariate analysis of variance. For discussions where this is used, significance of F has been set at $P \leq 0.10$.

Significant differences for pH ($P < 0.001$) were found by depths within separate vegetation types. This was most apparent in the Dwarf Birch vegetation type, where pH values had a broad range and a relatively high standard error. Significant differences ($P < 0.001$) in organic matter, total nitrogen, and total phosphorus were found by depth within separate vegetation types. This was true for all vegetation types sampled in the Alphabet Hills. This reinforces the conclusion that organic matter, total nitrogen, and total phosphorus decreased with increasing depth in the soil profile. Particle size did not significantly differ by depth within separate vegetation types for sand ($P = 0.18$), silt ($P = 0.51$), and clay ($P = 0.22$).

Comparisons among all vegetation types yielded significant differences ($P < 0.001$) for pH. This was not unexpected given the broad ranges (strongly acid to neutral) found for pH. Macronutrients were significantly different among all vegetation types for calcium ($P = 0.006$) and magnesium ($P = 0.002$) whereas no significant differences were found for potassium ($P = 0.14$). For micronutrients, particle size classes, total nitrogen, and total phosphorus, no significant differences ($P > 0.10$) were found when compared among vegetation types.

Following the Alphabet Hills burn, significant differences should be found in the soil variables measured in this study. Depth to permafrost measurements should increase with associated reductions in the organic layer (Dyrness 1982). Generally, nutrient availability will increase immediately after the fire. Erosion and/or leaching may cause a net decrease in succeeding years, although much of this depends on fire intensity (Boyer and Dell 1980).

It should be noted that the sampling scheme used for soils was consistent with that employed for vegetation sampling. Thus, our soil samples were not grouped with respect to strict soil types, rather they were grouped according to Level IV vegetation types. Enough variation in soil chemical composition exists within Level IV vegetation types to effectively mask much of the differences that may actually exist between vegetation types and/or soil types based on a finer classification scheme.

6.3.8 - Comparison of Susitna Basin and Alphabet Hills Vegetation Types

The 5 vegetation types in the Alphabet Hills corresponded to 5 of the 10 vegetation types in the browse inventory study in the middle Susitna River Basin. The Open White Spruce, Open Black Spruce, Dwarf Birch, and Dwarf Birch- Willow vegetation types were sampled at both study areas. The Woodland Spruce of the Susitna Basin and the Woodland White Spruce of the Alphabet Hills were also directly comparable. One of the 6 sites in the Susitna Basin Woodland Spruce vegetation type was classified as a Woodland Black Spruce type. The other 5 sites in that study area were considered Woodland White Spruce vegetation types. However, both species of Picea were generally found growing together in the forest types. The stem density and relative canopy cover of each species of _Picea_ usually was the determining factor in whether a site was classified as a Woodland White Spruce or Woodland Black Spruce vegetation type. Thus, for our purposes the Woodland Spruce and Woodland White Spruce vegetation types of the Susitna Basin and Alphabet Hills studies, respectively, were compared.

6.3.8.1 - Open White Spruce Vegetation Type

Percent canopy cover of all plant species common to the Open White Spruce vegetation type in both the Susitna Basin and Alphabet Hills study areas was not significantly correlated ($r=0.29$, $N=10$, $P > 0.05$). _Alnus_ spp. was present in both studies and total low shrub and total dwarf shrub were comparable. Average canopy cover of _Salix pulchra_ was approximately 8 times higher in the Alphabet Hills, but both ericaceous shrubs _Vaccinium uliginosum_ and _V. vitis-idaea_ were 2-3 times greater in the Susitna Basin. Average total forb cover was approximately 3 times greater in the Alphabet Hills during summer, 1982. Total stem density of _B. glandulosa_ was very similar between the 2 study areas. However, as indicated previously by canopy cover estimates, _S. pulchra_ was more abundant in the Alphabet Hills, averaging nearly 12 times as many stems/ha as in the Susitna Basin. However, utilization of both _B. glandulosa_ and _S. pulchra_ twigs was lower in the Susitna Basin, averaging about 50% as many browsed twigs/stem in this vegetation type even though stem densities were also lower than in the Alphabet Hills. Also reflecting these differences in stem densities was total available twig biomass for _S. pulchra_, which was over 600% higher in the Alphabet Hills.

6.3.8.2 - Open Black Spruce Vegetation Type

Total low shrub and total dwarf shrub canopy cover was very similar between the Susitna Basin and Alphabet Hills in the Open Black Spruce vegetation type. Percent canopy cover of plant species found in both the

Susitna Basin and Alphabet Hills study areas were highly correlated ($r=0.98$, $N=17$, $P < 0.01$). Similar to the Open White Spruce type, total forb cover was greater in the Alphabet Hills during summer, 1982. Canopy cover of Carex spp. and total lichens was also greater in the Alphabet Hills. Although canopy cover of B. glandulosa was nearly identical between the Susitna Basin (7%) and Alphabet Hills (5%), stem densities were nearly 3 times higher in the Alphabet Hills. Stem densities for S. pulchra averaged 11,549 stems/ha and 15,500 stems/ha for the Susitna Basin and Alphabet Hills study areas, respectively. Salix lanata in the Alphabet Hills and S. glauca in the Susitna Basin had the highest utilization estimates based on twig counts for the 2 studies. Excluding A. sinuata from the comparison, total available twig biomass was identical between the Alphabet Hills and Susitna Basin. In both study areas the bulk of total available shrub biomass was S. pulchra and B. glandulosa.

6.3.8.3 - Woodland White Spruce Vegetation Type

Species composition and canopy cover in the Woodland White Spruce type was highly correlated ($r=0.89$, $N=8$, $P < 0.01$) between sites sampled in the Susitna Basin and Alphabet Hills study areas. Canopy cover of B. glandulosa, S. pulchra, V. uliginosum, and L. groenlandicum were greatest sampled in the Alphabet Hills. Cover of lichens was greater in the Alphabet Hills, particularly Peltigera spp. Stem densities of B. glandulosa and S. pulchra were 200% and 11 times greater in the Alphabet Hills, respectively. Some of the highest utilization estimates of shrubs based on twig counts were observed in the Woodland Spruce type in both study areas. The average percent utilization for all shrub species (excluding Alnus spp., which were not measured in the Alphabet Hills) was 20% in the Susitna Basin and 33% in the Alphabet Hills. Estimates of available and utilized biomass were approximately 2-3 times greater for the Alphabet Hills.

6.3.8.4 - Dwarf Birch Vegetation Type

Canopy cover of B. glandulosa in the Dwarf Birch vegetation type was approximately 2 times greater at sites in the Alphabet Hills than at sites in the Susitna Basin. Empetrum nigrum, L. groenlandicum and V. uliginosum also had substantially greater canopy cover in the Alphabet Hills. Total forb, graminoid, and lichen cover was similar between the 2 study areas. The Alphabet Hills averaged 30% cover of litter whereas sites in the Susitna Basin had mean litter cover of only 7%. In spite of the apparent differences in cover percentages, there was a significant correlation ($r=0.90$, $N=25$, $P < 0.01$) of species composition and canopy cover between the 2 study areas in the Dwarf Birch vegetation type. Stem density estimates for B. glandulosa, Rosa acicularis, S. glauca, and S. pulchra were all greater at the Alphabet Hills sites, ranging from 1.6 to 2.4 times higher than in the Susitna Basin. Utilization of twigs was greater for B. glandulosa and S. pulchra in the Alphabet Hills. Utilization of S. pulchra was approximately equal for the 2 study areas. Betula glandulosa was the major component of total available biomass for both the Alphabet Hills and Susitna Basin. Total available biomass of B. glandulosa in the Alphabet Hills exceeded that of the Susitna Basin; the opposite was true for S. pulchra in the Dwarf Birch vegetation type.

6.3.8.5 - Dwarf Birch - Willow Vegetation Type

Species composition and percent canopy cover were significantly correlated ($r=0.85$, $N=4$, $P < 0.01$) between the 2 study areas for in the Dwarf Birch-Willow vegetation type. Canopy cover of the low shrubs B. glandulosa and S. glauca as well as the dwarf shrubs E. nigrum and V. uliginosum was greater in the Alphabet Hills sites. Total forb and graminoid cover was equal between the 2 study areas for this vegetation type. Lichen cover was much lower for the Susitna Basin sites, particularly *Peltigera* spp. and *Cladonia* spp., than for the Alphabet Hills sites. Stem densities of *B. glandulosa* and *S. pulchra* were both greater in the Alphabet Hills study area. Percent utilization of *S. glauca* twigs was greater in the Susitna Basin, while percent utilization of both *S. pulchra* and *B. glandulosa* were both greater in the Alphabet Hills. Total available biomass was approximately 2 times greater in the Alphabet Hills than in the Susitna Basin.

6.3.9 - Comparison of Soil Variables Between the Alphabet Hills and Susitna Basin Study Areas.

The following is a quantitative comparison between soil samples taken from the Alphabet Hills and the middle Susitna River Basin study areas. Due to the complexity involved in the analysis of variance between these two areas, the analysis was run separately by depth. Significance was set at $P \leq 0.1$.

At depth 0-5 cm, pH was significantly different ($P = 0.09$) between the two study areas when comparing the same vegetation type. The pH also differed significantly ($P < 0.001$) at depth 0-5 cm among all vegetation types when both study areas are combined. At depth 5-10 cm pH was not significantly different ($P = 0.37$) between the two study areas when comparing the same vegetation type. Comparisons among all vegetation types for both study areas combined indicated significant differences ($P < 0.001$) for pH at depth 5-10 cm. At depth 10-15 cm there were no significant differences $P = 0.80$ between the two study areas for pH when comparing the same vegetation type. Significant differences ($P < 0.001$) were found at depth 10-15 cm among all vegetation types for both study areas combined.

Macronutrients at the 0-5 cm depth were not significantly differentbetween the 2 study areas for calcium ($P = 0.13$), magnesium

(P = 0.23) and potassium (P = 0.84) when comparing the same vegetation type. Among all vegetation types, for both study areas combined, significant differences were found for calcium (P = 0.04) and magnesium (P = 0.01) although no significant differences were noted for potassium (P = 0.39). At the 5-10 cm depth, no significant differences were found between study areas when comparing the same vegetation type for calcium (P = 0.31) and magnesium (P = 0.50), however, potassium was significantly different (P < 0.001). Significant differences among all vegetation types sampled were found when combining the two study areas at depth 5-10 cm for calcium (P = 0.02), magnesium (P = 0.02), and potassium (P = 0.09). At the 10-15 cm depth, no significant differences were found between the two study areas when comparing the same vegetation type for calcium (P = 0.22) and potassium (P = 0.95) although significant differences were found for magnesium (P = 0.02). Differences among all vegetation types when the 2 study areas were combined were significant at the 10-15 cm depth for potassium (P = 0.05) and magnesium (P = 0.01, however differences were not significant for calcium (P = 0.17).

At the 0-5 cm depth no significant differences between study area were found when comparing the same vegetation type for iron (P = 0.62), manganese (P = 0.79), or zinc (P = 0.43). Significant differences did occur for copper (P < 0.001). No significant differences were found at the 0-5 cm depth among all vegetation types when the 2 study areas were combined for iron (P = 0.23), copper (P = 0.24), and zinc (P = 0.13), however, manganese was found to be significantly different (P = 0.08). At the 5-10 cm depth, significant differences between the 2 study areas were found for iron (P = 0.01), manganese (P = 0.09), copper (P = <0.001), and zinc (P = 0.10) when comparing the same vegetation type. Comparisons among all vegetation types when combined over the 2 study areas at the 5-10 cm depth indicated that significant differences occurred for manganese (P = 0.03), copper (P < 0.001), and zinc (P < 0.001), however, significant differences were not found for iron (P=0.18). At the 10-15 cm depth, significant differences between the 2 study areas were found for iron (P = 0.03), manganese (P < 0.001), copper (P < 0.001), and zinc (P < 0.001) when comparing the same vegetation type. Among all vegetation types when both study areas were combined, significant differences at the 10-15 cm depth were found for manganese (P < 0.001), copper (P = 0.05), and zinc (P = 0.05). However, no significant differences were found for iron (P = 0.21).

At the 0-5 cm depth, organic matter was not significantly different between the 2 study areas when comparing the same vegetation type (P = 0.82). Among all vegetation types when both study areas are combined there was also no significant difference at the 0-5 cm depth for organic matter (P = 0.99). At the 5-10 cm depth, no significant difference in organic matter (P = 0.79) was found between the 2 study areas when comparing the same vegetation type nor when both study areas were combined (P = 0.81). At the 10-15 cm depth, no significant difference (P = 0.90) in organic matter was found between the 2 study areas when comparing the same vegetation type nor when both study areas were combined among all vegetation types sampled (P = 0.44).

For 0-5 cm, 5-10 cm, and 10-15 cm depths, there were no significant differences between the two study areas for total nitrogen or total phosphorus when comparing the same vegetation type. Comparisons among all vegetation types when both study areas were combined also showed no significant differences for either total nitrogen or total phosphorus.

At all depths (0-5 cm, 5-10 cm, and 10-15 cm) there was no significant differences in any of the particle size classes (sand, silt, clay) between the two study areas when comparing the same vegetation type nor when the 2 study areas were combined.

6.3.9.1 - Conclusions

Comparisons indicated that, in general, many soil components are not significantly different (within a vegetation type) between the Alphabet Hills and middle Susitna River Basin area. However, the lack of significant statistical differences between the Alphabet Hills burn area and the middle Susitna River Basin are probably due to the fact that individual sites within a vegetation type in both study areas were often significantly different, producing large variance estimates when sites are averaged across a vegetation type and then vegetation types compared between study areas.

It should also be noted that the soil sampling scheme was designed to be consistent with our sampling scheme for vegetation types. Any differences in the results of the soils analysis may be attributable to the fact that soil samples were taken in a certain vegetation type rather than a specific soil type. Information presented will serve as useful baseline data after the Alphabet Hills burn is completed. Changes in soil nutrient concentrations are common following fire. Pre- and post-burn comparisons will provide important information in assessing the feasability of using controlled burns as a mitigation technique for manipulation of habitat for moose.

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8 - GLOSSARY

This glossary of terms, acronyms, and phrases is provided to assist readers, both scientists and laymen, in understanding the terminology as used in this report. Some definitions depart slightly from the norm for specialized cases.

Adequate sample size - refers to a statistical procedure used to determine the number of sampling units needed to estimate a parameter within a sampling site to a degree of precision determined by the investigators.

Anthesis - the action or period of opening a flower.

Aspect - a position facing a particular compass direct, usually defined qualitatively (north, south, east, west) or as a compass direction degrees; also the predominant direction of slope of the land.

Assessment - the act or an instance of determining the importance, size, or value of a resource.

Availability - the quality or state of being present or ready for immediate use. Used in this report to differentiate among forage units that for various reasons would or would not be accessible.

Available twig biomass - refers to twig biomass as accessible forage, twig biomass protected from browsing by snow cover, or dead plant parts was not considered as available.

Basal diameter - the diameter of shrub stems immediately above ground or moss level, measured at the internode.

Basal stem cover - the area of the cross section above the root swell of trees in a sampling unit.

Basidiomycetes - a large class of higher fungi having septate hyphae, bearing spores on a basidium (mushrooms).

Bimetallic thermometer - a thermometer composed of 2 different metals with different expansion rates the difference of which is used to estimate temperature; versus a mercury thermometer.

Biomass - the amount of living matter usually expressed as weight per unit area or part. As used here, biomass refers to dry weight standing crop of designated above-ground plant parts per unit area.

Browse - shoots, twigs, and leaves of shrubs or trees that are fit for consumption by animals.

Browsing pressure and intensity - the relative amount of plant defoliation resulting from consumption by animals.

Bryophytes - any nonflowering plant comprising the mosses or liverworts.

CAG - acronym for current annual growth dry weight standing crop biomass.

Cambium - a thin formative layer between the xylem and phloem of most vascular plants that gives rise to new cells and is responsible for secondary growth.

Canopy cover - the percentage of a sampling unit covered by a class of vegetation that is projected onto the ground. We did not include gaps in the vegetation canopy in our estimates.

Carices - plural for <u>Carex</u>.

Clipped plots - refers to sampling units in which plants were harvested at ground or moss level to estimate plant standing crop above ground dry weight biomass.

Composition - refers to the plant species present in any sampling unit, site, or vegetation type.

Controlled burn - the use of fire as a management tool under specified conditions for burning a predetermined area.

Cover increments - percentage units to which plant canopy cover was estimated.

Current annual growth - the primary growth (dry weight biomass) of plants, up to the point in time when sampling is conducted, that occurred during the present growing season; usually measured per unit area.

Current growth biomass - the amount of living matter produced by the vegetation during the current growing season, at the point of time of sampling; usually measured as dry weight per unit area.

DBH - acronym for diameter-at-breast-height.

Decadent - refers to vegetation that has died, or is deteriorating.

Density - the number of individuals per unit area.

Diameter class - refers to a unit class in which the basal diameter of a shrub belongs; 1-cm increments in this report.

Diameter-at-breast-height - diameter of the main stem of a tree at 1.13 m above the ground.

Diameter at point-of-browsing - the diameter of a twig or stem where it has been bitten off by an animal.

Distribution - the spatial arrangement of vegetation.

Dormant - plants that are not actively photosynthesizing or growing, but still alive.

DPB - acronym for diameter at point-of-browsing.

Dwarf shrub - a shrub less than 20 cm in height.

Ecotone - refers to the area influenced by the transition between plant communities or between successional stages or vegetative conditions within a plant community.

Edaphic factors - resulting from or influenced by the soil rather than the climate.

Elevational gradient - changes in parameters over a range in elevation.

Ericaceous shrubs - shrubs classified into the family Ericaceae.

Phenological state (stage) - a
characterized by certain morp
growth, flowering, fruiting, etc

Photographic points - designa
development were taken over time
of vegetation.

Plant community - a concret
recognized and are obvious to th
over many locations.

Plant production - the dry wei
growth over an entire growing se
grazing.

Plots - a unit of area in whi
usually refers to the basic sam
line. See quadrat.

Ppm - acronym for parts per mill

usually attached to a collar aro

Random sampling - sampling in suc
likely to be measured.

Range extension - the document
its previously known geographic a

Reconnaissance survey - done to
of an area prior to planning or i

Life form - the body form that characterizes a kind of organism at maturity such as graminoids, shrubs, trees, mosses, lichens, etc.

Life form total - the sum of an estimated parameter of all species of a life form in a sampling unit.

Litter - the uppermost, slightly decayed layer of organic matter on the ground surface, usually composed of leaves, stems, flower and fruit parts, etc.

Low-growing shrubs - shrubs that are from 20 cm to 1.5 m tall.

Mesoclimate - climate associated with spatial variation in a geographic area; i.e. Watana versus Devil Canyon impoundments.

Microclimate - the essentially uniform local climate of a small site or habitat.

Mg/g - acronym for milligrams per gram.

Mitigation - the act of compensating for, or decreasing the effect of a perturbation to a natural ecosystem.

N - symbol for sample size.

Nested design - an experimental design where levels of one factor are subsamples of levels of another factor.

Node - a joint of a plant stem; the place where branches and leaves are joined to the stem.

North-facing slope - a hillside or slope that has a northern exposure; when standing on this slope, facing away from the slope, one faces in a northerly direction.

Ocular - refers to estimating a parameter based on visual observation alone.

Palatable - agreeable to the taste or particularly sought out by an animal.

Parturition - the act or process of giving birth to offspring.

Phenology - a branch of science studying the relations among plant development and environmental conditions.

Phenological state (stage) - a point in time of plant development that is characterized by certain morphological attributes such as initiation of new growth, flowering, fruiting, etc.

Photographic points - designated points where photographs of vegetation development were taken over time so as to consistently observe the same unit of vegetation.

Plant community - a concrete definable unit of vegetation that can be recognized and are obvious to the eye, usually made up of the same species over many locations.

Plant production - the dry weight biomass per unit area resulting from plant growth over an entire growing season if the plants had been protected from grazing.

Plots - a unit of area in which estimates of various parameters are made; usually refers to the basic sampling units such as plots along a transect line. See quadrat.

Ppm - acronym for parts per million.

Quadrat - similar to a plot. See plot.

Quadrant - 1/4 of a sampling unit.

Quiescence - a state of being inactive, at rest, or dormant.

Radio-collared - refers to an animal which is carrying a radio transmitter, usually attached to a collar around the neck.

Random sampling - sampling in such a manner that any sampling unit is equally likely to be measured.

Range extension - the documented occurrence of a plant or animal outside of its previously known geographic area.

Reconnlassance survey - done to familiarize personnel with the main features of an area prior to planning or implementing a survey, inventory, or study.

Reservoir - a body of water which results from the damming of a river, stream, or drainage.

River bench - refers to the flat, plateau-like areas immediately above the slopes of the river channel.

River floodplain - that portion of the river channel experiencing periodic flooding and drying.

Root sprouts - vegetative parts of roots of plants that emerge above ground to eventually form clones of the parent plant.

Sampling site - usually a relatively large area in which the basic units of sampling will be distributed in a systematic or random manner.

SE - acronym for standard error.

Sedges - common name for members of the family Cyperaceae.

Seedlings - offspring of plants recently emerged from seeds.

Shrubs - woody plants that are not trees, usually with several main stems.

Slope - refers to the degree of steepness of a hillside, or the tangent of the angle made by a straight line with the x-axis.

South-facing slope - a hillside or slope that has a southern exposure; when standing on this slope facing away from the slope one faces in a southerly direction.

Species - a logical division of a genus; part of a biological classification of organism; the second word in a scientific name.

Standard error - a measure of the variation in a set of data calculated by dividing the standard deviation by the square root of N.

Standing crop biomass - the dry weight of above-ground plants parts per unit area at a point in time.

Strobili - a structure characterized by imbricated bracts or scales, as a pine cone. Refers to reproductive structure of *Equisetum* spp.

Tall shrub - shrubs that are 1.5 m or greater in height.

Terminal bud - a bud on the terminal portion at a twig or stem from which most primary growth originates.

Terminal twig - a twig on the terminal portion of a stem.

Timberline - the point at which trees cease to be dominant along an elevational or latitudinal gradient.

Topography - the configuration of the land surface including its relief and the position of its natural and man-made features.

Transect - a sample area usually in the form of a long continuous line or belt.

Trees - tall woody plants with a single main stem, at lease 3 m in height at maturity.

Tree rings - areas of banding in the xylem of trees caused by the differential growth rate of xylem cells during annual periods of accelerated growth and dormancy.

Tundra - a level or undulating treeless plain that is characteristic of arctic and subarctic regions.

Unbiquitous species - species found over a majority of a given area.

Utilization - refers to the amount of vegetative dry weight standing crop above ground biomass consumed by animals.

Variance - the square of the standard deviation or the fact, quality, or state of being variable.

Vascular plants - a plant having a specialized conducting system that includes xlyem or phloem; trees, shrubs, and forbs.

Vegetative classification - a scheme by which several recognizable and distinct units of vegetation are identified and named.

Vegetative state (stage) - the point at which a plant has not produced flowers or fruit.

Vegetative type - a homogeneous unit of vegetation similar to a plant community, usually at a a relatively refined level.

$\bar{X}$ - symbol for the mean or average of a data set.

Xylem - a complex tissue in the vascular system of plants with wood fibers, etc.; functions chiefly as a conductive system, but also in support and storage, and constitutes the woody element.

TABLE 3

Average diameter at point-of-browsing (DPB) for browsed twigs (estimated from a large but undetermined number of twigs), weight/twig, and weight of leaves attached to clipped twigs in the middle Susitna River Basin.

Species	DPB (mm)	Leaf (g)	Twig (g)	Sample size
Alnus sinuata	3.5	1.33	1.27	266
Betula glandulosa	2.4	0.39	0.51	922
Betula papyrifera	3.5	0.98	0.72	66
Salix glauca	3.5	0.87	0.84	284
Salix lanata	3.0	0.58	0.36	25
Salix pulchra	2.8	0.72	0.75	540

TABLE 2

New species reported for the plant ecology studies through the summer of 1982. Original species list in McKendrick et al. (1982). Updated list in Appendix A. (U = upstream, D = downstream)

Monocotyledoneae			
Cyperaceae			
Carex eleusinoides Turcz.	Sedge		D
Carex magellanica Lam. subsp. irrigua (Wahlenb.) Hult.	Bog sedge	U	
Carex rotundata Wahlenb.	Sedge		D
Orchidaceae			
Platanthera obtusata (Pursh) Lindl.	Small bog-orchis	U	
Dicotyledoneae			
Adoxaceae			
Adoxa moschatellina L.	Moschatel		D
Caryophyllaceae			
Moehringia lateriflora (L.) Fenzl	Grove sandwort		D
Cruciferae			
Parrya nudicaulis (L.) Regel	Mustard	U	
Rorippa islandica (Oeder) Borb.	Marsh yellowcress	U	
Ericaceae			
Cassiope stelleriana (Pall.) DC.	Alaska moss heath	U	
Leguminosae			
Oxytropis borealis DC.	Oxytrope		D
Primulaceae			
Primula egaliksensis Wormsk.	Greenland primrose	U	
Ranunculaceae			
Caltha palustris L.	Marsh marigold	U	
Rosaceae			
Potentilla villosa Pall.	Villous cinquefoil	U	
Saxifragaceae			
Chrysoplenium tetrandrum (Lund) T. Fries	Northern water carpet	U	
Ribes hudsonianum Richards	Northern black currant	U	

Table 4 (continued - 2)

Level IV		Site #
Dwarf Birch	ndulosa/Vaccinium uliginosum/Carex bigelowii/moss	32
	ndulosa/Vaccinium uliginosum-Ledum s/Cladonia-Cetraria	42,56
	ndulosa/Ledum groenlandicum-Vaccinium spp.	31
	ndulosa/Vaccinium uliginosum-Empetrum nigrum	6,8,23,39, 44,46,57,61
	ndulosa/Empetrum nigrum	54
	ndulosa/Empetrum nigrum-Ledum groenlandicum-m uliginosum	3,27,30

TABLE 4

Level IV and Level V (Viereck et al. 1982) classification of vegetation types sampled during summer, 1982 in the middle Susitna River Basin.

Level IV	Level V	Site #
Open White Spruce	Picea glauca/Vaccinium uliginosum-Betula glandulosa-Salix glauca-Petasites frigidus	67
	Picea glauca/Betula glandulosa/Sphagnum	66
	Picea glauca/Betula glandulosa/Cladonia	62
	Picea glauca/Vaccinium vitis-idaea-Cornus canadensis	64,68
	Picea glauca/Vaccinium uliginosum	21
	Picea glauca/Salix pulchra/Vaccinium uliginosum/ Calamagrostis canadensis	60
Open Black Spruce	Picea mariana/Vaccinium spp./feathermoss	22,25,53,99
	Picea mariana/Vaccinium uliginosum/Ledum groenlandicum	63
	Picea mariana/Betula glandulosa-Salix pulchra/Petasites frigidus	26,43
	Picea mariana/Alnus sinuata/Betula glandulosa/Vaccinium spp.	65
	Picea mariana/Vaccinium uliginosum/Empetrum nigrum/lichen	35,52
Woodland White Spruce[a]	Picea glauca/Betula glandulosa-Vaccinium uliginosum-Empetrum nigrum	29
Woodland Black Spruce[a]	Picea mariana/Ledum decumbens-caccinium spp.	5
	Picea mariana/Betula glandulosa-Vaccinium uliginosum-Empetrum nigrum/moss	19
Open Birch Forest	Betula papyrifera/Alnus sinuata/Calamagrostis canadensis	98
Open Spruce-Birch Forest	Picea glauca-Betula papyrifera/Ribes-forbs	45

Table 4 (continued - 2)

Level IV	Level V	Site #
Dwarf Birch	Betula glandulosa/Vaccinium uliginosum/Carex bigelowii/moss	32
	Betula glandulosa/Vaccinium uliginosum-Ledum decumbens/Cladonia-Cetraria	42,56
	Betula glandulosa/Ledum groenlandicum-Vaccinium spp.	31
	Betula glandulosa/Vaccinium uliginosum-Empetrum nigrum	6,8,23,39, 44,46,57,61
	Betula glandulosa/Empetrum nigrum	54
	Betula glandulosa/Empetrum nigrum-Ledum groenlandicum-Vaccinium uliginosum	3,27,30
	Betula glandulosa/Ledum groenlandicum-Vaccinium uliginosum-Vaccinium vitis-idaea-Empetrum nigrum	12,14,28
Dwarf Birch-Willow	Betula glandulosa-Salix pulchra/Vaccinium uliginosum-Ledum groenlandicum-Empetrum nigrum	34
Open Ericaceous Shrub Tundra	Vaccinium uliginosum-Vaccinium vitis-idaea-Ledum groenlandicum	1,7,58
Ericaceous Shrub-Sphagnum Bog	Vaccinium spp.-Empetrum nigrum/Carex/Rubus chamaemorus/Sphagnum	13
Low Willow Tundra	Salix pulchra/Empetrum nigrum-Vaccinium uliginosum/forbs	10

[a] Combined into Woodland Spruce vegetation type for analysis.

TABLE 5

Average percent canopy cover and number of plots required to sample within 20% of the mean with 67% confidence by life form and plant species in 105 - 0.5-m^2 quadrats from 7 sites in the Open White Spruce vegetation type, middle Susitna River Basin.

Life Form/Species	Mean	Standard Error	Estimated Sample Size
Total tall shrub	3	1.1	6
Alnus sinuata	3	1.1	6
Total low shrub	12	1.8	13
Betula glandulosa	3	1.0	4
Rosa acicularis	1	0.2	1
Salix glauca	2	0.8	3
Salix lanata	1	0.4	1
Salix pulchra	2	0.5	1
Viburnum edule	1	0.2	1
Total dwarf shrub	31	2.2	14
Arctostaphylos rubra	1	0.4	1
Empetrum nigrum	2	0.4	1
Ledum groenlandicum	5	0.7	3
Salix reticulata	1	0.3	1
Vaccinium uliginosum	16	1.6	11
Vaccinium vitis-idaea	9	1.3	7
Total forb	14	1.7	3
Cornus canadensis	3	1.0	3
Epilobium angustifolium	1	0.2	1
Linnaea borealis	1	0.1	1
Mertensia paniculata	1	0.1	1
Petasites frigidus	2	0.5	1
Rubus chamaemorus	1	0.2	1
Total graminoid	3	0.8	3
Carex spp.	1	0.3	1
Grass spp.	1	0.1	1
Total moss	41	3.2	17
Total lichen	4	1.0	5
Cladonia spp.	1	0.3	1
Peltigera spp.	2	0.4	1
Stereocaulon paschale	1	0.7	2
Litter	12	1.1	6
Dead wood	1	0.3	1
Bare ground	1	0.4	1

TABLE 6

Average percent canopy cover and number of plots required to sample within 20% of the mean with 67% confidence by life form and shrub species in 105 - 4-m^2 quadrats from 7 sites in the Open White Spruce vegetation type, middle Susitna River Basin.

Life Form/Species	Mean	Standard Error	Estimated Sample Size
Total tree	10	1.7	13
Total basal tree	1	0.2	1
Total tall shrub	3	1.0	5
Alnus sinuata	3	1.0	5
Total low shrub	14	1.4	8
Betula glandulosa	3	0.6	2
Salix glauca	3	0.6	2
Salix lanata	1	0.3	1
Salix pulchra	3	0.5	2

TABLE 7

Average density (number/ha) of stems, by size class and total, and number of plots required to sample within 20% of the mean with 67% confidence for shrub species in 105 - 4-m^2 quadrats at 7 sites in the Open White Spruce vegetation type, middle Susitna River Basin.

Species	Size Class (cm)	Mean	Standard Error	Estimated Sample Size
Alnus sinuata	0-1	1238	764	10
	1-2	1238	764	10
	2-3	691	363	3
	3-4	143	88	1
	Total	2095	873	13
Betula glandulosa	0-1	10833	2280	117
	1-2	595	181	1
	2-3	71	53	1
	Total	11548	2390	113
Salix glauca	0-1	2810	756	10
	1-2	1357	418	3
	2-3	238	129	1
	Total	4667	1234	26
Salix lanata	0-1	4595	1558	41
	1-2	48	34	1
	Total	4691	1575	42
Salix pulchra	0-1	6381	1127	82
	1-2	1810	433	4
	2-3	357	215	1
	Total	8548	1448	76

TABLE 8

Average basal diameter, height and percent twig utilization of shrub species, and number of plants required to sample within 20% of the mean with 67% confidence based on those measures, for 7 sites in the Open White Spruce vegetation type, middle Susitna River Basin.

Measure	Species	Mean	Standard Error	No. Plants	No. Sites	Estimated Sample Size
Basal Diameter (mm)	*Betula glandulosa*	10	0.4	240	7	1
	Salix pulchra	11	0.4	219	7	1
	Salix glauca	12	0.4	161	7	1
	Salix lanata	13	2.0	11	3	1
	Alnus sinuata	18	1.0	146	6	1
Height (cm)	*Betula glandulosa*	60	1.0	241	7	4
	Salix pulchra	50	1.0	219	7	2
	Salix glauca	70	2.0	161	7	4
	Salix lanata	80	16.0	11	3	13
	Alnus sinuata	110	4.0	146	6	5
Utilization (%)	*Betula glandulosa*	5	0.8	241	7	142
	Salix pulchra	4	0.7	219	6	99
	Salix glauca	6	0.9	161	6	97
	Salix lanata	4	2.3	12	2	62
	Alnus sinuata	6	1.3	146	5	165

TABLE 9

Gross available and utilized leaf, twig and total biomass (kg/ha) estimated from number of unbrowsed and browsed twigs/ha and stem densities (number/ha) from 6 sites in the Open White Spruce vegetation type, middle Susitna River Basin.

Species	No. Unbrowsed Twigs/ha	Available Leaf Biomass	Available Twig Biomass	Total Available Biomass	No. Browsed Twigs/ha	Utilized Leaf Biomass[a]	Utilized Twig Biomass	Total Utilized Biomass
<u>Alnus sinuata</u>	34568	46	44	90	6076	8	8	16
<u>Betula glandulosa</u>	102777	40	52	92	30025	12	15	27
<u>Salix glauca</u>	42470	37	36	73	10734	9	9	18
<u>Salix lanata</u>	47379	27	17	45	18764	11	7	18
<u>Salix pulchra</u>	78642	56	59	115	20515	15	15	30
Total Biomass		206	208	415		55	54	109

[a] Leaf biomass removed if browsing had occurred when leaves were attached.

TABLE 10

Average total current annual growth (kg/ha) and number of plots required to sample within 20% of the mean with 67% confidence by life form and shrub species for 7 sites in the Open White Spruce vegetation type, middle Susitna River Basin.

Life Form/Species	Category	Mean	Standard Error	Estimated Sample Size
Total forb		159	19.0	36
Total graminoid		62	14.3	139
Tree				
Betula papyrifera	leaf[a]	3	2.3	6
Betula papyrifera	twig	1	1.3	2
Tall shrub				
Alnus sinuata	leaf	20	7.7	64
Alnus sinuata	twig	12	5.2	29
Low shrub				
Betula glandulosa	leaf	6	2.0	5
Betula glandulosa	twig	4	1.6	3
Rosa acicularis	leaf	9	2.0	5
Rosa acicularis	twig	1	0.4	1
Salix fuscescens	leaf	1	0.8	1
Salix fuscescens	twig	<1	0.1	1
Salix glauca	leaf	17	6.8	49
Salix glauca	twig	7	2.7	8
Salix lanata	leaf	3	2.3	6
Salix lanata	twig	1	0.4	1
Salix pulchra	leaf	20	4.4	21
Salix pulchra	twig	9	2.2	5
Viburnum edule	leaf	3	1.4	3
Viburnum edule	twig	1	0.5	1

[a] Leaf CAG are only those leaves attached to twig CAG.

TABLE 11

Average percent canopy cover and number of plots required to sample within 20% of the mean with 67% confidence by life form and plant species in 149 - 0.5-m^2 quadrats from 10 sites in the Open Black Spruce vegetation type, middle Susitna River Basin.

Life Form/Species	Mean	Standard Error	Estimated Sample Size
Tree			
Picea mariana	4	0.7	4
Total tall shrub	1	0.7	3
Alnus sinuata	1	0.7	3
Total low shrub	12	1.2	8
Betula glandulosa	6	0.8	4
Salix pulchra	3	0.6	3
Total dwarf shrub	29	1.6	11
Empetrum nigrum	8	0.7	4
Ledum groenlandicum	4	0.4	2
Vaccinium uliginosum	15	1.1	7
Vaccinium vitis-idaea	5	0.5	2
Total forb	11	1.3	10
Cornus canadensis	1	0.3	1
Petasites frigidus	5	0.9	5
Rubus chamaemorus	3	0.4	1
Total graminoid	4	0.4	1
Calamagrostis canadensis	1	0.1	1
Carex spp.	3	0.4	1
Total moss	50	2.7	11
Total lichen	6	0.8	4
Cladonia spp.	4	0.5	2
Nephroma spp.	1	0.4	1
Peltigera spp.	1	0.2	1
Stereocaulon paschale	1	0.2	1
Litter	7	1.0	7
Dead wood	1	0.3	1
Bare ground	1	0.5	2

TABLE 12

Average percent canopy cover and number of plots required to sample within 20% of the mean with 67% confidence by life form and shrub species in 150 - 4-m^2 quadrats from 10 sites in the Open Black Spruce vegetation type, middle Susitna River Basin.

Life Form/Species	Mean	Standard Error	Estimated Sample Size
Total tree	16	1.4	13
Total basal tree	1	0.1	1
Total tall shrub	2	0.7	4
Alnus sinuata	2	0.7	4
Total low shrub	15	1.3	11
Betula glandulosa	7	0.8	4
Salix glauca	1	0.2	1
Salix pulchra	6	0.9	6

TABLE 13

Average density (number/ha) of stems, by size class and total, and number of plots required to sample within 20% of the mean with 67% confidence for shrub species in 150 - 4-m^2 quadrats at 10 sites in the Open Black Spruce vegetation type, middle Susitna River Basin.

Species	Size Class (cm)	Mean	Standard Error	Estimated Sample Size
Alnus sinuata	0-1	1233	570	8
	1-2	1233	570	8
	2-3	700	223	2
	3-4	633	313	3
	Total	3799	1041	26
Betula glandulosa	0-1	39467	2993	22
	1-2	1000	271	2
	2-3	50	50	1
	Total	40517	3092	22
Salix glauca	0-1	883	480	6
	1-2	367	156	1
	2-3	117	83	1
	Total	1367	648	11
Salix lanata	0-1	400	340	3
	Total	400	340	3
Salix pulchra	0-1	7200	982	70
	1-2	3883	717	13
	2-3	383	102	1
	3-4	83	44	1
	Total	11549	1560	67

TABLE 14

Average basal diameter, height and percent twig utilization of shrub species, and number of plants required to sample within 20% of the mean with 67% confidence based on those measures, for 10 sites in the Open Black Spruce vegetation type, middle Susitna River Basin.

Measure	Species	Mean	Standard Error	No. Plants	No. Sites	Estimated Sample Size
Basal Diameter (mm)	*Betula glandulosa*	7	0.4	510	10	1
	Salix pulchra	11	0.4	372	10	1
	Salix glauca	13	1.0	64	9	1
	Alnus sinuata	18	1.0	123	6	2
Height (cm)	*Betula glandulosa*	50	1.0	510	10	2
	Salix pulchra	60	1.0	372	10	2
	Salix glauca	60	3.0	64	9	4
	Alnus sinuata	120	5.0	123	6	6
Utilization (%)	*Betula glandulosa*	2	0.3	510	9	51
	Salix pulchra	9	0.8	370	9	70
	Salix glauca	12	1.8	64	6	34
	Alnus sinuata	2	0.6	123	6	44

TABLE 15

Gross available and utilized leaf, twig and total biomass (kg/ha) estimated from number of unbrowsed and browsed twigs/ha and stem densities (number/ha) from 10 sites in the Open Black Spruce vegetation type, middle Susitna River Basin.

Species	No. Unbrowsed Twigs/ha	Available Leaf Biomass	Available Twig Biomass	Total Available Biomass	No. Browsed Twigs/ha	Utilized Leaf Biomass[a]	Utilized Twig Biomass	Total Utilized Biomass
Alnus sinuata	73701	98	93	191	13676	18	17	36
Betula glandulosa	271464	105	138	243	97241	38	49	87
Salix glauca	15994	14	14	27	6015	5	5	10
Salix pulchra	138588	99	104	203	64674	46	49	95
Total Biomass		316	349	664		107	120	228

[a] Leaf biomass removed if browsing had occurred when leaves were attached.

TABLE 16

Average total current annual growth (kg/ha) and number of plots required to sample within 20% of the mean with 67% confidence by life form and shrub species for 9 sites in the Open Black Spruce vegetation type, middle Susitna River Basin.

Life Form/Species	Category	Mean	Standard Error	Estimated Sample Size
Total forb		104	12.8	58
Total graminoid		75	7.1	34
Tall shrub				
Alnus sinuata	leaf[a]	11	6.6	65
Alnus sinuata	twig	8	4.7	34
Low shrub				
Betula glandulosa	leaf	23	5.9	53
Betula glandulosa	twig	11	1.6	5
Spiraea beauverdiana	leaf	1	0.4	1
Spiraea beauverdiana	twig	1	0.4	1
Salix glauca	leaf	1	1.2	3
Salix glauca	twig	1	0.8	1
Salix pulchra	leaf	28	6.1	57
Salix pluchra	twig	11	2.6	11

[a] Leaf CAG are only those leaves attached to twig CAG.

TABLE 17

Average percent canopy cover and number of plots required to sample within 20% of the mean with 67% confidence by life form and plant species in 45 - 0.5-m^2 quadrats from 3 sites in the Woodland Spruce vegetation type, middle Susitna River Basin.

Life Form/Species	Mean	Standard Error	Estimated Sample Size
Tree			
Picea glauca	2	2.2	9
Picea mariana	1	0.4	1
Total tall shrub	1	0.4	1
Alnus sinuata	1	0.4	1
Total low shrub	11	2.0	8
Betula glandulosa	8	1.9	7
Salix pulchra	1	0.7	1
Total dwarf shrub	41	3.8	10
Empetrum nigrum	12	1.9	7
Ledum groenlandicum	6	0.9	2
Vaccinium uliginosum	16	2.4	11
Vaccinium vitis-idaea	12	2.1	9
Total forb	6	1.6	5
Cornus canadensis	2	0.5	1
Petasites frigidus	1	0.3	1
Rubus chamaemorus	1	0.3	1
Total graminoid	5	1.2	3
Calamagrostis canadensis	1	0.7	1
Carex spp.	3	1.1	3
Total moss	48	5.3	14
Total lichen	10	1.7	6
Cladonia spp.	6	1.1	3
Nephroma spp.	1	0.7	1
Peltigera spp.	1	0.4	1
Stereocaulon paschale	2	1.1	3
Litter	6	1.2	3
Dead wood	1	0.7	1

TABLE 18

Average percent canopy cover and number of plots required to sample within 20% of the mean with 67% confidence by life form and shrub species in 45 - 4-m^2 quadrats from 3 sites in the Woodland Spruce vegetation type, middle Susitna River Basin.

Life Form/Species	Mean	Standard Error	Estimated Sample Size
Total tree	9	2.0	8
Total basal tree	1	0.2	1
Total tall shrub	1	0.4	1
Alnus sinuata	1	0.4	1
Total low shrub	11	1.6	5
Betula glandulosa	9	1.3	3
Salix pulchra	2	0.8	2

TABLE 19

Average density (number/ha) of stems, by size class and total, and number of plots required to sample within 20% of the mean with 67% confidence for shrub species in 45 - 4-m^2 quadrats at 3 sites in the Woodland Spruce vegetation type, middle Susitna River Basin.

Species	Size Class (cm)	Mean	Standard Error	Estimated Sample Size
Alnus sinuata	0-1	111	111	1
	1-2	111	111	1
	2-3	56	56	1
	3-4	111	111	1
	Total	389	251	2
Betula glandulosa	0-1	26278	4154	29
	1-2	1778	494	2
	2-3	111	78	1
	Total	28167	4143	25
Salix glauca	0-1	1222	769	5
	1-2	56	56	1
	Total	1278	820	5
Salix pulchra	0-1	1444	772	5
	1-2	389	251	1
	2-3	278	278	1
	3-4	56	56	1
	Total	2167	828	5

TABLE 20

Average basal diameter, height and percent twig utilization of shrub species, and number of plants required to sample within 20% of the mean with 67% confidence based on those measures, for 3 sites in the Woodland Spruce vegetation type, middle Susitna River Basin.

Measure	Species	Mean	Standard Error	No. Plants	No. Sites	Estimated Sample Size
Basal Diameter (mm)	*Betula glandulosa*	11	0.4	139	3	1
	Salix pulchra	16	1.0	32	3	1
	Salix glauca	10	1.0	9	3	1
	Alnus sinuata	16	2.0	19	3	1
Height (cm)	*Betula glandulosa*	70	2.0	139	3	4
	Salix pulchra	60	4.0	32	3	3
	Salix glauca	50	2.0	9	3	1
	Alnus sinuata	110	12.0	19	3	6
Utilization (%)	*Betula glandulosa*	7	1.1	139	2	84
	Salix pulchra	30	4.0	32	3	15
	Salix glauca	22	7.8	9	3	30
	Alnus sinuata	11	3.8	19	3	63

TABLE 21

Gross available and utilized leaf, twig and total biomass (kg/ha) estimated from number of unbrowsed and browsed twigs/ha and stem densities (number/ha) from 3 sites in the Woodland Spruce vegetation type, middle Susitna River Basin.

Species	No. Unbrowsed Twigs/ha	Available Leaf Biomass	Available Twig Biomass	Total Available Biomass	No. Browsed Twigs/ha	Utilized Leaf Biomass[a]	Utilized Twig Biomass	Total Utilized Biomass
Alnus sinuata	5057	7	6	13	1595	2	2	4
Betula glandulosa	312654	121	159	280	104218	40	53	93
Salix glauca	6773	6	6	12	5112	4	4	9
Salix pulchra	35539	25	27	52	18636	13	14	27
Total Biomass		159	198	357		59	73	133

[a] Leaf biomass removed if browsing had occurred when leaves were attached.

TABLE 22

Average total current annual growth (kg/ha) and number of plots required to sample within 20% of the mean with 67% confidence by life form and shrub species for 3 sites in the Woodland Spruce vegetation type, middle Susitna River Basin.

Life Form/Species	Category	Mean	Standard Error	Estimated Sample Size
Total forb		54	13.1	66
Total graminoid		65	19.7	103
Tall shrub				
Alnus sinuata	leaf[a]	7	4.9	11
Alnus sinuata	twig	4	3.0	5
Low shrub				
Betula glandulosa	leaf	6	2.2	3
Betula glandulosa	twig	3	0.9	1
Rosa acicularis	leaf	1	0.6	1
Salix pulchra	leaf	6	5.0	12
Salix pulchra	twig	3	2.8	4

[a] Leaf CAG are only those leaves attached to twig CAG.

TABLE 23

Average percent canopy cover and number of plots required to sample within 20% of the mean with 67% confidence by life form and plant species in 15 - 0.5-m^2 quadrats from 1 site in the Open Birch Forest vegetation type, middle Susitna River Basin.

Life Form/Species	Mean	Standard Error	Estimated Sample Size
Total tall shrub	15	6.5	15
Alnus sinuata	15	6.5	15
Total low shrub	3	1.0	2
Echinopanax horridum	2	2.0	3
Ribes triste	1	0.5	1
Total dwarf shrub	7	2.9	5
Spiraea beauverdiana	9	2.9	5
Total forb	46	8.0	12
Cornus canadensis	2	0.5	1
Dryopteris spp.	33	7.2	19
Linnaea borealis	4	2.0	3
Lycopodium spp.	3	1.7	2
Polemonium spp.	1	0.7	1
Rubus articus	1	0.5	1
Rubus chamaemorus	2	1.7	2
Rumex spp.	1	0.7	1
Trientalis europaea	1	0.4	1
Total graminoid	2	0.8	1
Calamagrostis canadensis	2	0.8	1
Total moss	31	7.1	20
Litter	46	7.1	10
Bare rock	2	1.7	2

TABLE 24

Average percent canopy cover and number of plots required to sample within 20% of the mean with 67% confidence by life form and shrub species in 15 - 4-m^2 quadrats from 1 site in the Open Birch Forest vegetation type, middle Susitna River Basin.

Life Form/Species	Mean	Standard Error	Estimated Sample Size
Total tree	42	7.1	11
Total basal tree	1	0.6	1
Total tall shrub	14	6.1	23
Alnus sinuata	14	6.1	23

TABLE 25

Average density (number/ha) of stems, by size class and total, and number of plots required to sample within 20% of the mean with 67% confidence for shrub species in 15 - 4-m^2 quadrats at 1 site in the Open Birch Forest vegetation type, middle Susitna River Basin.

Species	Size Class (cm)	Mean	Standard Error	Estimated Sample Size
Alnus sinuata	0-1	2000	1658	7
	1-2	2000	1658	7
	2-3	500	500	1
	3-4	333	227	1
	Total	4833	2338	14
Betula glandulosa	0-1	500	362	1
	Total	500	362	1

TABLE 26

Average basal diameter, height and percent twig utilization of shrub species, and number of plants required to sample within 20% of the mean with 67% confidence based on those measures, for 1 site in the Open Birch Forest vegetation type, middle Susitna River Basin.

Measure	Species	Mean	Standard Error	No. Plants	No. Sites	Estimated Sample Size
Basal Diameter (mm)	*Betula glandulosa*	12	3.0	8	1	1
	Alnus sinuata	29	2.0	48	1	3
Height (cm)	*Betula glandulosa*	90	11.0	8	1	3
	Alnus sinuata	230	20.0	48	1	10
Utilization (%)	*Betula glandulosa*	0	0	8	1	--
	Alnus sinuata	1	1.1	48	1	55

TABLE 27

Gross available and utilized leaf, twig and total biomass (kg/ha) estimated from number of unbrowsed and browsed twigs/ha and stem densities (number/ha) from 1 site in the Open Birch Forest vegetation type, middle Susitna River Basin.

Species	No. Unbrowsed Twigs/ha	Available Leaf Biomass	Available Twig Biomass	Total Available Biomass	No. Browsed Twigs/ha	Utilized Leaf Biomass[a]	Utilized Twig Biomass	Total Utilized Biomass
Alnus sinuata	112126	149	142	291	208	<1	<1	1
Betula glandulosa	3650	1	2	3	0	0	0	0
Total Biomass		150	144	294		<1	<1	1

[a] Leaf biomass removed if browsing had occurred when leaves were attached.

TABLE 28

Average total current annual growth (kg/ha) and number of plots required to sample within 20% of the mean with 67% confidence by life form and shrub species for 1 site in the Open Birch Forest vegetation type, middle Susitna River Basin.

Life Form/Species	Category	Mean	Standard Error	Estimated Sample Size
Total forb		578	117.1	16
Total graminoid		62	21.2	45
Tall shrub				
Alnus sinuata	leaf[a]	8	6.4	7
Alnus sinuata	twig	2	2.2	1

[a] Leaf CAG are only those leaves attached to twig CAG.

TABLE 29

Average percent canopy cover and number of plots required to sample within 20% of the mean with 67% confidence by life form and plant species in 15 - 0.5-m^2 quadrats from 1 site in the Open Spruce-Birch Forest vegetation type, middle Susitna River Basin.

Life Form/Species	Mean	Standard Error	Estimated Sample Size
Total tall shrub	4	4.0	10
Alnus sinuata	4	4.0	10
Total low shrub	12	4.3	11
Ribes triste	15	9.0	49
Rosa acicularis	7	1.5	2
Shepherdia canadensis	4	2.3	4
Viburnum edule	2	1.7	2
Total dwarf shrub	19	4.5	13
Ledum groenlandicum	6	2.1	3
Vaccinium uliginosum	6	2.8	5
Vaccinium vitis-idaea	8	2.2	4
Total forb	26	5.5	18
Cornus canadensis	4	1.7	2
Epilobium angustifolium	7	3.1	6
Linnaea borealis	2	0.6	1
Mertensia paniculata	7	3.0	6
Petasites frigidus	1	0.4	1
Solidago multiradiata	1	1.0	1
Total graminoid	2	0.7	1
Calamagrostis canadensis	2	0.7	1
Total moss	6	5.3	17
Total lichen	1	0.7	1
Peltigera spp.	1	0.7	1
Litter	59	6.4	5

TABLE 30

Average percent canopy cover and number of plots required to sample within 20% of the mean with 67% confidence by life form and shrub species in 15 - 4-m^2 quadrats from 1 site in the Open Spruce-Birch Forest vegetation type, middle Susitna River Basin.

Life Form/Species	Mean	Standard Error	Estimated Sample Size
Total tree	21	6.6	27
Total basal tree	4	2.7	4
Total low shrub	2	1.3	1
Betula glandulosa	2	1.3	1

TABLE 31

Average basal diameter, height and percent twig utilization of shrub species, and number of plants required to sample within 20% of the mean with 67% confidence based on those measures, for 1 site in the Open Spruce-Birch Forest vegetation type, middle Susitna River Basin.

Measure	Species	Mean	Standard Error	No. Plants	No. Sites	Estimated Sample Size
Basal Diameter (mm)	*Betula glandulosa*	7	1.0	4	1	1
	Alnus sinuata	14	2.0	11	1	1
Height (cm)	*Betula glandulosa*	60	48.0	4	1	1
	Alnus sinuata	40	108.0	11	1	19
Utilization (%)	*Betula glandulosa*	32	11.8	4	1	14
	Alnus sinuata	33	11.6	10	1	31

TABLE 32

Average total current annual growth (kg/ha) and number of plots required to sample within 20% of the mean with 67% confidence by life form and shrub species for 1 sites in the Open Spruce - Birch Forest vegetation type, middle Susitna River Basin.

Life Form/Species	Category	Mean	Standard Error	Estimated Sample Size
Total forb		284	54.8	15
Total graminoid		64	23.9	53
Tree				
Populus balsamifera	leaf[a]	6	6.0	6
Populus balsamifera	twig	6	5.5	5
Low shrub				
Rosa acicularis	leaf	42	14.8	33
Rosa acicularis	twig	5	1.7	1
Shepherdia canadensis	leaf	4	3.6	2
Shepherdia canadensis	twig	1	1.1	1
Viburnum edule	leaf	9	6.0	6
Viburnum edule	twig	1	0.9	1

[a] Leaf CAG are only those leaves attached to twig CAG.

TABLE 33

Average percent canopy cover and number of plots required to sample within 20% of the mean with 67% confidence by life form and plant species in 258 - 0.5-m^2 quadrats from 19 sites[a] in the Dwarf Birch vegetation type, middle Susitna River Basin.

Life Form/Species	Mean	Standard Error	Estimated Sample Size
Total low shrub	19	1.1	13
Betula glandulosa	16	1.0	11
Salix pulchra	2	0.4	2
Total dwarf shrub	40	1.5	9
Empetrum nigrum	14	1.1	13
Ledum groenlandicum	8	0.7	5
Loiseleuria procumbens	1	0.3	1
Salix reticulata	1	0.2	1
Vaccinium uliginosum	17	0.9	9
Vaccinium vitis-idaea	6	0.4	2
Total forb	2	0.2	1
Cornus canadensis	1	0.2	1
Total graminoid	4	0.5	3
Carex spp.	3	0.5	3
Grass spp.	1	0.1	1
Total moss	33	1.9	23
Total lichen	20	1.5	22
Cetraria spp.	2	0.3	1
Cladonia spp.	12	1.0	11
Nephroma spp.	1	0.1	1
Peltigera spp.	2	0.2	1
Stereocaulon paschale	5	0.7	6
Lichen spp.	1	0.1	1
Litter	6	0.6	4
Bare ground	1	0.3	1

[a] Site 61 had only 3 plots.

TABLE 34

Average percent canopy cover and number of plots required to sample within 20% of the mean with 67% confidence by life form and shrub species in 257 - 4-m^2 quadrats from 18 sites in the Dwarf Birch vegetation type, middle Susitna River Basin.

Life Form/Species	Mean	Standard Error	Estimated Sample Size
Total tree	1	0.3	2
Total low shrub	24	1.2	14
Betula glandulosa	22	1.1	13
Salix pulchra	2	0.3	1

[a] Site 56 had only 14 plots and Site 61 had only 3 plots.

TABLE 35

Average density (number/ha) of stems, by size class and total, and number of plots required to sample within 20% of the mean with 67% confidence for shrub species in 257 - 4-m^2 quadrats at 18 sites[a] in the Dwarf Birch vegetation type, middle Susitna River Basin.

Species	Size Class (cm)	Mean	Standard Error	Estimated Sample Size
Betula glandulosa	0-1	65866	3473	18
	1-2	7977	642	42
	2-3	807	200	2
	3-4	27	17	1
	Total	74677	3516	15
Salix glauca	0-1	652	390	7
	1-2	234	102	1
	Total	886	474	10
Salix pulchra	0-1	3677	995	41
	1-2	652	132	1
	2-3	49	22	1
	Total	4378	1017	43

[a] Site 56 had only 14 plots and Site 61 had only 3 plots.

TABLE 36

Average basal diameter, height and percent twig utilization of shrub species, and number of plants required to sample within 20% of the mean with 67% confidence based on those measures, for 19 sites[a] in the Dwarf Birch vegetation type, middle Susitna River Basin.

Measure	Species	Mean	Standard Error	No. Plants	No. Sites	Estimated Sample Size
Basal Diameter (mm)	*Alnus sinuata*	9	1.0	4	8	1
	Betula glandulosa	10	0.4	921	19	1
	Salix pulchra	12	0.4	261	15	1
	Salix glauca	12	1.0	81	12	1
	Salix lanata	9	1.0	4	5	1
Height (cm)	*Alnus sinuata*	70	9.0	4	8	2
	Betula glandulosa	70	2.0	920	19	10
	Salix pulchra	60	2.0	262	16	7
	Salix glauca	50	2.0	81	12	2
	Salix lanata	50	5.0	4	5	1
Utilization (%)	*Alnus sinuata*	31	19.0	5	6	48
	Betula glandulosa	3	0.3	920	12	101
	Salix pulchra	9	1.1	259	11	100
	Salix glauca	10	2.0	81	9	74
	Salix lanata	26	9.2	4	4	13

[a] Site 61 had only 3 plots.

TABLE 37

Gross available and utilized leaf, twig and total biomass (kg/ha) estimated from number of unbrowsed and browsed twigs/ha and stem densities (number/ha) from 19 sites in the Dwarf Birch vegetation type, middle Susitna River Basin.

Species	No. Unbrowsed Twigs/ha	Available Leaf Biomass	Available Twig Biomass	Total Available Biomass	No. Browsed Twigs/ha	Utilized Leaf Biomass[a]	Utilized Twig Biomass	Total Utilized Biomass
Betula glandulosa	1052946	407	535	942	283773	110	144	254
Salix glauca	6999	6	6	12	2215	2	2	4
Salix pulchra	54725	39	41	80	18825	13	14	27
Total Biomass		452	582	1034		125	160	285

[a] Leaf biomass removed if browsing had occurred when leaves were attached.

TABLE 38

Average total current annual growth (kg/ha) and number of plots required to sample within 20% of the mean with 67% confidence by life form and shrub species for 19 sites[b] in the Dwarf Birch vegetation type, middle Susitna River Basin.

Life Form/Species	Category	Mean	Standard Error	Estimated Sample Size
Total forb		12	1.5	6
Total graminoid		56	9.7	204
Low shrub				
Betula glandulosa	leaf[a]	44	3.2	28
Betula glandulosa	twig	22	1.6	7
Salix pulchra	leaf	20	4.3	50
Salix pulchra	twig	13	3.6	36

[a] Leaf CAG are only those leaves attached to twig CAG.

[b] Site 61 had only 3 plots.

TABLE 39

Average percent canopy cover and number of plots required to sample within 20% of the mean with 67% confidence by life form and plant species in 15 - 0.5-m^2 quadrats from 1 site in the Dwarf Birch-Willow vegetation type, middle Susitna River Basin.

Life Form/Species	Mean	Standard Error	Estimated Sample Size
Total low shrub	25	4.9	14
Betula glandulosa	5	1.8	2
Echinopanax horridum	3	2.7	9
Salix glauca	1	0.7	1
Salix pulchra	5	4.6	13
Total dwarf shrub	20	3.4	14
Empetrum nigrum	4	0.7	2
Ledum groenlandicum	7	1.0	1
Spiraea beauverdiana	2	1.1	2
Vaccinium uliginosum	13	2.7	5
Vaccinium vitis-idaea	2	0.4	1
Total forb	18	3.2	12
Cornus canadensis	6	1.7	2
Petasites frigidus	3	1.7	2
Rubus chamaemorus	4	0.9	1
Total graminoid	8	2.2	3
Calamagrostis canadensis	6	2.5	8
Carex spp.	6	1.0	1
Eriophorum spp.	2	1.7	2
Total moss	10	5.0	15
Total lichen	4	1.1	1
Cladonia spp.	2	0.7	1
Peltigera spp.	3	0.8	1
Litter	16	2.6	5
Dead wood	1	1.6	1

TABLE 40

Average percent canopy cover and number of plots required to sample within 20% of the mean with 67% confidence by life form and shrub species in 15 - 4-m^2 quadrats from 1 site in the Dwarf Birch-Willow vegetation type, middle Susitna River Basin.

Life Form/Species	Mean	Standard Error	Estimated Sample Size
Total low shrub	10	2.7	5
Betula glandulosa	7	1.7	2
Salix pulchra	3	2.3	4

TABLE 41

Average density (number/ha) of stems, by size class and total, and number of plots required to sample within 20% of the mean with 67% confidence for shrub species in 15 - 4-m^2 quadrats at 1 site in the Dwarf Birch-Willow vegetation type, middle Susitna River Basin.

Species	Size Class (cm)	Mean	Standard Error	Estimated Sample Size
Betula glandulosa	0-1	38167	7350	14
	Total	38167	7350	14
Salix pulchra	0-1	3333	1594	7
	1-2	1333	1333	5
	2-3	333	333	1
	Total	4999	2845	20

TABLE 42

Average basal diameter, height and percent twig utilization of shrub species, and number of plants required to sample within 20% of the mean with 67% confidence based on those measures, for 1 site in the Dwarf Birch-Willow vegetation type, middle Susitna River Basin.

Measure	Species	Mean	Standard Error	No. Plants	No. Sites	Estimated Sample Size
Basal Diameter (mm)	*Betula glandulosa*	8	0.4	45	1	1
	Salix pulchra	14	1.0	16	1	1
	Salix glauca	13	2.0	11	1	1
Height (cm)	*Betula glandulosa*	50	1.0	45	1	1
	Salix pulchra	70	4.0	16	1	2
	Salix glauca	60	5.0	11	1	2
Utilization (%)	*Betula glandulosa*	0	0.0	45	1	--
	Salix pulchra	11	2.0	16	1	14
	Salix glauca	12	9.1	11	1	163

TABLE 43

Gross available and utilized leaf, twig and total biomass (kg/ha) estimated from number of unbrowsed and browsed twigs/ha and stem densities (number/ha) from 1 site in the Dwarf Birch - Willow vegetation type, middle Susitna River Basin.

Species	No. Unbrowsed Twigs/ha	Available Leaf Biomass	Available Twig Biomass	Total Available Biomass	No. Browsed Twigs/ha	Utilized Leaf Biomass[a]	Utilized Twig Biomass	Total Utilized Biomass
Betula glandulosa	416020	161	211	372	0	--	--	--
Salix pulchra	53989	39	41	79	0	--	--	--
Total Biomass		200	252	451		--	--	--

[a] Leaf biomass removed if browsing had occurred when leaves were attached.

TABLE 44

Average total current annual growth (kg/ha) and number of plots required to sample within 20% of the mean with 67% confidence by life form and shrub species for 1 site in the Dwarf Birch - Willow vegetation type, middle Susitna River Basin.

Life Form/Species	Category	Mean	Standard Error	Estimated Sample Size
Total forb		88	22.2	24
Total graminoid		138	29.6	18
Low shrub				
Betula glandulosa	leaf[a]	12	3.7	3
Betula glandulosa	twig	8	2.2	1
Salix pulchra	leaf	44	40.8	250
Salix pulchra	twig	16	14.7	33

[a] Leaf CAG are only those leaves attached to twig CAG.

TABLE 45

Average percent canopy cover and number of plots required to sample within 20% of the mean with 67% confidence by life form and plant species in 45 - 0.5-m^2 quadrats from 3 sites in the Open Ericaceous Shrub Tundra vegetation type, middle Susitna River Basin.

Life Form/Species	Mean	Standard Error	Estimated Sample Size
Total low shrub	3	1.1	3
Betula glandulosa	4	1.5	5
Total dwarf shrub	57	3.6	5
Arctostaphylos alpina	2	0.5	1
Empetrum nigrum	15	3.1	18
Ledum groenlandicum	15	2.2	9
Vaccinium uliginosum	24	2.8	14
Vaccinium vitis-idaea	12	1.7	5
Total forb	4	1.5	4
Cornus canadensis	2	0.5	1
Lycopodium spp.	1	0.3	1
Rubus chamaemorus	1	0.6	1
Total graminoid	1	0.3	1
Carex spp.	1	0.3	1
Total moss	36	5.3	25
Total lichen	34	4.2	18
Cetraria spp.	3	0.7	1
Cladonia spp.	20	2.4	11
Nephroma spp.	1	0.3	1
Peltigera spp.	1	0.5	1
Stereocaulon paschale	11	2.6	13
Litter	3	0.5	1

TABLE 46

Average percent canopy cover and number of plots required to sample within 20% of the mean with 67% confidence by life form and shrub species in 45 - 4-m^2 quadrats from 3 sites in the Open Ericaceous Shrub Tundra vegetation type, middle Susitna River Basin.

Life Form/Species	Mean	Standard Error	Estimated Sample Size
Total tree	1	0.4	1
Total low shrub	6	1.6	5
Betula glandulosa	5	1.3	3

TABLE 47

Average density (number/ha) of stems, by size class and total, and number of plots required to sample within 20% of the mean with 67% confidence for shrub species in 45 - 4-m^2 quadrats at 3 sites in the Open Ericaceous Shrub Tundra vegetation type, middle Susitna River Basin.

Species	Size Class (cm)	Mean	Standard Error	Estimated Sample Size
Betula glandulosa	0-1	21833	5732	78
	1-2	1333	467	2
	Total	23166	5864	72

TABLE 48

Average basal diameter, height and percent twig utilization of shrub species, and number of plants required to sample within 20% of the mean with 67% confidence based on those measures, for 3 sites in the Open Ericaceous Shrub Tundra vegetation type, middle Susitna River Basin.

Measure	Species	Mean	Standard Error	No. Plants	No. Sites	Estimated Sample Size
Basal Diameter (mm)	*Betula glandulosa*	9	0.4	108	3	1
	Alnus sinuata	28	7.0	5	3	3
Height (cm)	*Betula glandulosa*	50	4.0	108	3	19
	Alnus sinuata	130	24.0	5	3	5
Utilization (%)	*Betula glandulosa*	1	0.5	108	1	25
	Alnus sinuata	0	0.0	5	3	--

TABLE 49

Gross available and utilized leaf, twig and total biomass (kg/ha) estimated from number of unbrowsed and browsed twigs/ha and stem densities (number/ha) from 3 sites in the Open Ericaceous Shrub Tundra vegetation type, middle Susitna River Basin.

Species	No. Unbrowsed Twigs/ha	Available Leaf Biomass	Available Twig Biomass	Total Available Biomass	No. Browsed Twigs/ha	Utilized Leaf Biomass[a]	Utilized Twig Biomass	Total Utilized Biomass
<u>Betula glandulosa</u>	217760	84	111	195	39382	15	20	35
Total Biomass		84	111	195		15	20	35

[a] Leaf biomass removed if browsing had occurred when leaves were attached.

TABLE 50

Average total current annual growth (kg/ha) and number of plots required to sample within 20% of the mean with 67% confidence by life form and shrub species for 3 sites in the Open Ericaceous Shrub Tundra vegetation type, middle Susitna River Basin.

Life Form/Species	Category	Mean	Standard Error	Estimated Sample Size
Total forb		51	23.3	233
Total graminoid		17	4.2	8
Low shrub				
Betula glandulosa	leaf[a]	4	1.4	1
Betula glandulosa	twig	2	0.7	1

[a] Leaf CAG are only those leaves attached to twig CAG.

TABLE 51

Average percent canopy cover and number of plots required to sample within 20% of the mean with 67% confidence by life form and plant species in 15 - 0.5-m^2quadrats from 1 site in the Ericaceous Shrub - Sphagnum Bog vegetation type, middle Susitna River Basin.

Life Form/Species	Mean	Standard Error	Estimated Sample Size
Tree			
Picea mariana	1	0.4	1
Total low shrub	3	0.9	1
Betula glandulosa	3	0.9	1
Total dwarf shrub	15	2.7	5
Empetrum nigrum	5	1.2	1
Ledum groenlandicum	4	0.8	1
Vaccinium uliginosum	5	1.1	1
Vaccinium vitis-idaea	2	1.3	2
Total forb	13	2.6	4
Rubus chamaemorus	13	2.6	4
Total graminoid	12	2.7	5
Carex spp.	11	2.7	5
Grass spp.	1	1.3	2
Total moss	67	7.0	5
Total lichen	3	1.7	2
Cladonia spp.	3	1.6	2
Litter	4	0.7	1
Water	7	6.4	25

TABLE 52

Average percent canopy cover and number of plots required to sample within 20% of the mean with 67% confidence by life form and shrub species in 15 - 4-m^2 quadrats from 1 site in the Ericaceous Shrub - Sphagnum Bog vegetation type, middle Susitna River Basin.

Life Form/Species	Mean	Standard Error	Estimated Sample Size
Total tree	9	2.6	5
Total basal tree	1	0.3	1
Total low shrub	6	1.1	1
Betula glandulosa	6	1.1	1

TABLE 53

Average density (number/ha) of stems, by size class and total, and number of plots required to sample within 20% of the mean with 67% confidence for shrub species in 15 - 4-m^2 quadrats at 1 site in the Ericaceous Shrub - Sphagnum Bog vegetation type, middle Susitna River Basin.

Species	Size Class (cm)	Mean	Standard Error	Estimated Sample Size
Betula glandulosa	0-1	45550	11031	23
	Total	45550	11031	23

TABLE 54

Average basal diameter, height and percent twig utilization of shrub species, and number of plants required to sample within 20% of the mean with 67% confidence based on those measures, for 1 site in the Ericaceous Shrub - Sphagnum Bog vegetation type, middle Susitna River Basin.

Measure	Species	Mean	Standard Error	No. Plants	No. Sites	Estimated Sample Size
Basal Diameter (mm)	Betula glandulosa	41	0.2	43	1	2
Height (cm)	Betula glandulosa	40	0.1	43	1	1
Utilization (%)	Betula glandulosa	<1	0.3	43	1	1

TABLE 55

Gross available and utilized leaf, twig and total biomass (kg/ha) estimated from number of unbrowsed and browsed twigs/ha and stem densities (number/ha) from 1 site in the Ericaceous Shrub - Sphagnum Bog vegetation type, middle Susitna River Basin.

Species	No. Unbrowsed Twigs/ha	Available Leaf Biomass	Available Twig Biomass	Total Available Biomass	No. Browsed Twigs/ha	Utilized Leaf Biomass[a]	Utilized Twig Biomass	Total Utilized Biomass
Betula glandulosa	132551	51	67	119	386	<1	<1	<1
Total Biomass		51	67	119		<1	<1	<1

[a] Leaf biomass removed if browsing had occurred when leaves were attached.

TABLE 56

Average total current annual growth (kg/ha) and number of plots required to sample within 20% of the mean with 67% confidence by life form and shrub species for 1 site in the Ericaceous Shrub - Sphagnum Bog vegetation type, middle Susitna River Basin.

Life Form/Species	Category	Mean	Standard Error	Estimated Sample Size
Total forb		154	28.6	13
Total graminoid		182	41.4	20
Low shrub				
Betula glandulosa	leaf[a]	6	1.9	1
Betula glandulosa	twig	3	1.1	1

[a] Leaf CAG are only those leaves attached to twig CAG.

TABLE 57

Average percent canopy cover and number of plots required to sample within 20% of the mean with 67% confidence by life form and plant species in 15 - 0.5-m^2 quadrats from 1 site in the Low Willow Tundra vegetation type, middle Susitna River Basin.

Life Form/Species	Mean	Standard Error	Estimated Sample Size
Total low shrub	18	5.1	16
Salix pulchra	18	5.1	16
Total dwarf shrub	18	2.6	5
Cassiope stelleriana	1	0.7	1
Empetrum nigrum	12	2.3	4
Salix polaris	2	1.1	1
Salix reticulata	2	1.4	2
Spiraea beauverdiana	1	0.9	1
Vaccinium uliginosum	8	2.9	5
Vaccinium vitis-idaea	1	0.2	1
Total forb	15	2.7	5
Aconitum delphinifolium	1	0.2	1
Artemisia spp.	3	0.6	1
Polygonum bistorta	1	0.4	1
Leutkea pectinata	3	1.9	3
Lycopodium spp.	1	0.6	1
Rubus articus	2	1.2	1
Sedum rosea	2	0.6	1
Viola spp.	3	1.7	2
Total graminoid	9	1.5	2
Calamagrostis canadensis	2	1.2	1
Carex spp.	4	0.8	1
Grass spp.	2	1.0	1
Total moss	21	2.9	6
Total lichen	4	1.0	1
Cetraria spp.	2	0.8	1
Cladonia spp.	2	0.8	1
Litter	6	1.4	2
Bare ground	1	0.4	1
Water	2	1.4	2

TABLE 58

Average percent canopy cover and number of plots required to sample within 20% of the mean with 67% confidence by life form and shrub species in 15 - 4-m^2 quadrats from 1 site in the Low Willow Tundra vegetation type, middle Susitna River Basin.

Life Form/Species	Mean	Standard Error	Estimated Sample Size
Total low shrub	11	2.6	5
Salix pulchra	12	3.0	6

TABLE 59

Average density (number/ha) of stems, by size class and total, and number of plots required to sample within 20% of the mean with 67% confidence for shrub species in 15 - 4-m^2 quadrats at 1 site in the Low Willow Tundra vegetation type, middle Susitna River Basin.

Species	Size Class (cm)	Mean	Standard Error	Estimated Sample Size
Salix pulchra	0-1	52833	10405	15
	Total	52833	10405	15

TABLE 60

Average total current annual growth (kg/ha) and number of plots required to sample within 20% of the mean with 67% confidence by life form and shrub species for 1 site in the Low Willow Tundra vegetation type, middle Susitna River Basin.

Life Form/Species	Category	Mean	Standard Error	Estimated Sample Size
Total forb		86	16.2	14
Total graminoid		132	23.7	13
Low shrub				
Salix pulchra	leaf[a]	145	38.9	27
Salix pulchra	twig	24	7.0	8

[a] Leaf CAG are only those leaves attached to twig CAG.

TABLE 61

Summary of average current annual growth biomass of leaves and twigs, density, gross available twig biomass, and percent utilization of twigs for 4 major shrub species in 10 vegetation types, middle Susitna River Basin.

	Current Annual Growth Biomass (kg/ha)												Gross Available							
	Leaf[a]				Twig				Density (#/ha)				Twig Biomass (kg/ha)				Percent Utilization			
Vegetation Type	Alsi[b]	Begl[c]	Sagl[d]	Sapu[e]	Alsi	Begl	Sagl	Sapu	Alsi	Begl	Sagl	Sapu	Alsi	Begl	Sagl	Sapu	Alsi	Begl	Sagl	Sapu
Open White Spruce	20	6	17	20	12	4	7	9	2095	11548	4667	8548	44	52	36	59	6	5	6	4
Open Black Spruce	11	23	1	28	8	11	1	11	3799	40517	1367	11549	93	138	14	104	2	2	12	9
Woodland Spruce	7	6	—	6	4	3	—	3	389	28167	1278	2167	6	159	6	27	11	7	22	30
Open Birch Forest	8	—	—	—	2	—	—	—	4833	500	—	—	142	2	—	—	1	0	—	—
Open Spruce-Birch Forest	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	32	33	—	—
Dwarf Birch	—	44	—	20	—	22	—	13	—	74677	886	4378	—	535	6	41	31	3	10	9
Dwarf Birch-Willow	—	12	—	44	—	8	—	16	—	38167	—	4999	—	211	—	41	—	0	12	11
Open Ericaceous Shrub Tundra	—	4	—	—	—	2	—	—	—	23166	—	—	—	111	—	—	0	1	—	—
Ericaceous Shrub-Sphagnum Bog	—	6	—	—	—	3	—	—	—	45550	—	—	—	67	—	—	—	<1	—	—
Low Willow Tundra	—	—	—	145	—	—	—	24	—	—	—	52833	—	—	—	—	—	—	—	—

[a] Leaf current annual growth only for those leaves attached to twig CAG.
[b] Alsi = Alnus sinuata
[c] Begl = Betula glandulosa
[d] Sagl = Salix glauca
[e] Sapu = Salix pulchra

TABLE 62

Mean and standard error for variables measured for chemical analysis performed on soil samples collected from 6 sites in the Open White Spruce vegetation type, middle Susitna River Basin.

Soil Variables	0-5 cm Mean	0-5 cm Standard Deviation	5-10 cm Mean	5-10 cm Standard Deviation	10-15 cm Mean	10-15 cm Standard Deviation
pH	5.93	0.68	5.94	0.81	6.05	0.70
O.M (%)	13.44	8.66	7.02	5.56	5.43	4.26
Total Nitrogen (%)	0.37	0.24	0.27	0.26	0.16	0.12
Total Phosphorus (%)	0.07	0.03	0.08	0.03	0.08	0.03
Sand (%)	34.77	10.90	39.98	12.20	39.05	5.33
Silt (%)	47.86	8.50	43.92	9.87	46.75	5.43
Clay (%)	17.37	5.84	16.10	7.42	14.20	5.75
Potassium (ppm)	67.0	17.40	48.91	24.06	32.78	12.50
Calcium (ppm)	1996.21	1520.58	1737.91	1851.29	1120.89	885.67
Magnesium (ppm)	314.71	293.35	246.18	262.76	137.44	120.05
Copper (mg/g)	1.53	1.38	2.24	2.13	3.41	2.88
Zinc (mg/g)	2.23	1.92	0.84	0.29	1.04	0.83
Manganese (mg/g)	20.83	27.83	18.00	20.31	32.18	33.62
Iron (mg/g)	329.25	111.31	287.50	157.13	776.67	142.59

TABLE 63

Mean and standard error for variables measured for chemical analysis performed on soil samples collected from 3 sites in the Open Black Spruce vegetation type, middle Susitna River Basin.

	0-5 cm		5-10 cm		10-15 cm	
Soil Variables	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
pH	5.88	0.67	6.25	0.44	6.29	0.26
O.M. (%)	18.34	10.85	8.96	6.63	10.39	12.29
Total Nitrogen (%)	0.61	0.48	0.42	0.39	0.42	0.32
Total Phosphorus (%)	0.10	0.03	0.08	0.02	0.10	0.03
Sand (%)	30.73	13.72	38.48	10.21	32.72	7.60
Silt (%)	48.77	8.56	49.72	9.28	48.80	8.49
Clay (%)	20.50	11.48	11.80	7.33	18.48	6.19
Potassium (ppm)	89.00	48.67	40.17	20.11	36.00	12.88
Calcium (ppm)	2654.11	2592.27	2552.17	2584.85	2309.00	1894.38
Magnesium (ppm)	348.89	302.71	290.00	282.42	264.80	227.54
Copper (mg/g)	6.02	7.27	10.70	15.00	13.45	13.15
Zinc (mg/g)	2.83	3.37	2.57	3.12	2.85	3.45
Manganese (mg/g)	57.23	60.26	79.98	72.11	140.62	219.64
Iron (mg/g)	433.38	213.22	470.83	372.84	475.80	341.22

TABLE 64

Mean and standard error for variables measured for chemical analysis performed on soil samples collected from 1 site in the Woodland Black Spruce vegetation type, middle Susitna River Basin.

Soil Variables	0-5 cm Mean	0-5 cm Standard Deviation	5-10 cm Mean	5-10 cm Standard Deviation	10-15 cm Mean	10-15 cm Standard Deviation
pH	4.15	0[a]	4.22	0	4.26	0
O.M. (%)	12.06	0	8.58	0	10.72	0
Total Nitrogen (%)	0.45	0	0.36	0	0.32	0
Total Phosphorus (%)	0.09	0	0.09	0	0.09	0
Sand (%)	28.80	0	38.00	0	34.80	0
Silt (%)	44.00	0	40.80	0	44.60	0
Clay (%)	27.20	0	21.20	0	20.60	0
Potassium (ppm)	50.00	0	48.00	0	42.00	0
Calcium (ppm)	126.00	0	83.00	0	88.00	0
Magnesium (ppm)	36.00	0	29.00	0	25.00	0
Copper (mg/g)			0.31	0	0.43	0
Zinc (mg/g)			0.98	0	0.86	0
Manganese (mg/g)			23.30	0	24.50	0
Iron (mg/g)			477.00	0	488.00	0

[a] Only 1 plot sampled at 1 site.

TABLE 65

Mean and standard error for variables measured for chemical analysis performed on soil samples collected from 2 sites in the Dwarf Birch vegetation type, middle Susitna River Basin.

Soil Variables	0-5 cm Mean	Standard Deviation	5-10 cm Mean	Standard Deviation	10-15 cm Mean	Standard Deviation
pH	6.26	0.82	5.92	0.03	5.70	0[a]
O.M. (%)	12.67	14.79	6.70	7.40	2.21	0
Total Nitrogen (%)	0.32	0.33	0.25	0.28	0.08	0
Total Phosphorus (%)	0.06	0.01	0.07	0	0.06	0
Sand (%)	28.00	2.83	35.80	0.28	42.00	0
Silt (%)	46.10	0.99	41.00	4.81	42.40	0
Clay (%)	25.90	1.84	23.20	4.53	15.60	0
Potassium (ppm)	40.00	12.73	48.00	32.53	25.00	0
Calcium (ppm)	3720.00	4058.80	1200.50	1342.80	121.00	0
Magnesium (ppm)	175.00	120.21	137.00	152.74	11.00	0
Copper (mg/g)	12.62	16.10	0.64	0.21	0.55	0
Zinc (mg/g)	1.56	1.65	0.57	0.47	0.23	0
Manganese (mg/g)	14.35	7.28	22.00	28.00	1.10	0
Iron (mg/g)	327.00	321.51	272.50	265.17	70.00	0

[a] Only 1 plot sampled at this depth.

TABLE 66

Average soil temperatures (°C) during the plant phenology study by transect, elevation, and week, 1982.

	Position	Transect				
		Watana	Jay	Switchback	Tsusena	Mean
3 May - 4 June	Bench	0.5	1.0	2.0	0.0	0.9
	Top	2.5	2.0	2.0	2.0	2.1
	Middle	3.0	3.5	1.5	-	2.7
	Bottom	3.5	2.5	1.5	1.0	2.1
	Mean	2.4	2.3	1.8	1.0	1.9
7 June - 11 June	Bench	3.0	2.0	6.0	0.5	2.9
	Top	2.5	1.0	4.0	2.0	2.4
	Middle	2.0	5.5	3.0	-	3.5
	Bottom	3.5	2.5	2.5	1.5	2.5
	Mean	2.8	2.8	3.9	1.3	2.8
14 June - 18 June	Bench	3.5	3.0	4.0	2.0	3.1
	Top	3.0	3.5	4.0	2.0	3.1
	Middle	2.0	5.5	2.5	-	3.3
	Bottom	4.0	3.5	1.5	2.0	2.8
	Mean	3.1	3.9	3.0	2.0	3.1
21 June - 25 June	Bench	2.5	3.0	5.0	3.5	3.5
	Top	3.0	3.0	5.5	3.0	3.6
	Middle	3.0	8.0	2.5	-	4.5
	Bottom	4.0	5.0	4.5	2.5	4.0
	Mean	3.1	4.8	4.4	3.0	3.9
28 June - 2 July	Bench	5.5	5.5	6.5	3.0	5.1
	Top	6.0	5.0	6.5	4.0	5.4
	Middle	3.5	7.0	5.0	-	5.2
	Bottom	4.0	5.5	7.0	4.0	5.1
	Mean	4.8	5.8	6.3	3.7	5.2

TABLE 67

Average cover, height, and phenological state for plant species during week of 31 May to 4 June, 1982, at Watana Creek transect (transect #1) (32 - 0.5-m^2 quadrats).

Life form/Species	Cover (%) Mean	Cover (%) Standard Error	Height (cm) Mean	Height (cm) Standard Error	No. of Plots	Phenological State[a]
Tree						
Betula papyrifera	1	0.8	60	0.0	1	
Low Shrub						
Betula glandulosa	9	1.7	56	4.1	16	2
Rosa acicularis	1	0.2	44	3.8	5	2
Spiraea beauverdiana	-	-				
Dwarf Shrub						
Vaccinium vitis-idaea	15	2.0	12	2.2	23	2
Vaccinium uliginosum	7	1.8	25	2.4	21	2
Ledum groenlandicum	18	1.6	29	1.9	27	3
Ledum decumbens	-	-				
Empetrum nigrum	2	1.2	19	9.9	5	1
Arctostaphylos uva-ursi	3	1.9				
Forb						
Cornus canadensis	0	0.1	4	1.0	4	3
Other						
Total moss	76	3.8				
Total lichen	6	1.7				
Litter	9	3.9				

[a] Phenological state: (1) just emerging from ground, first signs of new growth or dormant for evergreens, (2) leaf buds, (3) leaves, (4) flower buds, (5) flowers, (6) seeds, (7) decadent.

TABLE 68

Average cover, height, and phenological state for plant species during week of 31 May to 4 June, 1982, at Jay Creek transect (transect #2) (32 - 0.5-m^2 quadrats).

Life form/Species	Cover (%) Mean	Cover (%) Standard Error	Height (cm) Mean	Height (cm) Standard Error	No. of Plots	Phenological State[a]
Tree						
Betula papyrifera	2	1.0	67	13.5	6	2
Picea glauca			10	0.0	1	
Low Shrub						
Betula glandulosa	10	1.7	51	2.4	21	2
Salix glauca	<1	0.1	44	2.5	2	2
Rosa acicularis	<1	0.2	39	13.5	5	2
Ribes triste	<1	0.0				
Potentilla fruticosa	<1	0.1	20	0.0	1	3
Dwarf Shrub						
Vaccinium vitis-idaea	18	3.8	11	0.8	21	2
Vaccinium uliginosum	4	1.0	22	1.6	15	2
Ledum groenlandicum	2	0.9	24	2.8	7	4
Ledum decumbens	12	3.0	21	1.5	17	4
Empetrum nigrum	2	0.9	8	0.8	5	1
Salix reticulata	<1	0.1				2
Arctostaphylos alpina	<1	0.1				1
Arctostaphylos uva-ursi	1	0.5				
Forb						
Cornus canadensis	1	0.5	5	2.5	3	2
Epilobium angustifolium						
Mertensia paniculata	1	0.3	8	0.9	6	3
Equisetum silvaticum	<1	0.1	9	2.9	4	
Graminoid						
Calamagrostis canadensis	<1	0.1	15	0.0	2	3
Unknown grass	1	0.2	8	2.2	7	1
Other						
Total moss	27	5.7				
Total lichen	7	1.9				
Litter	20	5.7				

[a] Phenological state: (1) just emerging from ground, first signs of new growth or dormant for evergreens, (2) leaf buds, (3) leaves, (4) flower buds, (5) flowers, (6) seeds, (7) decadent.

TABLE 69

Average cover, height, and phenological state for plant species during week of 31 May to 4 June, 1982, at Switchback transect (transect #3) (32 - 0.5-m^2 quadrats).

Life form/Species	Cover (%) Mean	Cover (%) Standard Error	Height (cm) Mean	Height (cm) Standard Error	No. of Plots	Phenological State[a]
Tall shrub						
Alnus sinuata	3	1.1	165	30.1	8	2
Low Shrub						
Betula glandulosa	11	2.0	57	5.9	20	2
Salix pulchra	1	0.9	45	5.0	2	3
Salix glauca	1	0.3	39	3.8	5	2
Rosa acicularis	<1	0.1	34	8.8	4	2
Ribes triste	<1	0.2	25	8.8	4	3
Dwarf Shrub						
Vaccinium vitis-idaea	11	2.3	15	3.8	24	1
Vaccinium uliginosum	5	1.3	21	1.6	14	2
Ledum groenlandicum	3	1.1	23	1.5	10	3
Ledum decumbens	8	2.4	17	2.5	15	3
Empetrum nigrum	<1	0.2	10	0.0	1	1
Arctostaphylos uva-ursi	1	0.4				
Forb						
Equisetum silvaticum			2	0.5	2	1
Graminoid						
Unknown grass	<1	0.1	7	1.3	10	1
Other						
Total moss	30	4.7				
Total lichen	13	3.2				
Litter	11	3.7				

[a] Phenological state: (1) just emerging from ground, first signs of new growth or dormant for evergreens, (2) leaf buds, (3) leaves, (4) flower buds, (5) flowers, (6) seeds, (7) decadent.

TABLE 70

Average cover, height, and phenological state for plant species during week of 31 May to 4 June, 1982, at Tsusena Creek transect (transect #4) (24 - 0.5-m^2 quadrats).

	Cover (%)		Height (cm)			
Life form/Species	Mean	Standard Error	Mean	Standard Error	No. of Plots	Phenological State[a]
Low Shrub						
Betula glandulosa	12	2.2	60	3.6	19	2
Dwarf Shrub						
Vaccinium vitis-idaea	5	0.6	8	1.0	19	1
Vaccinium uliginosum	4	1.1	22	1.0	12	2
Ledum groenlandicum	5	1.5	26	2.7	9	3
Ledum decumbens	4	1.0	21	2.3	11	1
Empetrum nigrum	8	2.3	15	4.7	15	1
Arctostaphylos uva-ursi	9	3.3				
Forb						
Cornus canadensis	<1	0.2	4	0.6	4	2
Graminoid						
Unknown grass						
Other						
Total moss	86	2.6				
Total lichen	4	0.7				

[a] Phenological state: (1) just emerging from ground, first signs of new growth or dormant for evergreens, (2) leaf buds, (3) leaves, (4) flower buds, (5) flowers, (6) seeds, (7) decadent.

TABLE 71

Average cover, height, and phenological state for plant species during week of 7 June to 11 June, 1982, at Watana Creek transect (transect #1) (32 - 0.5-m^2 quadrats).

Life form/Species	Cover (%) Mean	Cover (%) Standard Error	Height (cm) Mean	Height (cm) Standard Error	No. of Plots	Phenological State[a]
Low Shrub						
Betula glandulosa	8	1.8	51	3.8	17	3
Rosa acicularis	<1	0.1	33	13.3	3	2
Dwarf Shrub						
Vaccinium vitis-idaea	8	1.5	8	0.5	27	1
Vaccinium uliginosum	7	2.1	22	2.0	20	3
Ledum groenlandicum	10	1.8	29	2.2	23	4
Ledum decumbens	6	1.5	18	2.1	15	4
Empetrum nigrum	2	1.1	7	0.9	7	1
Arctostaphylos uva-ursi	2	0.5				
Other						
Total moss	62	5.8				
Total lichen	10	2.8				
Litter	6	3.0				

[a] Phenological state: (1) just emerging from ground, first signs of new growth or dormant for evergreens, (2) leaf buds, (3) leaves, (4) flower buds, (5) flowers, (6) seeds, (7) decadent.

TABLE 72

Average cover, height, and phenological state for plant species during week of 7 June to 11 June, 1982, at Jay Creek transect (transect #2) (32 - 0.5-m^2 quadrats).

Life form/Species	Cover (%) Mean	Cover (%) Standard Error	Height (cm) Mean	Height (cm) Standard Error	No. of Plots	Phenological State[a]
Low Shrub						
Betula glandulosa	9	1.9	45	3.5	20	3
Betula papyrifera	3	1.4	91	10.8	6	3
Salix glauca						4
Rosa acicularis	<1	0.1	13	3.4	5	3
Potentilla fruticosa	<1	0.1	25	0.0	1	3
Dwarf Shrub						
Vaccinium vitis-idaea	16	3.2	10	1.2	21	2
Vaccinium uliginosum	3	0.8	21	2.1	16	3
Ledum groenlandicum	5	1.7	26	1.9	14	4
Ledum decumbens	9	2.6	17	1.3	12	4
Empetrum nigrum	<1	0.2	6	0.9	3	2
Salix reticulata	1	0.6				3
Arctostaphylos alpina	2	1.1				3
Forb						
Cornus canadensis	1	0.3	5	0.6	4	2
Epilobium angustifolium	<1	0.1	23	2.3	3	3
Mertensia paniculata	1	0.5	13	2.3	5	4
Equisetum silvaticum	1	0.3	17	2.7	4	5
Graminoid						
Calamagrostis canadensis	<1	0.2	25	0.0	1	
Unknown grass	1	0.2	11	1.9	9	3
Other						
Total moss	30	6.2				
Total lichen	10	3.4				
Litter	10	3.9				

[a] Phenological state: (1) just emerging from ground, first signs of new growth or dormant for evergreens, (2) leaf buds, (3) leaves, (4) flower buds, (5) flowers, (6) seeds, (7) decadent.

TABLE 73

Average cover, height, and phenological state for plant species during week of 7 June to 11 June, 1982, at Switchback transect (transect #3) (32 - 0.5-m^2 quadrats).

	Cover (%)		Height (cm)			
Life form/Species	Mean	Standard Error	Mean	Standard Error	No. of Plots	Phenological State[a]
Tall shrub						
Alnus sinuata	5	1.9	158	28.0	8	3
Low Shrub						
Betula glandulosa	14	2.6	55	3.7	21	3
Salix pulchra	2	1.2	43	5.3	5	3
Rosa acicularis	<1	0.1	20	7.7	3	3
Ribes triste	2	0.6	19	4.1	7	5
Dwarf Shrub						
Vaccinium vitis-idaea	6	1.5	7	0.6	20	2
Vaccinium uliginosum	7	1.7	18	1.7	18	3
Ledum groenlandicum	1	0.4	29	2.0	5	4
Ledum decumbens	6	1.9	19	1.7	12	4
Empetrum nigrum	1	0.5	9	0.8	6	2
Arctostaphylos uva-ursi	2	0.6				
Forb						
Equisetum silvaticum	<1	0.1	10	0.0	1	
Graminoid						
Unknown grass	<1	0.1	12	2.0	11	2
Other						
Total moss	29	5.7				
Total lichen	10	2.7				
Litter	9	3.2				

[a] Phenological state: (1) Just emerging from ground, first signs of new growth or dormant for evergreens, (2) leaf buds, (3) leaves, (4) flower buds, (5) flowers, (6) seeds, (7) decadent.

TABLE 74

Average cover, height, and phenological state for plant species during week of 7 June to 11 June, 1982, at Tsusena Creek transect (transect #4) (24 - 0.5-m^2 quadrats).

Life form/Species	Cover (%) Mean	Cover (%) Standard Error	Height (cm) Mean	Height (cm) Standard Error	No. of Plots	Phenological State[a]
Low Shrub						
Betula glandulosa	11	2.1	67	6.0	21	2
Dwarf Shrub						
Vaccinium vitis-idaea	5	0.8	8	0.9	20	1
Vaccinium uliginosum	3	1.1	19	1.7	12	2
Ledum groenlandicum	4	1.3	29	4.0	8	4
Ledum decumbens	10	2.1	21	1.6	15	4
Empetrum nigrum	8	3.1	8	0.5	13	2
Arctostaphylos uva-ursi	4	0.9				
Forb						
Cornus canadensis	<1	0.2				1
Other						
Total moss	82	3.9				
Total lichen	5	0.9				

[a] Phenological state: (1) just emerging from ground, first signs of new growth or dormant for evergreens, (2) leaf buds, (3) leaves, (4) flower buds, (5) flowers, (6) seeds, (7) decadent.

TABLE 75

Average cover, height, and phenological state for plant species during week of 14 June to 18 June, 1982, at Watana Creek transect (transect #1) (32 - 0.5-m^2 quadrats).

Life form/Species	Cover (%) Mean	Cover (%) Standard Error	Height (cm) Mean	Height (cm) Standard Error	No. of Plots	Phenological State[a]
Low Shrub						
Betula glandulosa	13	2.3	55	4.7	20	3
Rosa acicularis	<1	0.1	24	3.6	6	3
Spiraea beauverdiana	<1	0.1	40	0.0	1	3
Dwarf Shrub						
Vaccinium vitis-idaea	7	1.1	8	0.7	26	2
Vaccinium uliginosum	12	2.7	22	1.2	27	3
Ledum groenlandicum	10	1.6	28	2.6	24	4
Ledum decumbens	6	2.0	14	1.6	12	3
Empetrum nigrum	2	1.4	8	1.1	5	1
Arctostaphylos uva-ursi	1	0.5				
Other						
Total moss	60	5.2				
Total lichen	5	1.8				
Litter	3	2.5				

[a] Phenological state: (1) just emerging from ground, first signs of new growth or dormant for evergreens, (2) leaf buds, (3) leaves, (4) flower buds, (5) flowers, (6) seeds, (7) decadent.

TABLE 76

Average cover, height, and phenological state for plant species during week of 14 June to 18 June, 1982, at Jay Creek transect (transect #2) (32 - 0.5-m^2 quadrats).

Life form/Species	Cover (%) Mean	Cover (%) Standard Error	Height (cm) Mean	Height (cm) Standard Error	Height (cm) No. of Plots	Phenological State[a]
Tree						
Betula papyrifera			89	5.0	8	3
Low Shrub						
Betula glandulosa	13	0.3	51	3.8	17	3
Rosa acicularis	<1	0.1	35	7.1	7	3
Ribes triste	<1	0.2	10	0.0	1	3
Potentilla fruticosa			18	1.7	3	3
Dwarf Shrub						
Vaccinium vitis-idaea	7	1.1	10	1.3	22	3
Vaccinium uliginosum	12	2.7	21	1.5	24	3
Ledum groenlandicum	10	1.6	24	1.5	13	4
Ledum decumbens	6	2.0	21	2.8	7	4
Empetrum nigrum	2	1.4	8	0.4	5	1
Salix reticulata						3
Arctostaphylos alpina						3
Arctostaphylos uva-ursi	1	0.5				
Forb						
Cornus canadensis			8	2.3	3	3
Epilobium angustifolium			26	2.9	5	4
Mertensia paniculata	<1	0.0	23	0.9	6	4
Equisetum silvaticum	<1	0.3	25	2.0	4	4
Graminoid						
Calamagrostis canadensis			30	5.0	2	3
Unknown grass	<1	0.1	15	2.7	6	2
Other						
Total moss	60	5.2				
Total lichen	5	1.8				
Litter	3	2.5				

[a] Phenological state: (1) just emerging from ground, first signs of new growth or dormant for evergreens, (2) leaf buds, (3) leaves, (4) flower buds, (5) flowers, (6) seeds, (7) decadent.

TABLE 77

Average cover, height, and phenological state for plant species during week of 14 June to 18 June, 1982, at Switchback transect (transect #3) (32 - 0.5-m^2 quadrats).

Life form/Species	Cover (%) Mean	Cover (%) Standard Error	Height (cm) Mean	Height (cm) Standard Error	No. of Plots	Phenological State[a]
Tall shrub						
Alnus sinuata	5	2.4	176	33.5	6	3
Low Shrub						
Betula glandulosa	15	3.0	58	4.5	21	3
Salix pulchra	2	1.3	46	12.1	5	3
Salix glauca	1	0.5	46	15.5	2	3
Rosa acicularis	<1	0.2	24	5.9	6	3
Ribes triste	2	0.6	27	3.3	6	4
Dwarf Shrub						
Vaccinium vitis-idaea	7	2.1	8	0.6	21	2
Vaccinium uliginosum	13	2.2	21	1.6	22	4
Ledum groenlandicum	3	0.9	28	2.0	12	4
Ledum decumbens	7	2.9	20	2.3	10	4
Empetrum nigrum	1	0.8	8	1.7	3	2
Arctostaphylos uva-ursi	1	0.5				2
Forb						
Equisetum silvaticum	<1	0.1	6	0.8	6	3
Graminoid						
Unknown grass	2	0.9	12	2.4	12	2
Other						
Total moss	31	5.7				
Total lichen	15	3.5				
Litter	6	3.0				

[a] Phenological state: (1) just emerging from ground, first signs of new growth or dormant for evergreens, (2) leaf buds, (3) leaves, (4) flower buds, (5) flowers, (6) seeds, (7) decadent.

TABLE 78

Average cover, height, and phenological state for plant species during week of 14 June to 18 June, 1982, at Tsusena Creek transect (transect #4) (24 - 0.5-m^2 quadrats).

Life form/Species	Cover (%) Mean	Cover (%) Standard Error	Height (cm) Mean	Height (cm) Standard Error	No. of Plots	Phenological State[a]
Low Shrub						
Betula glandulosa	13	1.7	70	5.8	21	3
Dwarf Shrub						
Vaccinium vitis-idaea	9	1.8	8	0.9	23	2
Vaccinium uliginosum	5	1.4	22	2.5	13	3
Ledum groenlandicum	7	2.0	29	2.5	10	4
Ledum decumbens	10	2.8	19	1.2	14	4
Empetrum nigrum	10	2.9	7	0.4	15	3
Arctostaphylos uva-ursi	5	0.8				
Forb						
Cornus canadensis	1	0.3	4	0.7	3	2
Graminoid						
Unknown grass	<1	0.0	8	0.0	1	1
Other						
Total moss	69	3.9				
Total lichen	11	2.7				

[a] Phenological state: (1) just emerging from ground, first signs of new growth or dormant for evergreens, (2) leaf buds, (3) leaves, (4) flower buds, (5) flowers, (6) seeds, (7) decadent.

TABLE 79

Average cover, height, and phenological state for plant species during week of 21 June to 25 June, 1982, at Watana Creek transect (transect #1) (32 - 0.5-m^2 quadrats).

Life form/Species	Cover (%) Mean	Cover (%) Standard Error	Height (cm) Mean	Height (cm) Standard Error	No. of Plots	Phenological State[a]
Tree						
Betula papyrifera	1	1.1	99	0.0	1	3
Low Shrub						
Betula glandulosa	15	3.4	58	4.7	15	3
Rosa acicularis	1	0.3	36	10.2	6	3
Spiraea beauverdiana	1	0.4	32	8.3	3	3
Dwarf Shrub						
Vaccinium vitis-idaea	9	1.5	9	1.8	27	3
Vaccinium uliginosum	18	3.2	27	2.2	27	4
Ledum groenlandicum	9	1.4	27	2.2	26	4
Ledum decumbens	4	1.3	16	3.6	8	4
Empetrum nigrum	4	1.7	7	0.8	8	3
Arctostaphylos uva-ursi	2	0.6				
Forb						
Cornus canadensis	<1	0.1	3	1.0	3	4
Other						
Total moss	50	4.5				
Total lichen	11	2.9				
Litter	6	2.8				

[a] Phenological state: (1) just emerging from ground, first signs of new growth or dormant for evergreens, (2) leaf buds, (3) leaves, (4) flower buds, (5) flowers, (6) seeds, (7) decadent.

TABLE 80

Average cover, height, and phenological state for plant species during week of 21 June to 25 June, 1982, at Jay Creek transect (transect #2) (32 - 0.5-m^2 quadrats).

Life form/Species	Cover (%)		Height (cm)			
	Mean	Standard Error	Mean	Standard Error	No. of Plots	Phenological State[a]
Tree						
Betula papyrifera	8	2.9	68	6.4	9	2
Low Shrub						
Betula glandulosa	9	2.4	54	5.1	13	3
Salix glauca	3	2.5	15	0.0	1	3
Rosa acicularis	1	0.3	40	14.2	7	3
Ribes triste	<1	0.1	15	0.0	1	3
Potentilla fruticosa	<1	0.1	15	0.0	1	3
Dwarf Shrub						
Vaccinium vitis-idaea	13	2.7	14	1.9	19	3
Vaccinium uliginosum	9	1.9	24	2.3	20	4
Ledum groenlandicum	2	0.8	20	1.8	5	4
Ledum decumbens	11	2.9	21	1.9	16	4
Empetrum nigrum	1	0.5	8	0.0	3	4
Salix reticulata	3	1.2				3
Arctostaphylos alpina	<1	0.2				3
Arctostaphylos uva-ursi	1	0.5				
Forb						
Cornus canadensis	1	0.4	7	2.7	4	4
Epilobium angustifolium	1	0.2	25	2.2	7	3
Mertensia paniculata	2	0.9	19	3.9	8	4
Equisetum silvaticum	1	0.5	32	4.4	3	3
Graminoid						
Calamagrostis canadensis	1	0.5	38	2.5	2	3
Unknown grass	2	1.1	22	4.4	5	3
Other						
Total moss	20	5.2				
Total lichen	10	3.3				
Litter	7	2.8				

[a] Phenological state: (1) just emerging from ground, first signs of new growth or dormant for evergreens, (2) leaf buds, (3) leaves, (4) flower buds, (5) flowers, (6) seeds, (7) decadent.

TABLE 81

Average cover, height, and phenological state for plant species during week of 21 June to 25 June, 1982, at Switchback transect (transect #3) (32 - 0.5-m^2 quadrats).

	Cover (%)		Height (cm)			
Life form/Species	Mean	Standard Error	Mean	Standard Error	No. of Plots	Phenological State[a]
Tall shrub						
Alnus sinuata	6	3.3	233	32.1	5	3
Low Shrub						
Betula glandulosa	17	3.4	60	4.4	20	3
Salix pulchra	2	1.0	50	0.0	1	5
Salix glauca	1	0.5	46	0.0	1	3
Rosa acicularis	1	0.3	26	4.3	4	3
Ribes triste	3	1.3	32	6.0	5	4
Dwarf Shrub						
Vaccinium vitis-idaea	4	1.1	9	1.1	19	6
Vaccinium uliginosum	19	3.6	24	1.5	20	4
Ledum groenlandicum	2	1.0	29	3.2	7	4
Ledum decumbens	7	2.9	20	2.3	10	4
Empetrum nigrum	1	0.4	8	1.2	4	3
Arctostaphylos uva-ursi	1	0.5				
Forb						
Equisetum silvaticum	<1	0.2	13	2.4	7	3
Graminoid						
Grass spp.	2	0.7	19	2.1	14	3
Other						
Total moss	21	4.5				
Total lichen	11	2.9				
Litter	5	2.2				

[a] Phenological state: (1) just emerging from ground, first signs of new growth or dormant for evergreens, (2) leaf buds, (3) leaves, (4) flower buds, (5) flowers, (6) seeds, (7) decadent.

TABLE 82

Average cover, height, and phenological state for plant species during week of 21 June to 25 June, 1982, at Tsusena Creek transect (transect #4) (24 - 0.5-m^2 quadrats).

Life form/Species	Cover (%)		Height (cm)			
	Mean	Standard Error	Mean	Standard Error	No. of Plots	Phenological State[a]
Low Shrub						
<u>Betula glandulosa</u>	19	2.9	80	6.5	22	3
Dwarf Shrub						
<u>Vaccinium vitis-idaea</u>	6	1.1	9	0.8	19	2
<u>Vaccinium uliginosum</u>	7	1.6	24	2.3	16	4
<u>Ledum groenlandicum</u>	12	3.4	25	2.7	14	4
<u>Ledum decumbens</u>	5	1.9	24	3.1	5	4
<u>Empetrum nigrum</u>	15	4.6	10	1.0	14	4
<u>Arctostaphylos uva-ursi</u>	6	1.1				
Forb						
<u>Cornus canadensis</u>	<1	0.1	7	1.5	2	2
Graminoid						
Unknown grass	<1	0.1	8	0.0	2	3
Other						
Total moss	72	5.3				
Total lichen	3	0.7				

[a] Phenological state: (1) just emerging from ground, first signs of new growth or dormant for evergreens, (2) leaf buds, (3) leaves, (4) flower buds, (5) flowers, (6) seeds, (7) decadent.

TABLE 83

Average cover, height, and phenological state for plant species during week of 28 June to 2 July, 1982, at Watana Creek transect (transect #1) (32 - 0.5-m^2 quadrats).

Life form/Species	Cover (%) Mean	Cover (%) Standard Error	Height (cm) Mean	Height (cm) Standard Error	No. of Plots	Phenological State[a]
Tree						
Betula papyrifera	2	1.3	76	3.8	3	3
Low Shrub						
Betula glandulosa	12	3.0	68	8.0	14	3
Rosa acicularis	1	0.5	27	8.6	8	3
Spiraea beauverdiana	1	0.9	25	10.0	2	4
Dwarf Shrub						
Vaccinium vitis-idaea	9	2.6	12	3.3	26	4
Vaccinium uliginosum	25	3.7	26	1.5	28	4
Ledum groenlandicum	4	1.3	34	4.0	13	4
Ledum decumbens	7	1.5	27	1.6	17	4
Empetrum nigrum	3	1.8	7	1.4	8	3
Arctostaphylos uva-ursi	2	0.6				
Forb						
Cornus canadensis	1	0.4	5	0.4	10	4
Other						
Total moss	55	6.4				
Total lichen	5	1.6				
Litter	3	2.0				

[a] Phenological state: (1) just emerging from ground, first signs of new growth or dormant for evergreens, (2) leaf buds, (3) leaves, (4) flower buds, (5) flowers, (6) seeds, (7) decadent.

TABLE 84

Average cover, height, and phenological state for plant species during week of 28 June to 2 July, 1982, at Jay Creek transect (transect #2) (32 - 0.5-m^2 quadrats).

Life form/Species	Cover (%) Mean	Cover (%) Standard Error	Height (cm) Mean	Height (cm) Standard Error	No. of Plots	Phenological State[a]
Tree						
Betula papyrifera	3	2.7	92	8.3	3	3
Picea glauca	4	3.1	357	321.2	3	3
Low Shrub						
Betula glandulosa	14	3.8	53	6.1	15	3
Salix glauca	5	3.0	53	10.1	6	3
Rosa acicularis	2	0.9	38	9.6	7	3
Ribes triste	1	0.8	31	0.0	1	3
Potentilla fruticosa	1	0.9	14	7.2	7	3
Dwarf Shrub						
Vaccinium vitis-idaea	11	3.3	12	2.2	20	4
Vaccinium uliginosum	8	2.2	19	2.2	20	4
Ledum groenlandicum	1	0.4	23	2.5	5	5
Ledum decumbens	10	2.7	20	1.6	17	5
Empetrum nigrum	1	0.6	4	0.8	4	6
Salix reticulata	1	0.5				3
Arctostaphylos alpina	3	1.6				3
Loiseleuria procumbens	1	0.8				4
Forb						
Cornus canadensis	4	2.2	9	1.8	7	4
Epilobium angustifolium	2	1.0	38	7.9	8	3
Mertensia paniculata	4	2.0	38	9.9	5	5
Equisetum silvaticum	4	2.4	49	5.9	4	3
Graminoid						
Calamagrostis canadensis	1	0.4	50	12.6	3	3
Unknown grass	4	1.4	30	3.8	10	3
Other						
Total moss	19	5.5				
Total lichen	13	3.7				

[a] Phenological state: (1) just emerging from ground, first signs of new growth or dormant for evergreens, (2) leaf buds, (3) leaves, (4) flower buds, (5) flowers, (6) seeds, (7) decadent.

TABLE 85

Average cover, height, and phenological state for plant species during week of 28 June to 2 July, 1982, at Switchback transect (transect #3) (32 - 0.5-m^2quadrats).

Life form/Species	Cover (%) Mean	Cover (%) Standard Error	Height (cm) Mean	Height (cm) Standard Error	No. of Plots	Phenological State[a]
Tree						
Picea glauca	3	3.1	520	479.5	2	3
Tall shrub						
Alnus sinuata	17	5.3	190	31.5	8	3
Low Shrub						
Betula glandulosa	18	3.6	71	4.9	20	3
Salix pulchra	1	0.7	39	20.2	3	3
Salix glauca	1	0.8				
Rosa acicularis	1	0.4	25	6.1	5	3
Ribes triste	1	0.5	24	6.2	7	4
Dwarf Shrub						
Vaccinium vitis-idaea	9	2.9	13	3.9	22	4
Vaccinium uliginosum	21	4.0	26	1.9	23	4
Ledum groenlandicum	3	1.5	30	1.5	7	4
Ledum decumbens	8	2.3	21	2.4	13	4
Empetrum nigrum	1	0.4	8	0.6	7	3
Arctostaphylos uva-ursi	2	0.6				
Forb						
Equisetum silvaticum	1	0.4	23	1.7	11	3
Graminoid						
Unknow grass	3	2.0	20	3.3	12	3
Other						
Total moss	29	5.2				
Total lichen	9	2.3				
Litter	2	1.1				

[a] Phenological state: (1) just emerging from ground, first signs of new growth or dormant for evergreens, (2) leaf buds, (3) leaves, (4) flower buds, (5) flowers, (6) seeds, (7) decadent.

TABLE 86

Average cover, height, and phenological state for plant species during week of 28 June to 2 July, 1982, at Tsusena Creek transect (transect #4) (24 - 0.5-m^2 quadrats).

Life form/Species	Cover (%) Mean	Cover (%) Standard Error	Height (cm) Mean	Height (cm) Standard Error	No. of Plots	Phenological State[a]
Low Shrub						
Betula glandulosa	25	3.8	67	6.1	23	3
Dwarf Shrub						
Vaccinium vitis-idaea	6	2.1	17	5.8	18	4
Vaccinium uliginosum	16	2.8	22	2.1	20	4
Ledum groenlandicum	3	1.5	28	1.9	7	4
Ledum decumbens	13	3.2	22	1.9	15	5
Empetrum nigrum	13	3.9	7	0.5	14	3
Arctostaphylos uva-ursi	4	0.8				
Forb						
Cornus canadensis	3	0.6	7	0.5	18	4
Graminoid						
Unknown grass	2	1.3	15	4.9	4	3
Other						
Total moss	65	5.8				
Total lichen	6	1.6				

[a] Phenological state: (1) just emerging from ground, first signs of new growth or dormant for evergreens, (2) leaf buds, (3) leaves, (4) flower buds, (5) flowers, (6) seeds, (7) decadent.

TABLE 87

Average cover, height, and phenological state for <u>Betula glandulosa</u> during week of 7 June to 11 June, 1982, at each elevation within each tansect.

Position	Transect				
	Watana	Jay	Switchback	Tsusena	Mean
			Cover (%)		
Bench	15	14	21	14	16
Top	13	16	17	16	16
Middle	4	-	18	-	6
Bottom	-	6	-	2	2
Mean	8	9	14	11	10
			Height (cm)		
Bench	51	49	58	86	61
Top	57	47	50	68	56
Middle	39	-	59	-	49
Bottom	-	33	-	36	35
Mean	51	45	55	67	55
			Phenological State[a]		
Bench	2.4	2.6	3.0	1.9	2.5
Top	2.8	3.1	2.8	2.0	2.6
Middle	3.0	-	3.0	-	3.0
Bottom	-	3.0	-	2.0	2.5
Mean	2.7	2.9	2.9	2.0	2.6

[a] Phenological state: (1) just emerging from ground, first signs of new growth or dormant for evergreens, (2) leaf buds, (3) leaves, (4) flower buds, (5) flowers, (6) seeds, (7) decadent.

TABLE 88

Average cover, height, and phenological state for *Mertensia panicualata* during each week at the mid-slope elevation of the Jay Creek transect, 1982.

Date	Cover (%)	Height (cm)	Phenological State[a]
1 June	3	8	2.8
8 June	4	13	3.8
15 June	8	23	4.2
22 June	9	19	3.6
29 June	14	38	4.6

[a] Phenological state: (1) just emerging from ground, first signs of new growth or dormant for evergreens, (2) leaf buds, (3) leaves, (4) flower buds, (5) flowers, (6) seeds, (7) decadent.

TABLE 89

n (±SE) biomass of forbs (kg/ha), graminoids (kg/ha), and total current growth biomass (±SE) of twigs and attached leaves (g/100 twigs) clipped from the
r shrubs sampled inside and outside exclosures during weeks 1 through 6 (5/82 - 8/82) in the middle Susitna River Basin.

					Betula glandulosa		*Betula papyrifera*		*Salix pulchra*		*Salix glauca*		*Alnus sinuata*	
Transect	Elevation	In Out	Forbs	Grasses	leaf	twig	leaf	twig	leaf	twig	leaf	twig	leaf	twig
1	1	(out				11.25±1.46								
	2	only				8.42±1.93								
	3	weeks		1±1		8.42±1.46								
	4	1-5)		5±1						1.25±1.25				
2	1					6.40±1.00								
	2			1±1		6.87±1.04								
	3		15±12	28±22			3.93±1.76	14.55±1.92						
	4			29±16		6.38±1.29								
3	1					4.88±0.73								
	2			3±2		4.30±0.76								
	3			1±1		4.43±1.64								
	4		5±5	18±7										35.25±7.25
4	1					4.63±0.63								
	2					3.13±0.35								
	4					2.88±1.69								
1	1				1.25±1.00	8.05±1.94								
	2				2.18±0.48	5.30±0.31								
	3		54±34		1.43±0.84	1.63±0.94								
	4			10±7										
2	1			3±3	2.18±1.34	5.05±0.59			2.18±2.18	2.63±2.63				
	2			2±1	2.25±0.38	3.55±0.51								
	3			32±21	8.88±0.89	9.38±1.23								
	4			78±23	3.25±1.91	2.30±1.38								
3	1				2.63±0.68	3.88±0.89								
	2				2.63±0.55	3.63±0.38								
	3			4±4	3.93±1.51	5.18±1.77			1.75±1.75	1.18±1.13				
	4		5±5	41±10									10.50±2.43	14.38±4.30
4	1					6.80±0.79								
	2					3.80±1.20								
	4					3.38±1.18								

TABLE 89 (continued 2)

Week	Transect	Elevation	In Out	Forbs	Grasses	*Betula glandulosa* leaf	*Betula glandulosa* twig	*Betula papyrifera* leaf	*Betula papyrifera* twig	*Salix pulchra* leaf	*Salix pulchra* twig	*Salix glauca* leaf	*Salix glauca* twig	*Alnus sinuata* leaf	*Alnus sinuata* twig
3	1	1				2.63±0.33	4.00±0.10								
		2				5.55±1.34	5.63±1.10								
		3				4.13±0.31	4.50±0.75								
		4		18±18											
	2	1				3.05±1.39	4.88±1.08								
		2		9±9		3.63±1.33	3.80±1.48			1.63±1.63	2.55±2.50				
		3		67±67	32±32			10.80±0.90	8.12±1.49						
		4			83±30										
	3	1				2.25±0.41	1.93±0.35								
		2		1±1		2.93±1.00	2.38±0.81								
		3			9±5	3.30±1.28	2.75±0.96								
		4		73±37	121±63					4.00±4.00	1.50±1.50			1.88±1.88	1.25±1.25
	4	1					2.63±0.99								
		2				0.93±0.35	3.13±0.43								
		3				1.06±0.90	3.30±1.29								
4	1	1				1.30±0.48	1.68±0.50								
		2				4.25±1.58	4.00±1.54								
		3		3±3		3.30±1.94	2.38±1.38								
		4		50±29	15±7										
	2	1				2.75±1.07	2.63±0.94								
		2			13±13	2.80±1.13	2.25±0.86								
		3		140±72	117±69			9.55±5.74	4.38±2.63						
		4		13±10	93±32	1.93±1.61	1.30±1.08								
	3	1		2±2		4.43±1.71	3.13±1.15								
		2		4±3	35±31	4.00±2.05	2.88±1.28								
		3		19±13	14±1	5.75±2.69	3.43±1.16								
		4		37±25	94±28									9.38±9.38	10.05±10.05
	4	1				3.30±0.69	4.38±0.21								
		2				3.93±1.51	4.63±1.63			5.00±5.00	4.38±4.38				
		4		2±2		5.37±0.88	4.00±0.80								

E 89 (continued 3)

Tran- sect	Eleva- tion	In Out	Forbs	Grasses	*Betula glandulosa* leaf	*Betula glandulosa* twig	*Betula papyrifera* leaf	*Betula papyrifera* twig	*Salix pulchra* leaf	*Salix pulchra* twig	*Salix glauca* leaf	*Salix glauca* twig	*Alnus sinuata* leaf	*Alnus sinuata* twig
1	1				4.13±1.46	3.92±1.63								
	2		2±2		5.30±3.06	3.88±2.34								
	3			8±3										
	4		2±2	31±24										
2	1			1±1										
	2			6±3	16.55±4.85	10.87±3.10								
	3		152±63	119±88			3.13±3.13	1.88±1.88						
	4			210±38	3.30±1.94	3.43±2.00								
3	1				4.55±0.95	3.05±0.74								
	2		7±7	15±9	1.75±1.75	2.00±2.00								
	3		34±22	8±2	4.75±3.14	3.43±2.68								
	4		6±2	114±49										
4	1			1±1	6.00±1.23	5.50±1.18								
	2		51±51	91±63	6.50±1.16	6.55±1.00								
	4				5.75±1.18	5.62±1.13								
1	1	In		5±4	6.25±0.76	2.77±1.19								
		out	6±6	11±5	3.13±1.88	3.92±2.38								
	2	In	13±7	1±1	2.80±0.19	3.25±1.21								
		out	1±1	1±1	9.38±3.08	8.05±0.63			9.55±5.93	3.93±2.60				
	3	In	4±2	1±1	1.30±1.30	1.75±1.81								
		out	3±2	1±1	1.63±1.63	1.55±1.55								
	4	In	35±14	11±7										
		out	34±17	167±154										

TABLE 89 (continued 4)

Week	Tran-sect	Eleva-tion	In Out	Forbs	Grasses	*Betula glandulosa* leaf	*Betula glandulosa* twig	*Betula papyrifera* leaf	*Betula papyrifera* twig	*Salix pulchra* leaf	*Salix pulchra* twig	*Salix glauca* leaf	*Salix glauca* twig	*Alnus sinuata* leaf	*Alnus sinuata* twig
	2	1	in		1±	11.62±6.38	36.13±29.00								
			out		2±2	6.43±3.10	5.00±2.41								
		2	in		1±1	5.18±2.04	6.38±2.01								
			out	30±8	6±4	4.68±1.89	4.63±1.72								
		3	in	1176±345	579±310										
			out	316±85	281±209										
		4	in	94±31	76±30	2.13±2.13	2.55±2.55								
			out	19±19	116±46	1.56±0.94	2.13±1.88								
	3	1	in	1±1	3±2	5.80±1.41	7.05±1.81								
			out	5±5	1±1	7.30±3.48	9.00±4.86			0.63±0.63	1.88±1.88				
		2	in	<1	3±1	3.55±1.44	4.13±1.44			3.75±3.75	1.25±1.25				
			out	19±12	32±15	2.43±1.48	3.00±2.24								
		3	in	78±47	30±10	5.30±0.35	6.05±0.33								6.88±6.88
			out	42±22	4±3									6.87±6.87	
		4	in	121±49	238±82									30.67±4.88	23.37±5.74
			out	16±2	411±278			3.75±3.75	3.30±3.30					18.75±8.43	16.63±16.12
	4	1	in	26±23		5.38±1.35	5.88±2.26								
			out	47±22		2.25±0.83	5.63±1.38								
		2	in	54±23	2±1	5.25±1.71	3.68±0.33								
			out	22±9	13±8	3.00±0.84	5.30±1.49								
		4	in	60±13		4.43±1.56	4.68±2.19								
			out	35±16	1±1	3.38±2.73	3.88±2.96								

[a] Elevation 3 not established at transect 4.

TABLE 90

Mean (±SE) current annual growth (kg/ha) of twigs and leaves of major shrubs sampled inside and outside of exclosures during September 1982 in the middle Susitna River Basin.

			Vaccinium vitis-idaea		*Betula glandulosa*		*Salix pulchra*		*Salix glauca*		*Alnus sinuata*		*Betula papyrifera*	
Transect	Elevation	In-Out	leaf	twig	leaf	twig	leaf	twig	leaf	twig	leaf	twig	leaf	twig
1	1	in		140±40	40±20	40±20								
1	1	out		140±40	60±40	40±20								
1	2	in		140±40	20±9	20±7								
1	2	out		340±120	20±2	20±5	5±5	60±15	20±7	80±20				
1	3	in		240±100	4±4	5±5								
1	3	out		340±60	9±9	20±20								
1	4	in		300±80										
1	4	out		580±340										
2	1	in		720±40	20±20	20±20								
2	1	out		500±140	20±20	40±40								
2	2	in		400±80	20±6	20±20								
2	2	out		1340±800	20±6	20±8								
2	3	in		560±320										
2	3	out		200±80									60±20	8±4
2	4	in		20±20	20±20	20±20			3±3	20±7				
2	4	out		60±60	20±8	5±4			8±5	20±6				

TABLE 90 (continued 2)

Transect	Elevation	In-Out	*Vaccinium vitis-idaea* leaf	*Vaccinium vitis-idaea* twig	*Betula glandulosa* leaf	*Betula glandulosa* twig	*Salix pulchra* leaf	*Salix pulchra* twig	*Salix glauca* leaf	*Salix glauca* twig	*Alnus sinuata* leaf	*Alnus sinuata* twig	*Betula papyrifera* leaf	*Betula papyrifera* twig
3	1	in		260±100	20±20	20±8								
3	1	out		300±160	60±40	60±40								
3	2	in		120±40	20±4	20±6	2±2	20±20						
3	2	out		200±80	20±20	40±20	5±5	20±20	60±60	180±180				
3	3	in		600±400	40±20	20±20	20±<1	40±20						
3	3	out		280+140			<1±<1	<1±<1	40±20	80±80	60±60	60±60		
3	4	in		40±40							80±20	140±20		
3	4	out		20±20					2±2	3±3	60±40	8±4	3±3	3±3
4	1	in		420±60	40±20	40±20								
4	1	out		320±80	20±20	20±20								
4	2	in		220±100	20±5	20±5								
4	2	out		220±120	40±20	20±20								
4	4[a]	in		200±60	20±8	20±20								
4	4	out		360±160	5±4	4±3								

[a] Elevation 3 not established at transect 4.

TABLE 91

Means, standard errors, and number of twigs required to sample within 10% of the mean with 95% confidence for basal diameters (mm) and length (mm) of current annual growth twigs for major shrubs sampled for the plant phenology study, middle Susitna River Basin.

Shrub Species/Category	Mean	Standard Error	Estimated Sample Size
Betula glandulosa			
Diameter	1.8	0.01	15
Length	47.2	0.82	121
Salix pulchra			
Diameter	1.9	0.06	25
Length	53.4	3.76	115
Salix glauca			
Diameter	1.9	0.06	33
Length	63.5	5.02	223
Alnus sinuata			
Diameter	2.9	0.09	26
Length	87.0	5.00	86
Betula papyrifera			
Diameter	2.3	0.07	23
Length	119.4	7.03	90

TABLE 92

Hectares and percentage of each the Primary, Secondary and Control burn areas by vegetation type in the Alphabet Hills.

Vegetation Type	Primary		Secondary		Control	
	Hectares	Area (%)	Hectares	Area (%)	Hectares	Area(%)
Forest	2203	75.65	10606	77.41	9143	83.06
Open spruce	2134	73.27	9125	66.59	5296	48.10
Open spruce/Woodland spruce	--	--	--	--	1124	10.22
Woodland spruce	69	2.38	1461	10.67	2000	18.17
Woodland spruce/Mesic graminoid herbaceous/Low shrub	--	--	20	0.15	723	6.57
Shrub	623	21.39	2596	18.95	595	5.40
Low shrub	582	19.98	2146	15.67	566	5.14
Low shrub/Mesic graminoid herbaceous	--	--	253	1.85	--	--
Dwarf shrub	--	--	63	0.45	--	--
Low willow	30	1.04	91	0.66	29	0.26
Low willow/Mesic graminoid herbaceous	11	0.37	43	0.32	--	--
Herbaceous	63	2.15	137	0.99	149	1.36
Mesic graminoid herbaceous	63	2.15	137	0.99	149	1.36
Unvegetated	24	0.81	363	2.65	1120	10.18
Lake	24	0.81	363	2.65	1120	10.18
Total Area	2913	100.00	13,702	100.00	11,007	100.00

TABLE 93

Average diameter at point-of-browsing (DPB) for browsed twigs (estimated from a large but undetermined number of twigs), weight/twig, and weight of leaves attached to clipped twigs in the Alphabet Hills.

Species	DPB (mm)	Leaf (g)	Twig (g)	Sample size
Betula glandulosa	2.4	0.30	0.35	648
Salix glauca	3.5	0.74	0.46	199
Salix lanata	3.0	0.58	0.36	25
Salix pulchra	2.8	0.66	0.51	589

TABLE 94

Average percent canopy cover and number of plots required to sample within 20% of the mean with 67% confidence by life form and plant species in 30 - 4-m2 and 1-m2 quadrats from 3 sites in the Open White Spruce vegetation type, Alphabet Hills.

Life Form/Species	Mean	Standard Error	Estimated Sample Size
Tree (4-m2)	10	2.9	10
Total tall shrub	1	0.6	1
Alnus crispa	1	0.6	1
Total low shrub	19	3.2	13
Betula glandulosa	3	1.2	2
Salix pulchra	15	2.7	9
Total dwarf shrub (1-m2)	11	2.0	5
Cassiope tetragona	1	0.3	1
Empetrum nigrum	3	0.9	1
Ledum groenlandicum	1	0.5	1
Salix reticulata	1	0.6	1
Vaccinium uliginosum	5	1.4	1
Vaccinium vitis-idaea	3	1.0	1
Total forb	34	3.5	8
Astragalus spp.	1	0.3	1
Chrysosplenium tetrandrum	1	0.5	1
Cornus canadensis	5	1.8	4
Equisetum arvense	6	2.3	6
Equisetum silvaticum	3	1.1	1
Petasites frigidus	7	1.6	3
Pyrola spp.	1	0.2	1
Rubus chamaemorus	1	0.3	1
Valeriana capitata	1	0.2	1
Total graminoid	10	1.1	4
Calamagrostis canadensis	5	1.8	4
Carex spp.	3	1.8	4
Grass spp.	2	1.0	1
Total moss	55	5.9	9
Total lichen	2	0.6	1
Peltigera spp.	1	0.4	1
Litter	9	1.4	2
Dead wood	3	1.2	2
Bare ground	1	0.2	1

TABLE 95

Average density (number/ha) of stems for living and dead shrub and mature tree, tree sapling and tree seedling species at 2 sites in the Open White Spruce vegetation type, Alphabet Hills.

Life Form/Species	Live Shrub[a]	Dead Shrub[a]	Live Tree[b]	Dead Tree[b]	Tree Sapling[b]	Tree Seedling[a]
Tree						
Picea glauca			455	28	133	750
Picea mariana			172	13	32	333
Tall shrub						
Alnus crispa	4167	1583				
Alnus sinuata	83	--				
Low shrub						
Betula glandulosa	11583	333				
Salix lanata	750	167				
Salix pulchra	48000	3333				

[a] 4-m^2 quadrat

[b] Point-centered quarter

TABLE 96

Average basal diameter class and percent twig utilization of shrub species, and number of plants required to sample within 20% of the mean with 67% confidence based on those measures, for 2 sites[a] in the Open White Spruce vegetation type, Alphabet Hills.

Measure	Species	Mean	Standard Error	No. Plants	No. Sites	Estimated Sample Size
Basal Diameter Class (cm)	*Betula glandulosa*	0-1	--	64	2	1
	Salix pulchra	1-2	--	80	2	1
Utilization (%)	*Betula glandulosa*	12	2.5	64	2	77
	Salix pulchra	12	2.0	80	2	54

[a] Shrubs at site 23 heavily browsed, no data.

TABLE 97

Gross available and utilized leaf, twig and total biomass (kg/ha) estimated from number of unbrowsed and browsed twigs/ha and stem densities (number/ha) from 3 sites in the Open White Spruce vegetation type, Alphabet Hills.

Species[a]	No. Unbrowsed Twigs/ha	Available Leaf Biomass	Available Twig Biomass	Total Available Biomass	No. Browsed Twigs/ha	Utilized Leaf Biomass[b]	Utilized Twig Biomass	Total Utilized Biomass
Betula glandulosa	82239	25	28	53	40541	12	14	26
Salix pulchra	374400	249	192	441	115200	77	59	136
Total Biomass		274	220	494		89	73	162

[a] *Alnus crispa* twigs not counted.

[b] Leaf biomass removed if browsing had occurred when leaves were attached.

TABLE 98

Average percent canopy cover and number of plots required to sample within 20% of the mean with 67% confidence by life form and plant species in 70 - 4-m^2 and 1-m^2 quadrats from 7 sites in the Open Black Spruce vegetation type, Alphabet Hills.

Life Form/Species	Mean	Standard Error	Estimated Sample Size
Tree (4-m^2)	13	1.7	8
Total low shrub	12	1.6	7
Betula glandulosa	5	0.7	1
Salix pulchra	7	1.5	7
Total dwarf shrub (1-m^2)	31	2.5	11
Empetrum nigrum	9	1.9	10
Ledum decumbens	5	1.0	3
Ledum groenlandicum	3	0.6	1
Vaccinium uliginosum	14	1.8	9
Vaccinium vitis-idaea	7	1.2	4
Total forb	20	2.2	13
Equisetum silvaticum	2	0.7	1
Petasites frigidus	4	0.9	3
Rubus chamaemorus	3	0.7	1
Total graminoid	10	2.8	11
Carex spp.	10	2.8	11
Total moss	53	3.3	7
Total lichen	19	2.2	13
Peltigera spp.	3	0.7	1
Stereocaulon spp.	1	0.7	1
Litter	9	1.9	10
Dead wood	1	0.4	1
Bare ground	1	0.3	1
Water	1	0.5	1

TABLE 99

Average density (number/ha) of stems for living and dead shrub and mature tree, tree sapling and tree seedling species at 7 sites in the Open Black Spruce vegetation type, Alphabet Hills.

Life Form/Species	Live Shrub[a]	Dead Shrub[a]	Live Tree[b]	Dead Tree[b]	Tree Sapling[b]	Tree Seedling[a]
Tree						
Picea glauca			29	14	93	--
Picea mariana			1207	56	921	6679
Low shrub						
Betula glandulosa	33786	1143				
Rosa acicularis	1500	--				
Salix glauca	357	--				
Salix lanata	643	250				
Salix pulchra	15500	1857				

[a] 4-m^2 quadrat

[b] Point-centered quarter

TABLE 100

Average basal diameter class and percent twig utilization of shrub species, and number of plants required to sample within 20% of the mean with 67% confidence based on those measures, for 7 sites in the Open Black Spruce vegetation type, Alphabet Hills.

Measure	Species	Mean	Standard Error	No. Plants	No. Sites	Estimated Sample Size
Basal Diameter Class (cm)	Betula glandulosa	0-1	--	261	7	1
	Salix glauca	0-1	--	13	2	1
	Salix lanata	1-2	--	22	1	1
	Salix pulchra	1-2	--	237	7	1
Utilization (%)	Betula glandulosa	3	0.6	261	6	102
	Salix glauca	6	5.8	13	1	325
	Salix lanata	27	5.8	22	1	26
	Salix pulchra	8	0.9	237	7	68

TABLE 101

Gross available and utilized leaf, twig and total biomass (kg/ha) estimated from number of unbrowsed and browsed twigs/ha and stem densities (number/ha) from 7 sites in the Open Black Spruce vegetation type, Alphabet Hills.

Species[a]	No. Unbrowsed Twigs/ha	Available Leaf Biomass	Available Twig Biomass	Total Available Biomass	No. Browsed Twigs/ha	Utilized Leaf Biomass[b]	Utilized Twig Biomass	Total Utilized Biomass
Betula glandulosa	320967	97	111	208	60815	18	21	39
Salix glauca	2785	2	1	3	1071	1	<1	1
Salix lanata	3729	2	1	4	1865	1	1	2
Salix pulchra	275900	183	142	325	79050	53	41	93
Total Biomass		284	255	540		73	64	135

[a] Alnus crispa twigs not counted.

[b] Leaf biomass removed if browsing had occurred when leaves were attached.

TABLE 102

Average percent canopy cover and number of plots required to sample within 20% of the mean with 67% confidence by life form and plant species in 50 - 4-m^2 and 1-m^2 quadrats from 5 sites in the Woodland White Spruce vegetation type, Alphabet Hills.

Life Form/Species	Mean	Standard Error	Estimated Sample Size
Tree (4-m^2)	6	2.1	9
Total low shrub	25	2.5	13
Betula glandulosa	14	2.3	11
Salix pulchra	12	2.1	9
Total dwarf shrub (1-m^2)	45	4.0	10
Arctostaphylos rubra	1	0.6	1
Empetrum nigrum	13	1.7	6
Ledum groenlandicum	15	3.8	28
Vaccinium uliginosum	27	3.9	26
Vaccinium vitis-idaea	8	1.4	4
Salix reticulata	2	1.3	3
Total forb	8	1.6	5
Equisetum silvaticum	4	1.3	4
Rubus chamaemorus	1	0.4	1
Petasites frigidus	1	0.3	1
Total moss	46	4.2	11
Total lichen	21	3.3	21
Cetraria spp.	2	0.7	1
Cladonia spp.	9	1.1	2
Peltigera spp.	7	2.2	9
Stereocaulon spp.	1	0.8	1
Litter	17	2.9	17
Dead wood	1	0.2	1
Bare ground	1	0.6	1

TABLE 103

Average density (number/ha) of stems for living and dead shrub and mature tree, tree sapling and tree seedling species at 5 sites in the Woodland White Spruce vegetation type, Alphabet Hills.

Life Form/Species	Live Shrub[a]	Dead Shrub[a]	Live Tree[b]	Dead Tree[b]	Tree Sapling[b]	Tree Seedling[a]
Tree						
<u>Picea glauca</u>			361	15	95	200
<u>Picea mariana</u>			87	1	48	200
Tall shrub						
<u>Alnus sinuata</u>	150	--				
Low shrub						
<u>Betula glandulosa</u>	57950	4300				
<u>Rosa acicularis</u>	3200	--				
<u>Salix glauca</u>	100	--				
<u>Salix lanata</u>	100					
<u>Salix pulchra</u>	25400	4150				

[a] 4-m^2 quadrat

[b] Point-centered quarter

TABLE 104

Average basal diameter class and percent twig utilization of shrub species, and number of plants required to sample within 20% of the mean with 67% confidence based on those measures, for 5 sites in the Woodland White Spruce vegetation type, Alphabet Hills.

Measure	Species	Mean	Standard Error	No. Plants	No. Sites	Estimated Sample Size
Basal Diameter Class (cm)	*Betula glandulosa*	0-1	--	178	5	1
	Salix glauca	1-2	--	164	5	1
	Salix lanata	1-2	--	2	2	1
	Salix pulchra	1-2	--	164	5	1
Utilization (%)	*Betula glandulosa*	8	1.1	177	5	75
	Salix glauca	25	3.3	38	1	17
	Salix lanata	51	7.7	2	2	2
	Salix pulchra	16	1.5	164	5	38

TABLE 105

Gross available and utilized leaf, twig and total biomass (kg/ha) estimated from number of unbrowsed and browsed twigs/ha and stem densities (number/ha) from 4 sites in the Woodland White Spruce vegetation type, Alphabet Hills.

Species[a]	No. Unbrowsed Twigs/ha	Available Leaf Biomass	Available Twig Biomass	Total Available Biomass	No. Browsed Twigs/ha	Utilized Leaf Biomass[b]	Utilized Twig Biomass	Total Utilized Biomass
Betula glandulosa	701195	212	242	454	214415	65	74	139
Salix glauca	1080	1	<1	1	450	<1	<1	1
Salix lanata	650	<1	<1	1	650	<1	<1	1
Salix pulchra	325760	216	167	384	117070	78	60	138
Total Biomass		430	411	840		145	136	279

[a] *Alnus crispa* twigs not counted.

[b] Leaf biomass removed if browsing had occurred when leaves were attached.

TABLE 106

Average percent canopy cover and number of plots required to sample within 20% of the mean with 67% confidence by life form and plant species in 70 - 4-m^2 and 1-m^2 quadrats from 7 sites in the Dwarf Birch vegetation type, Alphabet Hills.

Life Form/Species	Mean	Standard Error	Estimated Sample Size
Total low shrub (4-m^2)	49	3.2	7
Betula glandulosa	45	3.3	9
Total dwarf shrub (1-m^2)	55	3.9	9
Empetrum nigrum	26	3.8	36
Ledum decumbens	2	1.2	4
Ledum groenlandicum	21	2.9	24
Vaccinium uliginosum	35	3.6	19
Vaccinium vitis-idaea	8	1.4	5
Total forb	8	1.5	6
Cornus canadensis	3	1.2	4
Total graminoid	3	0.9	2
Grass spp.	1	0.8	2
Hiercochloe alpina	1	0.3	1
Total moss	53	3.8	9
Total lichen	23	2.6	19
Cetraria spp.	3	0.7	1
Cladonia spp.	11	0.8	2
Peltigera spp.	7	1.1	3
Litter	30	3.5	24
Dead wood	2	0.4	1
Bare ground	1	0.5	1

TABLE 107

Average density (number/ha) of stems for living and dead shrub and mature tree, tree sapling and tree seedling species at 7 sites in the Dwarf Birch vegetation type, Alphabet Hills.

Life Form/Species	Live Shrub[a]	Dead Shrub[a]	Live Tree[b]	Dead Tree[b]	Tree Sapling[b]	Tree Seedling[a]
Tree						
Picea glauca			14	2	4	--
Picea mariana			13	1	12	18
Low shrub						
Betula glandulosa	125232	12196				
Rosa acicularis	1503	143				
Salix glauca	1321	821				
Salix pulchra	10857	1125				

[a] 4-m^2 quadrat

[b] Point-centered quarter

TABLE 108

Average basal diameter class and percent twig utilization of shrub species, and number of plants required to sample within 20% of the mean with 67% confidence based on those measures, for 7 sites in the Dwarf Birch vegetation type, Alphabet Hills.

Measure	Species	Mean	Standard Error	No. Plants	No. Sites	Estimated Sample Size
Basal	Betula glandulosa	1-2	--	276	7	1
Diameter	Salix glauca	1-2	--	36	5	1
Class (cm)	Salix pulchra	1-2	--	117	7	1
Utilization	Betula glandulosa	5	0.5	276	6	82
(%)	Salix glauca	10	2.5	36	5	53
	Salix pulchra	15	1.7	117	7	38

TABLE 109

Gross available and utilized leaf, twig and total biomass (kg/ha) estimated from number of unbrowsed and browsed twigs/ha and stem densities (number/ha) from 7 sites in the Dwarf Birch vegetation type, Alphabet Hills.

Species[a]	No. Unbrowsed Twigs/ha	Available Leaf Biomass	Available Twig Biomass	Total Available Biomass	No. Browsed Twigs/ha	Utilized Leaf Biomass[b]	Utilized Twig Biomass	Total Utilized Biomass
Betula glandulosa	2492117	754	860	1614	438312	133	151	284
Salix glauca	13738	10	6	16	5416	4	2	6
Salix pulchra	162855	108	84	192	41257	27	21	49
Total Biomass		872	950	1822		164	174	339

[a] *Alnus crispa* twigs not counted.

[b] Leaf biomass removed if browsing had occurred when leaves were attached.

TABLE 110

Average percent canopy cover and number of plots required to sample within 20% of the mean with 67% confidence by life form and plant species in 30 - 4-m^2 and 1-m^2 quadrats from 3 sites in the Dwarf Birch - Willow vegetation type, Alphabet Hills.

Life Form/Species	Mean	Standard Error	Estimated Sample Size
Total low shrub (4-m^2)	37	4.7	12
Betula glandulosa	19	3.7	17
Salix glauca	1	1.3	2
Salix pulchra	18	4.1	20
Total dwarf shrub (1-m^2)	68	4.5	3
Arctostaphylos rubra	2	1.3	2
Empetrum nigrum	21	3.7	16
Ledum decumbens	8	2.0	5
Ledum groenlandicum	11	2.2	6
Vaccinium uliginosum	56	5.1	6
Vaccinium vitis-idaea	7	2.1	5
Total forb	12	1.9	4
Equisetum silvaticum	2	0.5	1
Petasites frigidus	1	0.4	1
Total graminoid	9	0.9	2
Carex spp.	8	1.8	4
Grass spp.	1	0.4	1
Total moss	59	4.8	5
Total lichen	26	4.0	18
Cetraria spp.	1	0.3	1
Cladonia spp.	7	1.5	3
Peltigera spp.	1	0.5	1
Peltigera spp.	18	2.9	10
Litter	33	5.5	21
Dead wood	3	0.6	1

TABLE 111

Average density (number/ha) of stems for living and dead shrub and mature tree, tree sapling and tree seedling species at 3 sites in the Dwarf Birch - Willow vegetation type, Alphabet Hills.

Life Form/Species	Live Shrub[a]	Dead Shrub[a]	Live Tree[b]	Dead Tree[b]	Tree Sapling[b]	Tree Seedling[a]
Tree						
Picea glauca			9	29	9	167
Picea mariana			14	20	9	--
Low shrub						
Betula glandulosa	39833	750				
Rosa acicularis	4167	--				
Salix glauca	1500	500				
Salix pulchra	33417	4000				

[a] 4-m^2 quadrat

[b] Point-centered quarter

TABLE 112

Average basal diameter class and percent twig utilization of shrub species, and number of plants required to sample within 20% of the mean with 67% confidence based on those measures, for 3 sites in the Dwarf Birch - Willow vegetation type, Alphabet Hills.

Measure	Species	Mean	Standard Error	No. Plants	No. Sites	Estimated Sample Size
Basal Diameter Class (cm)	*Betula glandulosa*	1-2	--	120	3	1
	Salix glauca	1-2	--	14	3	1
	Salix pulchra	1-2	--	98	3	1
Utilization (%)	*Betula glandulosa*	6	1.3	120	3	147
	Salix glauca	5	2.5	14	3	80
	Salix pulchra	8	1.7	98	3	101

TABLE 113

Gross available and utilized leaf, twig and total biomass (kg/ha) estimated from number of unbrowsed and browsed twigs/ha and stem densities (number/ha) from 3 sites in the Dwarf Birch - Willow vegetation type, Alphabet Hills.

Species[a]	No. Unbrowsed Twigs/ha	Available Leaf Biomass	Available Twig Biomass	Total Available Biomass	No. Browsed Twigs/ha	Utilized Leaf Biomass[b]	Utilized Twig Biomass	Total Utilized Biomass
Betula glandulosa	820560	248	283	531	171282	52	59	111
Salix glauca	22950	17	11	28	4500	3	2	5
Salix pulchra	407687	271	209	480	93568	62	48	110
Total Biomass		536	503	1039		117	109	226

[a] Alnus crispa twigs not counted.

[b] Leaf biomass removed if browsing had occurred when leaves were attached.

TABLE 114

Summary of average density, gross available twig biomass, and percent utilization of twigs for 4 major shrub species in 5 vegetation types, Alphabet Hills.

Vegetation type	Density (#/ha)				Twig Biomass (kg/ha)				Percent Utilization			
	Begl[a]	Sagl[b]	Sala[c]	Sapu[d]	Begl	Sagl	Sala	Sapu	Begl	Sagl	Sala	Sapu
Open White Spruce	11583	--	750	48000	28	--	--	193	12	--	--	12
Open Black Spruce	33786	357	643	15500	111	1	1	142	3	6	27	8
Woodland White Spruce	57950	100	100	25400	242	<1	<1	167	8	25	51	16
Dwarf Birch	125232	1321	--	10857	860	6	--	84	5	10	--	15
Dwarf Birch-Willow	39833	1500	--	33417	283	11	--	209	6	5	--	8

[a] Begl = Betula glandulosa
[b] Sagl = Salix glauca
[c] Sala = Salix lanata
[d] Sapu = Salix pulchra

TABLE 115

Mean and standard error for variables measured for chemical analysis performed on soil samples collected from 3 sites in the Open White Spruce vegetation type, Alphabet Hills.

	0-5 cm		5-10 cm		10-15 cm	
Soil Variables	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
pH	6.28	0.65	6.45	0.60	6.34	0.46
O.M. (%)	16.71	10.75	11.75	11.27	6.80	5.24
Total Nitrogen (%)	0.58	0.29	0.34	0.29	0.34	0.44
Total Phosphorus (%)	0.09	0.02	0.09	0.01	0.08	0.02
Sand (%)	35.39	9.43	31.51	9.64	34.40	10.66
Silt (%)	47.50	8.05	46.51	8.38	44.63	7.85
Clay (%)	17.47	4.96	22.00	3.27	20.97	5.00
Potassium (ppm)	240.75	300.67	739.67	1197.46	85.13	77.90
Calcium (ppm)	4750.00	3053.98	3315.56	2832.09	3052.50	3585.45
Magnesium (ppm)	618.88	251.39	428.56	335.71	410.50	253.60
Copper (mg/g)	2.54	1.70	2.10	0.86	2.19	0.82
Zinc (mg/g)	4.65	5.14	0.99	0.79	1.03	0.95
Manganese (mg/g)	42.81	53.94	19.36	12.46	22.22	23.10
Iron (mg/g)	201.19	118.51	162.41	66.93	206.99	46.72

TABLE 116

Mean and standard error for variables measured for chemical analysis performed on soil samples collected from 7 sites in the Open Black Spruce vegetation type, Alphabet Hills.

	0-5 cm		5-10 cm		10-15 cm	
Soil Variables	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
pH	5.82	0.62	6.20	0.45	6.31	.52
O.M. (%)	15.19	12.28	8.55	10.41	8.40	8.82
Total Nitrogen (%)	0.55	0.44	0.26	0.31	0.24	0.26
Total Phosphorus (%)	0.09	0.02	0.08	0.02	0.09	0.03
Sand (%)	31.35	12.60	31.49	8.88	31.80	7.14
Silt (%)	44.60	6.09	43.97	8.79	39.44	5.81
Clay (%)	24.05	11.00	24.53	9.56	28.75	6.90
Potassium (ppm)	139.95	134.60	83.30	47.02	76.20	31.02
Calcium (ppm)	2616.36	1762.57	2425.89	2220.47	2359.33	1366.78
Magnesium (ppm)	473.45	283.27	342.47	241.97	394.20	166.92
Copper (mg/g)	2.94	1.54	2.92	1.45	3.07	1.18
Zinc (mg/g)	5.14	6.15	1.32	1.40	0.90	0.76
Manganese (mg/g)	93.18	163.54	35.03	39.70	47.48	23.72
Iron (mg/g)	401.07	276.45	239.45	109.45	222.67	141.60

TABLE 117

Mean and standard error for variables measured for chemical analysis performed on soil samples collected from 5 sites in the Woodland White Spruce vegetation type, Alphabet Hills.

	0-5 cm		5-10 cm		10-15 cm	
Soil Variables	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
pH	6.04	0.27	6.22	0.21	6.24	0.20
O.M. (%)	15.64	9.21	4.32	2.52	2.24	1.75
Total Nitrogen (%)	0.49	0.27	0.15	0.08	0.08	0.05
Total Phosphorus (%)	0.10	0.04	0.08	0.01	0.08	0.01
Sand (%)	34.38	15.84	29.00	11.32	30.60	17.57
Silt (%)	42.71	12.84	45.18	5.52	40.95	9.26
Clay (%)	22.92	9.41	25.82	9.80	28.49	15.45
Potassium (ppm)	471.36	962.69	328.67	557.96	347.10	710.48
Calcium (ppm)	2995.00	1619.04	1642.50	889.05	1414.55	693.29
Magnesium (ppm)	544.50	292.89	332.33	157.49	312.82	134.90
Copper (mg/g)	1.92	1.24	2.12	0.70	2.10	0.90
Zinc (mg/g)	1.51	1.79	0.81	0.60	0.41	0.21
Manganese (mg/g)	25.73	24.05	18.95	17.33	20.19	21.14
Iron (mg/g)	292.14	125.64	200.62	89.27	168.50	113.26

TABLE 118

Mean and standard error for variables measured for chemical analysis performed on soil samples collected from 7 sites in the Dwarf Birch vegetation type, Alphabet Hills.

	0-5 cm		5-10 cm		10-15 cm	
Soil Variables	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
pH	4.66	0.61	5.25	0.61	5.52	0.55
O.M. (%)	16.57	9.12	8.15	7.31	6.24	7.25
Total Nitrogen (%)	0.46	0.24	0.20	0.15	0.16	0.16
Total Phosphorus (%)	0.09	0.02	0.07	0.02	0.07	0.02
Sand (%)	37.00	9.69	29.85	8.85	35.29	10.63
Silt (%)	44.88	10.21	46.45	8.24	44.21	8.52
Clay (%)	18.14	6.26	23.70	10.11	20.50	8.15
Potassium (ppm)	188.26	271.08	55.50	36.72	64.95	93.65
Calcium (ppm)	745.66	766.22	546.82	467.62	868.50	1093.93
Magnesium (ppm)	168.13	153.08	124.59	113.41	159.70	164.90
Copper (mg/g)	0.85	0.63	1.07	0.76	1.17	0.76
Zinc (mg/g)	1.78	4.58	0.40	0.27	0.61	0.92
Manganese (mg/g)	10.22	12.03	9.25	10.32	11.44	12.78
Iron (mg/g)	301.72	91.01	188.70	66.87	197.05	98.14

TABLE 119

Mean and standard error for variables measured for chemical analysis performed on soil samples collected from 3 sites in the Dwarf Birch-Willow vegetation type, Alphabet Hills.

Soil Variables	0-5 cm Mean	0-5 cm Standard Deviation	5-10 cm Mean	5-10 cm Standard Deviation	10-15 cm Mean	10-15 cm Standard Deviation
pH	5.64	0.39	5.87	0.42	6.07	0.38
O.M. (%)	17.02	13.25	10.34	9.67	5.28	6.79
Total Nitrogen (%)	0.60	0.30	0.28	0.23	0.23	0.30
Total Phosphorus (%)	0.10	0.02	0.08	0.02	0.08	0.01
Sand (%)	34.48	9.96	30.00	9.64	30.73	8.00
Silt (%)	44.34	4.87	43.94	5.15	42.34	4.68
Clay (%)	21.18	7.43	26.06	8.65	26.92	5.85
Potassium (ppm)	144.00	56.72	89.90	35.64	74.09	29.36
Calcium (ppm)	2795.45	1278.98	1970.00	760.35	1496.36	571.77
Magnesium (ppm)	578.90	271.56	477.20	202.61	379.18	153.71
Copper (mg/g)	1.25	0.65	1.59	0.93	2.59	1.00
Zinc (mg/g)	1.50	0.91	0.46	0.19	0.55	0.31
Manganese (mg/g)	17.58	12.48	9.67	9.07	15.28	12.15
Iron (mg/g)	352.91	77.56	249.09	73.34	222.53	64.74

TABLE 120

Mean depth to permafrost and depth of organic layer by vegetation type, Alphabet Hills.

Vegetation type	Permafrost (cm) Mean	Permafrost (cm) Standard Deviation	Organic Layer (cm) Mean	Organic Layer (cm) Standard Deviation
Open White Spruce	69	8.3	8.6	6.5
Open Black Spruce	56	21.3	9.0	4.4
Woodland White Spruce	70	12.2	9.6	1.8
Dwarf Birch	72	20.7	7.5	2.4
Dwarf Birch-Willow	82	0.7	8.2	2.2

TABLE 121

Average total nitrogen and phosphorus by vegetation type, Alphabet Hills.

Vegetation type	Total Nitrogen (metric tons/ha)	Total Phosphorus (metric tons/ha)
Open Spruce	7.4[a]	1.7
Woodland Spruce	4.9	1.7
Low Shrub	6.3	1.6

[a] Totals represent soils within the Primary and Secondary burn areas over entire 0-15 cm profile depth.

FIGURE 1

Location of Susitna River Basin and Alphabet Hills study areas in southcentral Alaska.

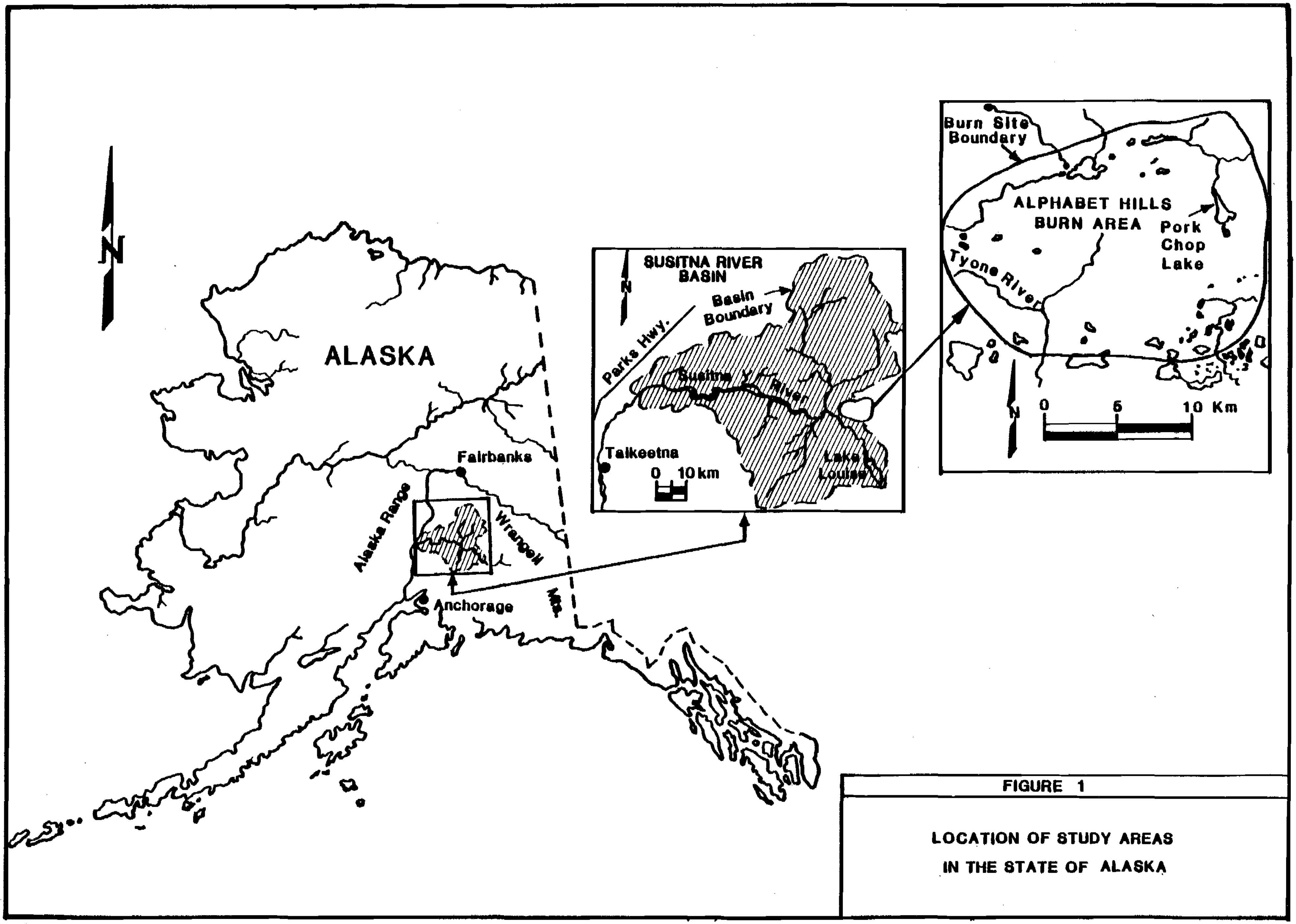


FIGURE 1

LOCATION OF STUDY AREAS IN THE STATE OF ALASKA

FIGURE 2

Location of individual sites from 1982 browse inventory study, middle Susitna River Basin.

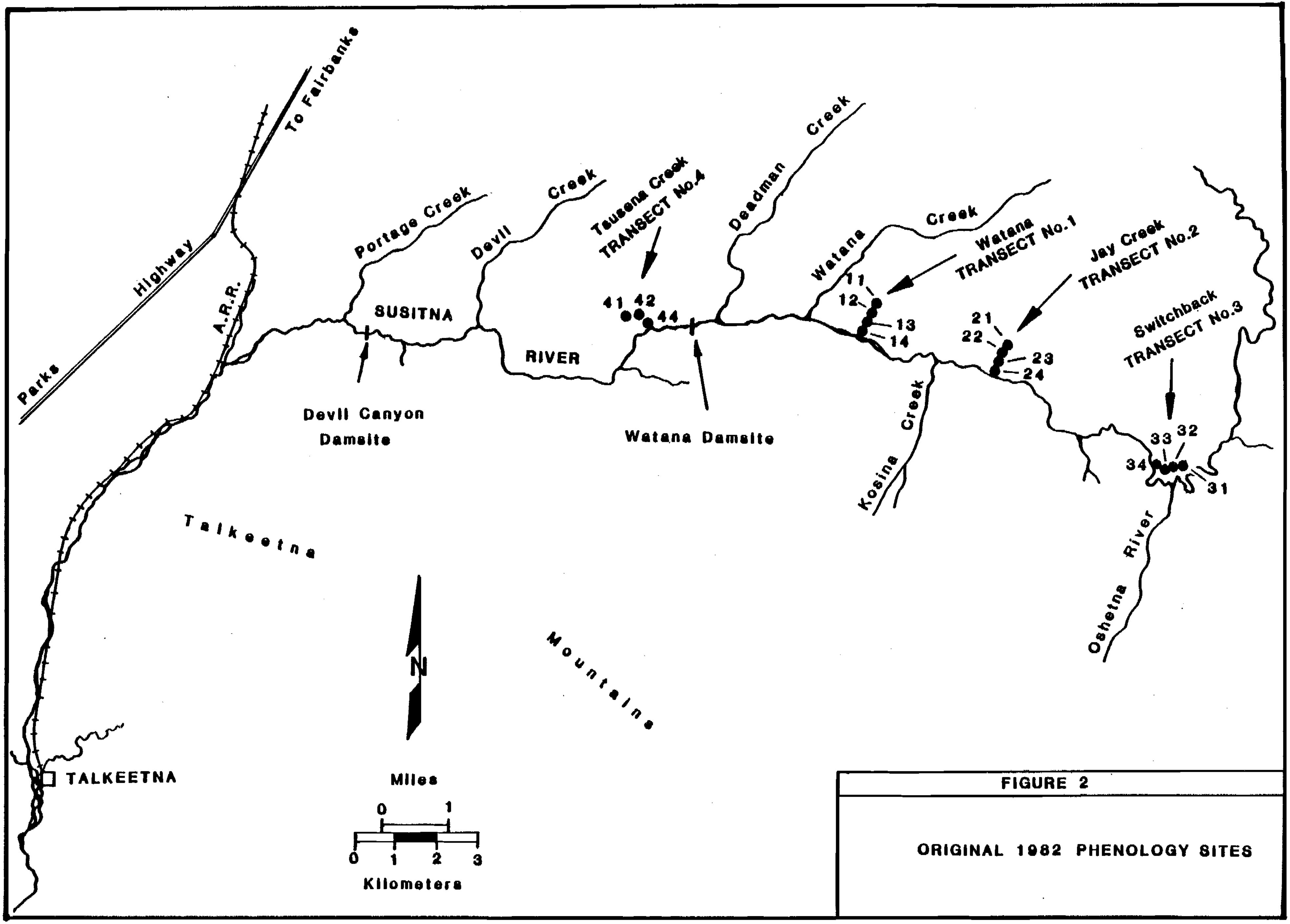


FIGURE 2

ORIGINAL 1982 PHENOLOGY SITES

FIGURE 3

Location of transects for 1982 plant phenology study, middle Susitna River Basin.

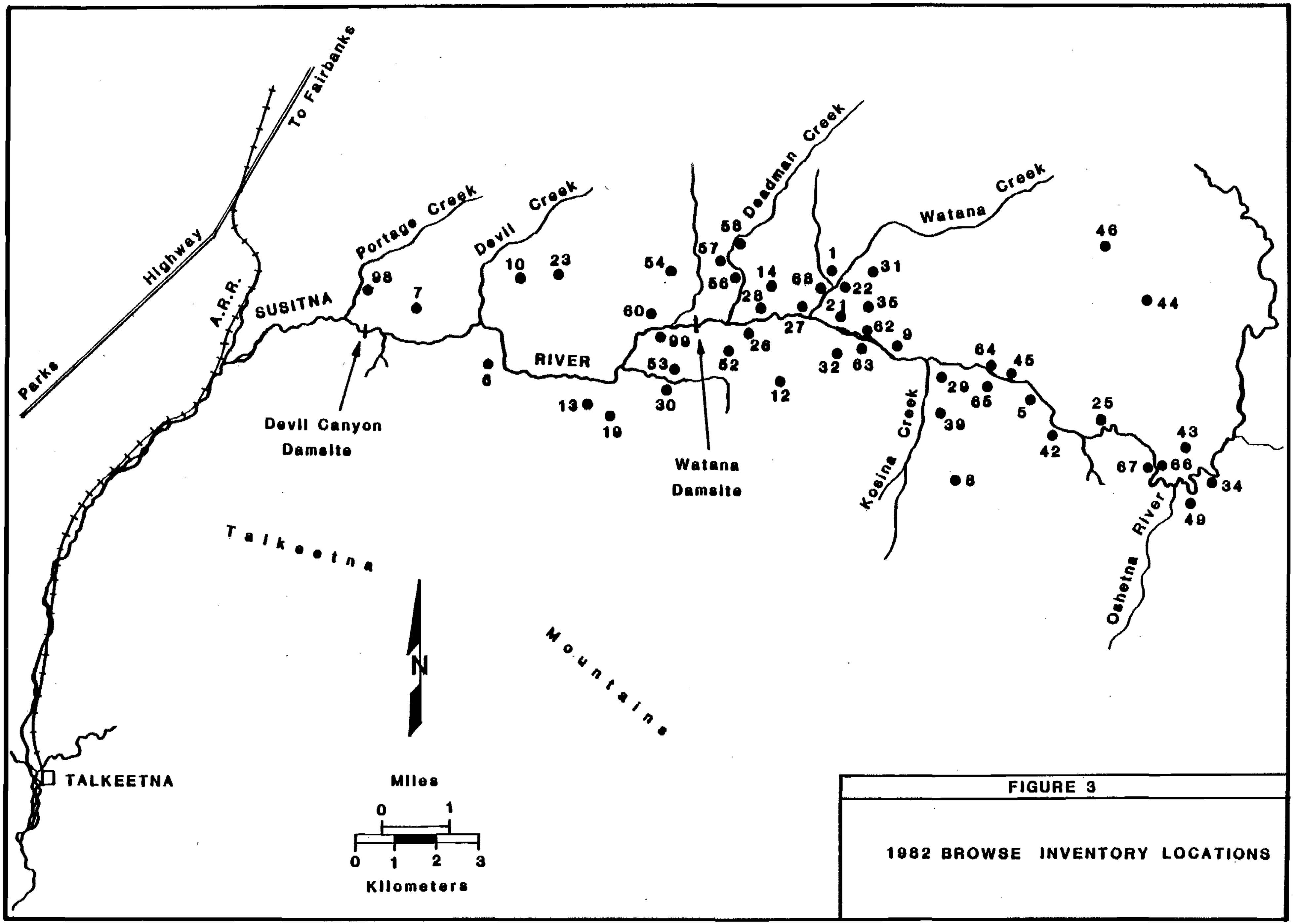


FIGURE 3

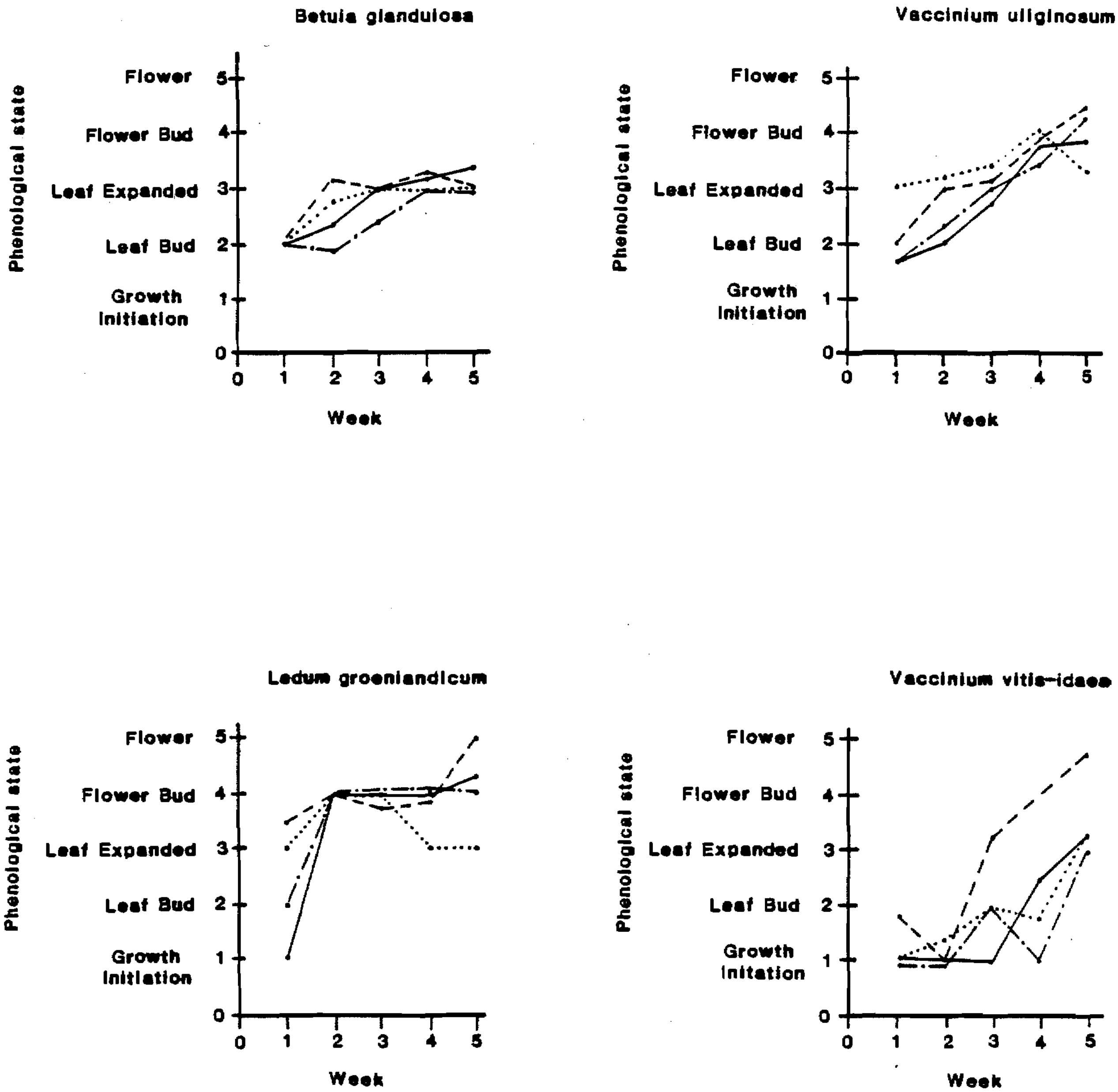
1982 BROWSE INVENTORY LOCATIONS

FIGURE 4

Vegetation map (1:24,000) of 1982 Alphabet Hills pre-burn inventory and assessment study (back pocket) showing primary burn, secondary burn, and control boundaries, southcentral Alaska.

FIGURE 5

Effect of transect location on phenological development of 4 shrub species over weeks with elevation held relatively constant, 1982.



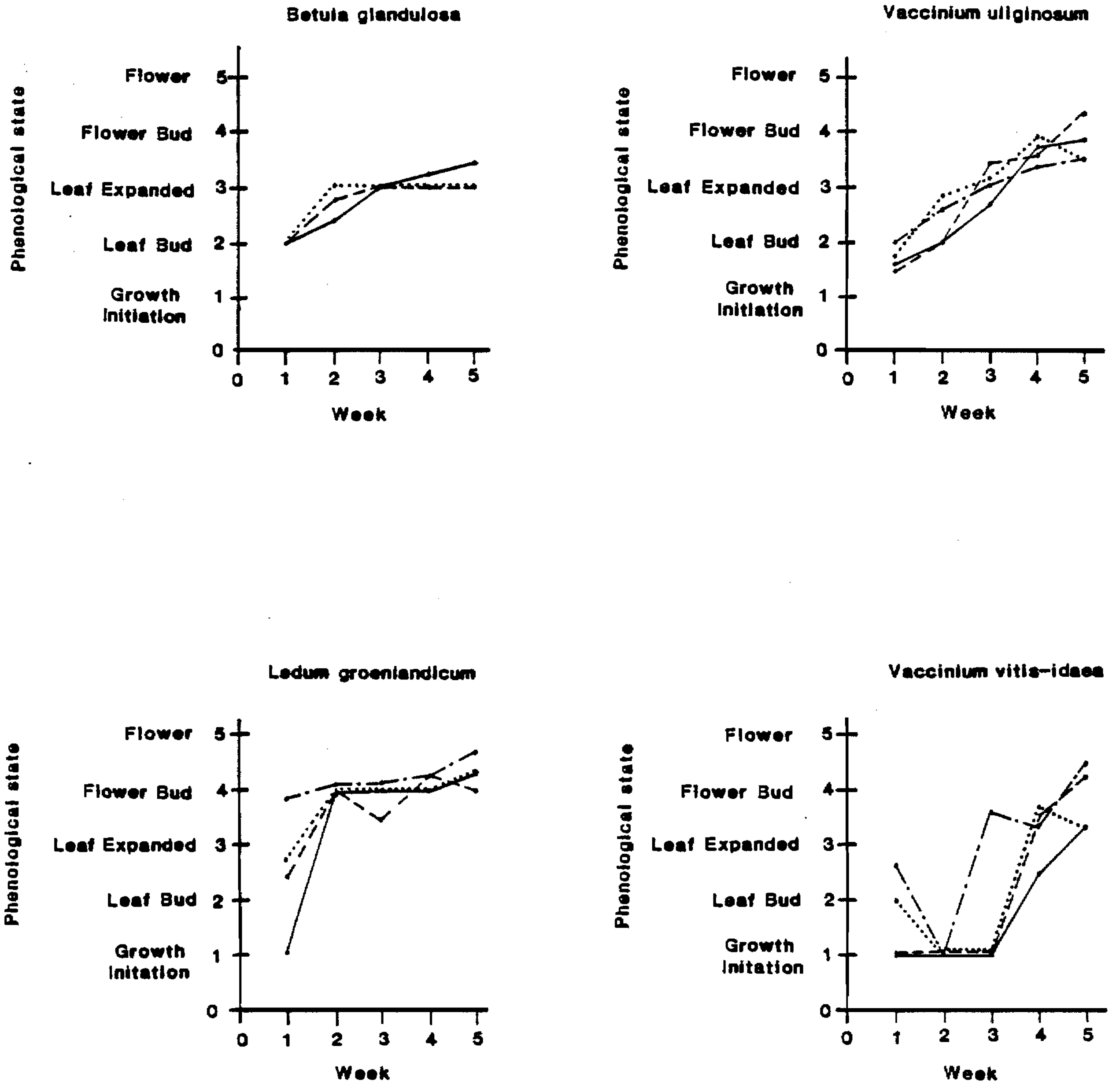
LEGEND

———	Watana Creek	Elevation 1	774 m
– – – –	Jay Creek	Elevation 2	792 m
········	Switchback	Elevation 2	762 m
—·—	Tsusena Creek	Elevation 1	758 m

WEEK	INITIAL DATES
1	31 May
2	7 June
3	14 June
4	21 June
5	28 June

FIGURE 6

Effect of elevation on phenological development of 4 shrub species over weeks on 1 transect, 1982.



LEGEND

Watana Creek Transect

	Elevation 1	774 m
	Elevation 2	683 m
	Elevation 3	610 m
	Elevation 4	549 m

WEEK	INITIAL DATES
1	31 May
2	7 June
3	14 June
4	21 June
5	28 June

FIGURE 7

Mean biomass of forbs and graminoids (kg/ha current annual growth) by week, plant phenology study, middle Susitna River Basin.

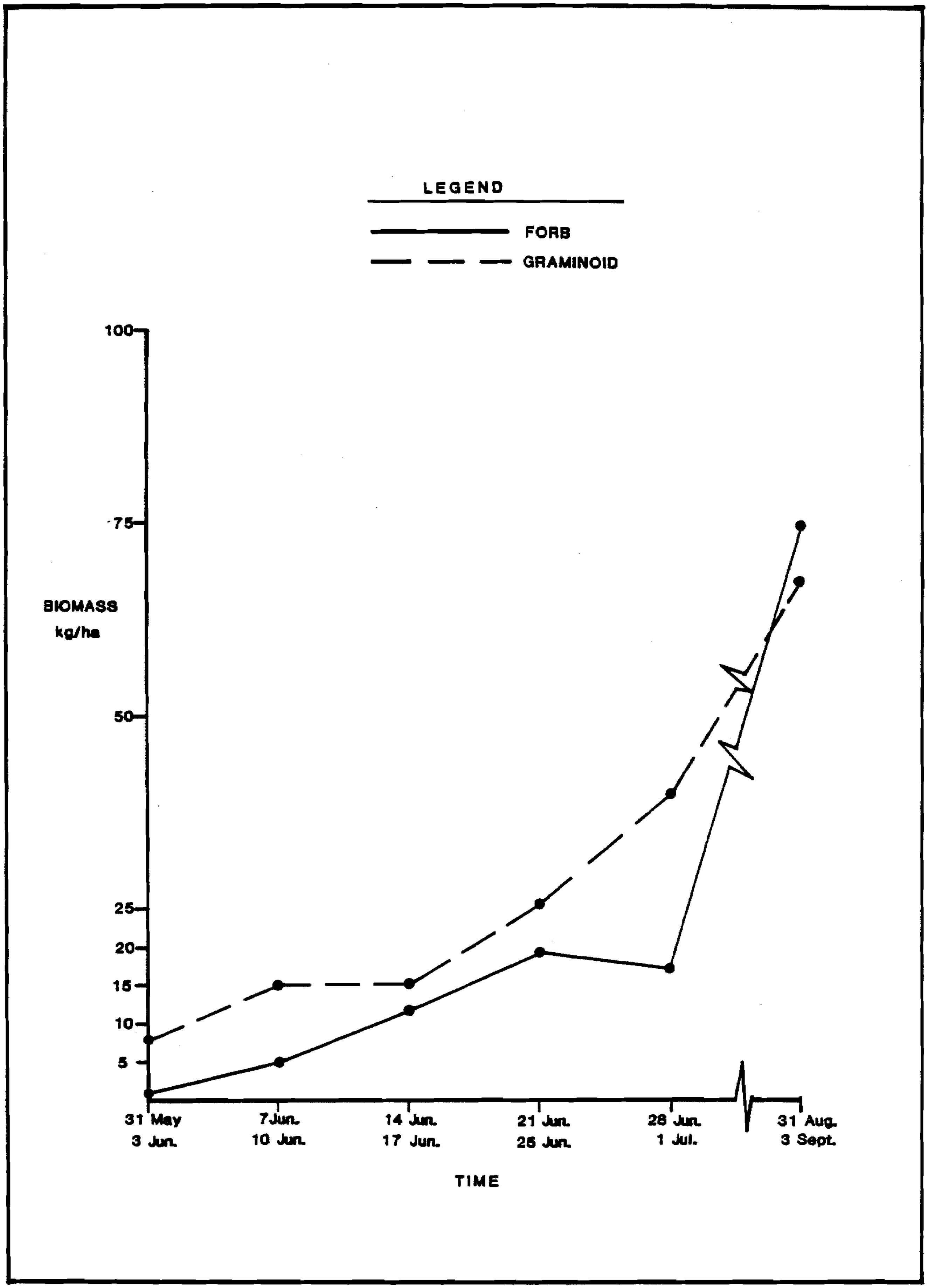

LEGEND
FORB
GRAMINOID
BIOMASS kg/ha
100
75
50
25
20
15
10
5
31 May
3 Jun.
7Jun.
10 Jun.
14 Jun.
17 Jun.
21 Jun.
25 Jun.
28 Jun.
1 Jul.
31 Aug.
3 Sept.
TIME

FIGURE 8

Plot of basal diameter and length of twigs of current annual growth for 5 shrubs, plant phenology study, middle Susitna River Basin.

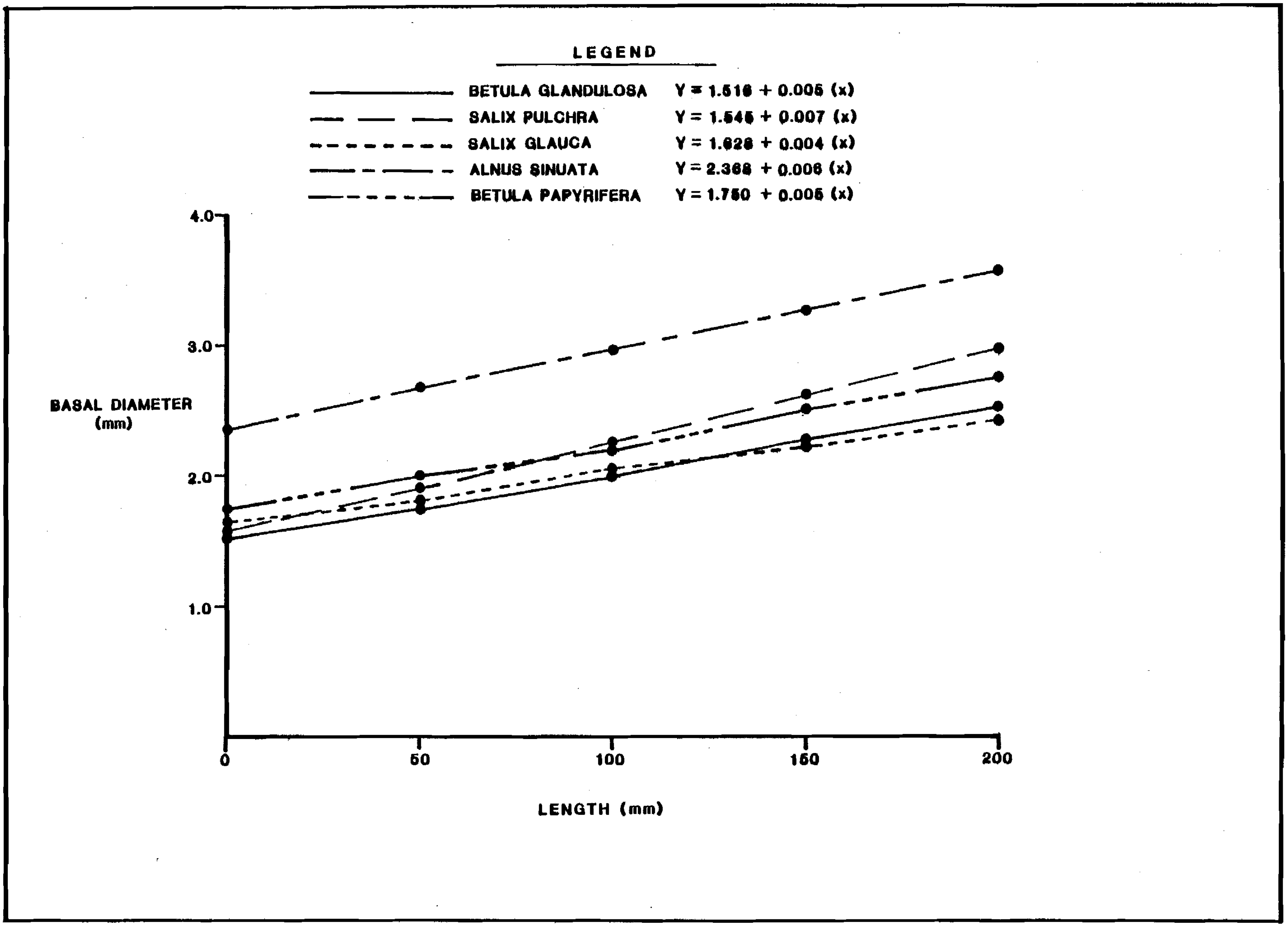

LEGEND
BETULA GLANDULOSA Y = 1.516 + 0.005 (x)
SALIX PULCHRA Y = 1.545 + 0.007 (x)
SALIX GLAUCA Y = 1.628 + 0.004 (x)
ALNUS SINUATA Y = 2.368 + 0.006 (x)
BETULA PAPYRIFERA Y = 1.750 + 0.005 (x)
4.0
3.0
2.0
1.0
BASAL DIAMETER (mm)
0
50
100
150
200
LENGTH (mm)

FIGURE 9

Individual sites of relocated exclosures following 1982 plant phenology study, middle Susitna River Basin.

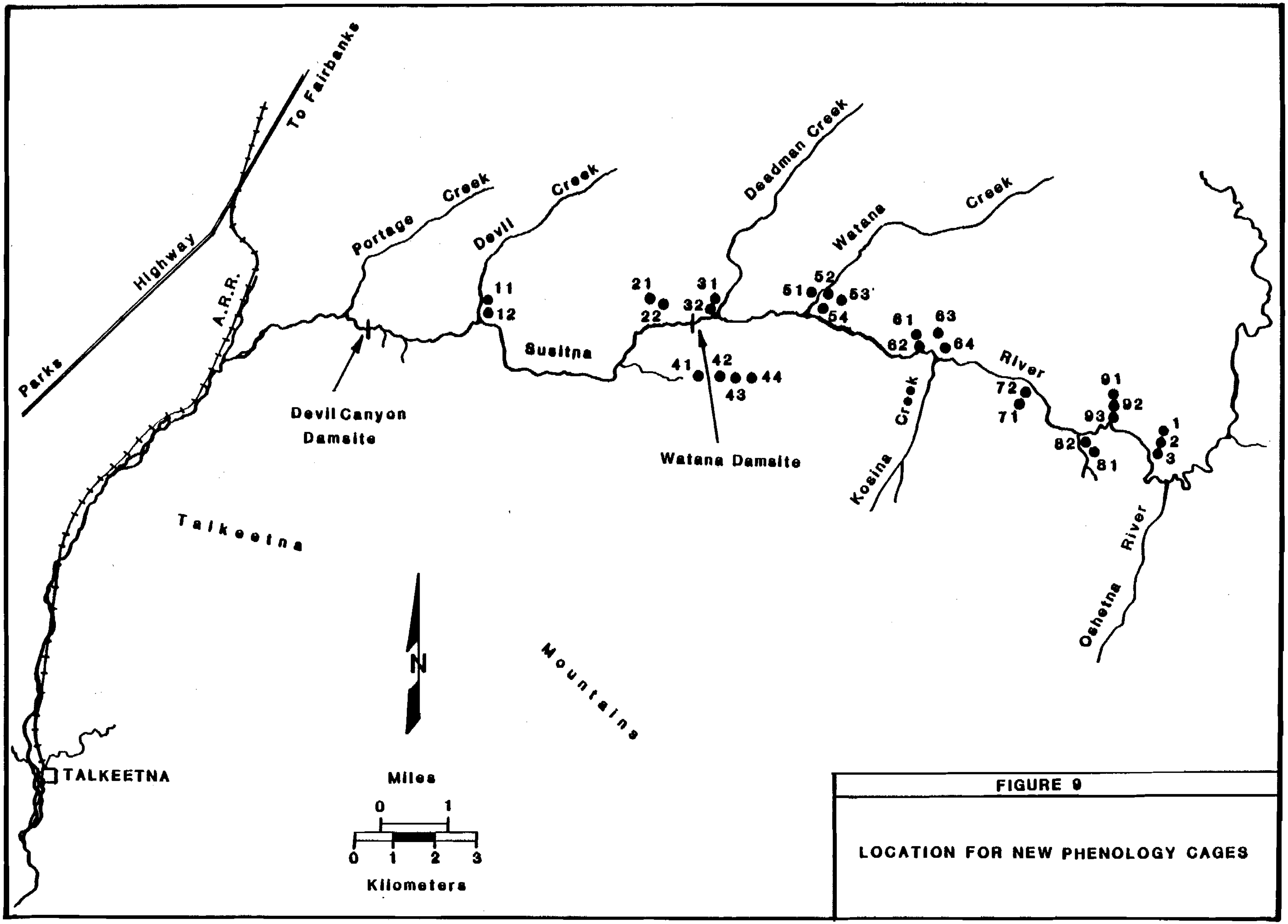


FIGURE 9

LOCATION FOR NEW PHENOLOGY CAGES

FIGURE 10

Location of individual sites from 1982 Alphabet Hills pre-burn inventory and assessment study.

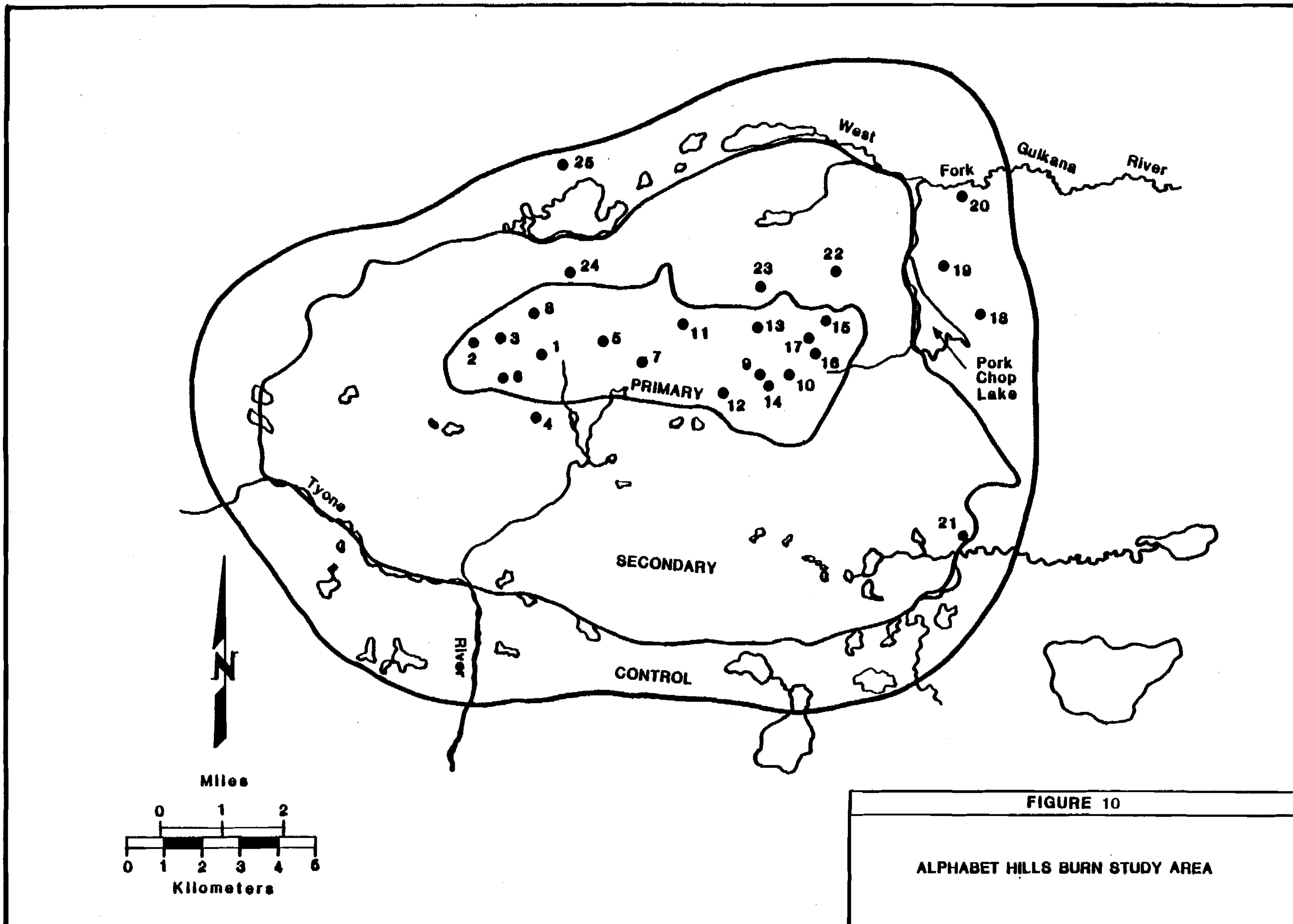


FIGURE 10

ALPHABET HILLS BURN STUDY AREA

APPENDIX A

List of plant species identified during summers of 1980-1982 in the middle and upper Susitna River Basin[a] (U) and downstream floodplain (D). List modified from preliminary list of McKendrick et al. (1982).

Pteridophyta

Aspidiaceae

Dryopteris dilatata (Hoffm.) Gray	Shield fern	U	D
Dryopteris fragrans (L.) Schott	Fragrant shield-fern	U	
Gymnocarpium dryopteris (L.) Newm.	Oak-fern	U	D

Athyriaceae

Athyrium filix-femina (L.) Roth	Lady fern	U	D
Cystopteris fragilis (L.) Bernh.	Fragile-fern	U	
Cystopteris montana (Lam.) Bernh.	Mountain fragile-fern	U	
Matteuccia struthiopteris (L.) Todaro	Ostrich fern		D
Woodsia alpina (Bolton) S. F. Gray	Alpine woodsia	U	

Equisetaceae

Equisetum arvense L.	Meadow horsetail	U	
Equisetum fluviatile L. ampl. Ehrh.	Swamp horsetail	U	
Equisetum palustre L.	Marsh horsetail		D
Equisetum pratense L.	Meadow horsetail	U	D
Equisetum silvaticum L.	Woodland horsetail	U	
Equisetum variegatum Schleich.	Variegated scouring-rush	U	D

Isoetaceae

Isoetes muricata Dur.	Quillwort	U	

Lycopodiaceae

Lycopodium alpinum L.	Alpine clubmoss	U	
Lycopodium annotinum L.	Stiff clubmoss	U	
Lycopodium clavatum L.	Running clubmoss	U	
Lycopodium complanatum L.	Ground cedar	U	
Lycopodium selago L. ssp. *selago*	Fir clubmoss	U	

Thelypteridaceae

Thelypteris phegopteris (L.) Slosson	Long beech fern	U	

Gymnospermae

Cupressaceae

Juniperus communis L.	Common juniper	U	

Pinaceae			
Picea glauca (Moench) Voss	White spruce	U	D
Picea mariana (Mill.) Britt., Sterns & Pogg.	Black spruce	U	
Monocotyledoneae			
Cyperaceae			
Carex aquatilis Wahlenb.	Water sedge	U	
Carex bigelowii Torr.	Bigelow sedge	U	
Carex capillaris L.	Hairlike sedge	U	
Carex canescens L.	Silvery sedge		D
Carex concinna R. Br.	Low northern sedge	U	
Carex eleusinoides Turcz.	Sedge		D
Carex filifolia Nutt.	Thread-leaf sedge	U	
Carex garberi Fern.	Sedge		D
Carex limosa L.	Shore sedge	U	
Carex loliacea L.	Sedge	U	
Carex magellanica Lam. subsp. irrigua (Wahlenb.) Hult.	Bog sedge	U	
Carex media R. Br. ex Richards.	Sedge	U	
Carex membranacea Hook.	Fragile sedge	U	
Carex podocarpa C. B. Clarke	Short-stalk sedge	U	
Carex rhynchophysa C. A. Mey.	Sedge	U	
Carex rotundata Wahlenb.	Sedge		D
Carex saxatilis L.	Sedge		D
Carex spp.	Sedge	U	D
Eriophorum angustifolium Honck.	Tall cottongrass	U	
Eriophorum scheuchzeri Hoppe	White cottongrass	U	
Eriophorum vaginatum L.	Tussock cottongrass	U	
Eriophorum sp.	Cottongrass		D
Scirpus microcarpus Presl.	Small-fruit bullrush		D
Trichophorum caespitosum (L.) Hartm.	Tufted clubrush	U	
Gramineae (Poaceae)			
Agropyron boreale (Turcz.) Drobov	Northern wheatgrass		D
Agropyron caninum (L.) Beauv.	Wheatgrass		D
Agropyron macrourum (Turcz.) Drobov	Wheatgrass		D
Agropyron sp.	Wheatgrass	U	
Agrostis scabra Willd.	Tickle grass	U	D
Agrostis sp.	Bent grass	U	
Alopecurus alpinus Sm.	Mountain foxtail	U	
Arctagrostis latifolia (R. Br.) Griseb.	Polargrass	U	
Beckmannia syzigachne (Steud.) Fern	Slough grass		D
Calamagrostis canadensis (Michx.) Beauv.	Bluejoint	U	D
Calamagrostis purpurascens R. Br.	Purple reedgrass	U	
Cinna latifolia (Trev.) Griseb. in Ledeb	Woodreed		D
Danthonia intermedia Vasey	Timber oatgrass	U	

Deschampsia atropurpurea (Wahlenb.) Scheele	Mountain hairgrass	U
Deschampsia caespitosa (L.) Beauv.	Tufted hairgrass	U D
Festuca altaica Trin.	Fescue grass	U
Festuca rubra L. Coll.	Red fescue	U
Hierochloe alpina (Swartz) Roem. & Schult.	Alpine holygrass	U
Hierochloe odorata (L.) Wahlenb.	Vanilla grass	U D
Phleum commutatum Gandoger	Timothy	U
Poa alpina L.	Alpine bluegrass	U
Poa arctica R. Br.	Arctic bluegrass	U
Poa palustris L.	Bluegrass	U
Trisetum spicatum (L.) Richter	Downy oatgrass	U D

Iridaceae

Iris setosa Pellas	Wild iris	U

Juncaceae

Juncus arcticus Willd.	Arctic rush	U D
Juncus castaneus Sm.	Chestnut rush	U
Juncus drummondii E. Mey.	Drummond rush	U
Juncus mertensianus Bong.	Mertens rush	U
Juncus triglumis L.	Rush	U
Luzula campestris (L.) DC. ex DC. & Lam.	Woodrush	U
Luzula confusa Lindeb.	Northern woodrush	U
Luzula multiflora (Retz.) Lej.	Woodrush	U
Luzula parviflora (Ehrh.) Desv.	Small-flowered woodrush	U
Luzula tundricola Gorodk.	Tundra woodrush	U
Luzula wahlenbergii Rupr.	Wahlenberg woodrush	U

Liliaceae

Lloydia serotina (L.) Rchb.	Alp lily	U
Streptopus amplexifolius (L.) DC.	Cucumber root	U D
Tofieldia coccinea Richards	Northern asphodel	U
Tofieldia pusilla (Michx.) Pers.	Scotch asphodel	U
Veratrum viride Ait.	Helebore	U
Zygadenus elegans Pursh	Elegant death camas	U

Orchidaceae

Listera cordata (L.) R. Br.	Heart-leaved twinblade	U
Platanthera convallariaefolia (Fisch.) Lindl.	Northern bog-orchis	U
Platanthera dilatata (Pursh) Lindl.	White bog-orchis	U
Platanthera hyperborea (L.) Lindl.	Northern bog-orchis	U
Platanthera obtusata (Pursh) Lindl.	Small bog-orchis	U

Potamogetomaceae			
Potamogeton epihydrous Raf.	Nuttall pondweed	U	
Potamogeton filiformis Pers.	Filiform pondweed	U	
Potamogeton gramineus L.	Pondweed	U	
Potamogeton perfoliatus L.	Clasping-leaf pondweed	U	
Potamogeton robbinsii Oakes	Robbins pondweed	U	
Sparganiaceae			
Sparganium angustifolium Michx.	Narrow-leaved burreed	U	
Dicotyledoneae			
Adoxaceae			
Adoxa moschatellina L.	Moschatel		D
Araliaceae			
Echinopanax horridum (Sm.) Decne. & Planch.	Devil's club	U	D
Betulaceae[c]			
Alnus crispa (Ait.) Pursh	American green alder	U	
Alnus sinuata (Reg.) Rydb.	Sitka alder	U	D
Alnus tenuifolia Nutt.	Thinleaf alder		D
Betula glandulosa Michx.	Resin birch	U	
Betula nana L.	Dwarf arctic birch	U	D
Betula occidentalis Hook.	Water birch	U	
Betula papyrifera Marsh.	Paper birch	U	D
Boraginaceae			
Mertensia paniculata (Ait.) G. Don	Tall bluebell	U	D
Myosotis alpestris F. W. Schmidt	Forget-me-not	U	
Callitrichaceae			
Callitriche hermaphroditica L.	Water starwort	U	
Callitriche verna L.	Vernal water-starwort	U	
Campanulaceae			
Campanula lasiocarpa Cham.	Mountain harebell	U	
Caprifoliaceae			
Linnaea borealis L.	Twin-flower	U	
Viburnum edule (Michx.) Raf.	High bush cranberry	U	D
Caryophyllaceae			
Minuartia obtusiloba (Rydb.) House	Alpine sandwort	U	
Moehringia lateriflora (L.) Fenzl	Grove sandwort		D

Silene acaulis L.	Moss campion	U	
Stellaria sp.	Starwort	U	
Wilhelmsia physodes (Fisch.) McNeill	Merckia	U	

Compositae (Asteraceae)

Achillea borealis Bong.	Yarrow	U	D
Achillea sibirica Ledeb.	Siberian yarrow	U	D
Antennaria alpina (L.) Gaertn.	Alpine pussytoes	U	
Antennaria monocephala DC.	Pussytoes	U	
Antennaria rosea Greene	Pussytoes	U	
Arnica amplexicaulis Nutt. ssp. *prima* Maguire	Arnica	U	
Arnica chamissonis Less. (?)	Arnica		D
Arnica frigida C. A. Mey.	Arnica	U	
Arnica lessingii Greene	Arnica	U	
Artemisia alaskana Rydb.	Alaska wormwood	U	
Artemisia arctica Less.	Wormwood	U	
Artemisia tilesii Ledeb.	Wormwood	U	D
Aster sibiricus L.	Siberian aster	U	D
Erigeron humilis Graham	Fleabane daisy	U	
Erigeron lonchophyllous Hook.	Daisy		D
Hieracium triste Willd.	Woolly hawkweed	U	
Petasites frigidus (L.) Franch.	Arctic sweet coltsfoot	U	
Petasites sagittatus (Banks) Gray	Arrowleaf sweet coltsfoot	U	
Petasites sp.	Sweet coltsfoot		D
Saussurea angustifolia (Willd.) DC.	Saussurea	U	
Senecio atropurpureus (Ledeb.) Fedtsch.	Ragwort	U	
Senecio lugens Richards.	Ragwort	U	
Senecio sheldonensis Pors.	Sheldon groundsel	U	
Solidago multiradiata Ait.	Northern goldenrod	U	D
Taraxacum alaskanum Rydb.	Dandelion	U	

Cornaceae

Cornus canadensis L.	Bunchberry	U	D

Crassulaceae

Sedum rosea (L.) Scop.	Roseroot	U	

Cruciferae (Brassicaceae)

Arabis lyrata L.	Rockcress	U	
Cardamine bellidifolia L.	Alpine bittercress	U	
Cardamine pratensis L.	Cuckoo flower	U	
Cardamine umbellata Greene	Bittercress	U	
Draba nivalis Liljebl.	Rockcress	U	
Draba stenoloba Ledeb.	Rockcress	U	
Parrya nudicaulis (L.) Regel	Mustard	U	
Rorippa islandica (Oeder) Borb.	Marsh yellowcress	U	

Diapensiaceae			
Diapensia lapponica L.	Diapensia	U	
Elaeagnaceae			
Shepherdia canadensis (L.) Nutt.	Soapberry	U	D
Empetraceae			
Empetrum nigrum L.	Crowberry	U	
Ericaceae			
Andromeda polifolia L.	Bog rosemary	U	
Arctostaphylos alpina (L.) Spreng.	Alpine bearberry	U	
Arctostaphylos rubra (Rehd. & Wilson) Fern.	Red-fruit bearberry	U	
Arctostaphylos uva-ursi (L.) Spreng.	Bearberry	U	
Cassiope stelleriana (Pall.) DC.	Alaska moss heath	U	
Cassiope tetragona (L.) D. Don	Four-angle mountain-heather	U	
Ledum decumbens (Ait.) Small[c]	Northern Labrador tea	U	
Ledum groenlandicum Oeder	Labrador tea	U	
Ledum sp.	Labrador tea		D
Loiseleuria procumbens (L.) Desv.	Alpine azalea	U	
Oxycoccus microcarpus Turcz.	Swamp cranberry	U	D
Rhododendron lapponicum (L.) Wahlenb.	Lapland rosebay	U	
Vaccinium caespitosum Michx.	Dwarf blueberry	U	
Vaccinium uliginosum L.	Bog blueberry	U	D
Vaccinium vitis-idaea L.	Mountain cranberry	U	
Fumariaceae			
Corydalis pauciflora (Steph.) Pers.	Few-flowered corydalis	U	
Gentianaceae			
Gentiana glauca Pall.	Glaucous gentian	U	
Gentiana propinqua Richards.	Gentian	U	
Menyanthes trifoliata L.	Buckbean	U	D
Swertia perennis L.	Gentian	U	
Geraniaceae			
Geranium erianthum DC.	Northern geranium	U	
Haloragaceae			
Hippuris vulgaris L.	Common marestail	U	

Leguminosae (Fabaceae)

Astragalus aboriginum[b] Richards.	Milk-vetch	U	
Astragalus alpinus L.	Milk-vetch	U	D
Astragalus umbellatus Bunge	Milk-vetch	U	
Hedysarum alpinum L.	Alpine sweet-vetch	U	D
Lupinus arcticus S. Wats.	Arctic lupine	U	
Oxytropis borealis DC.	Oxytrope		D
Oxytropis campestris (L.) DC.	Field oxytrope		D
Oxytropis huddelsonii Porsild	Huddelson oxytrope	U	
Oxytropis maydelliana Trautv.	Maydell oxytrope	U	
Oxytropis nigrescens (Pall.) Fisch.	Blackish oxytrope	U	
Oxytropis viscida Nutt.	Viscid oxytrope	U	

Lentibulariaceae

Pinguicula villosa L.	Hairy butterwort	U	
Utricularia vulgaris L.	Common bladderwort	U	

Myricaceae

Myrica gale L.	Sweet gale	U	D

Nymphaceae

Nuphar polysepalum Engelm.	Yellow pond lily	U	

Onagraceae

Circaea alpina L.	Enchanter's nightshade		D
Epilobium angustifolium L.	Fireweed	U	D
Epilobium latifolium L.	Dwarf fireweed	U	D
Epilobium palustre L.	Swamp willow-herb	U	

Orobanchaceae

Boschniakia rossica (Cham. & Schlecht.) Fedtsch.	Poque	U	D

Polemoniaceae

Polemonium acutiflorum Willd.	Jacob's ladder	U	D

Polygonaceae

Oxyria digyna (L.) Hill	Mountain sorrel	U	
Polygonum bistorta L.	Meadow bistort	U	
Polygonum viviparum L.	Alpine bistort	U	
Rumex arcticus Trautv.	Arctic dock	U	
Rumex sp.	Dock	U	

Portulacaceae

Claytonia sarmentosa C. A. Mey.	Spring-beauty	U

Primulaceae

Dodecatheon frigidum Cham. & Schlecht.	Northern shooting star	U
Primula cuneifolia Ledeb.	Wedge-leaf primrose	U
Primula egaliksensis Wormsk.	Greenland primrose	U
Trientalis europaea L.	Arctic starflower	U D

Pyrolaceae

Moneses uniflora (L.) Gray	Single delight	U D
Pyrola asarifolia Michx.	Liverleaf wintergreen	D
Pyrola grandiflora Radius	Large-flower wintergreen	U
Pyrola minor L.	Lesser wintergreen	U
Pyrola secunda L.	One-sided wintergreen	U D

Ranunculaceae

Aconitum delphinifolium DC.	Monkshood	U
Actaea rubra (Ait.) Willd.	Baneberry	D
Anemone narcissiflora L.	Anemone	U
Anemone parviflora Michx.	Northern anemone	U
Anemone richardsonii Hook	Anemone	U D
Caltha leptosepala DC.	Mountain marsh-marigold	U
Caltha palustris L.	Marsh marigold	U
Ranunculus confervoides (E. Fries) E. Fries	Water crowfoot	U
Ranunculus macounii Britt. (may be *R. pacificus* or something similar)	Macoun buttercup	D
Ranunculus nivalis L.	Snow buttercup	U
Ranunculus occidentalis Nutt.	Western buttercup	U
Ranunculus pygmaeus Wahlenb.	Pygmy buttercup	U
Ranunculus sp.	Buttercup	U
Thalictrum alpinum L.	Arctic meadowrue	U
Thalictrum sparsiflorum Turcz.	Few-flower meadowrue	U D

Rosaceae

Dryas drummondii Richards.	Drummond mountain-avens	U D
Dryas integrifolia M. Vahl.	Dryas	U
Dryas octopetala L.	White mountain-avens	U
Geum rossii (R. Br.) Ser.	Ross avens	U
Luetkea pectinata (Pursh) Ktze.	Luetkea	U
Potentilla biflora Willd.	Two-flower cinquefoil	U
Potentilla fruticosa L.	Shrubby cinquefoil	U
Potentilla hyparctica Malte	Arctic cinquefoil	U
Potentilla palustris (L.) Scop.	Marsh cinquefoil	U D
Potentilla villosa Pall.	Villous cinquefoil	U
Rosa acicularis Lindl.	Prickly rose	U D

Rubus arcticus L.	Nagoon berry	U	D
Rubus chamaemorus L.	Cloudberry	U	
Rubus idaeus L.	Raspberry	U	D
Rubus pedatus Sm.	Five-leaf bramble	U	
Sanguisorba stipulata Raf.	Sitka burnet	U	
Sibbaldia procumbens L.	Sibbaldia	U	
Sorbus scopulina Greene	Western mountain ash	U	
Spiraea beauverdiana Schneid.	Beauverd spirea	U	D

Rubiaceae

Galium boreale L.	Northern bedstraw	U	
Galium trifidum L.	Small bedstraw	U	
Galium triflorum Michx.	Sweet-scented bedstraw		D

Salicaceae[c]

Populus balsamifera L.	Balsam poplar	U	D
Populus tremuloides Michx.	Quaking aspen	U	
Salix alaxensis (Anderss.) Cov.	Feltleaf willow	U	D
Salix arbusculoides Anderss.	Littletree willow	U	D
Salix arctica Pall.	Arctic willow	U	
Salix barclayi Anderss.	Barclay willow	U	
Salix brachycarpa Nutt.	Barren-ground willow	U	
Salix fuscescens Anderss.	Alaska bog willow	U	D
Salix glauca L.	Grayleaf willow	U	
Salix lanata L. subsp. richardsonii (Hook) A. Skwortz.	Richardson willow	U	
Salix monticola Bebb	Park willow	U	
Salix novae-angliae Anderss.	Tall blueberry willow	U	D
Salix phlebophylla Anderss.	Skeletonleaf willow	U	
Salix planifolia Pursh ssp. planifolia	Planeleaf willow	U	
Salix planifolia Pursh ssp. pulchra (Cham.) Argus	Diamondleaf willow	U	
Salix polaris Wahlenb.	Polar willow	U	
Salix reticulata L.	Netleaf willow	U	
Salix rotundifolia Trautv.	Least willow	U	
Salix scouleriana Barratt	Scouler willow	U	
Salix sp.	Willow	U	D

Santalaceae

Geocaulon lividum (Richards.) Fern.	Sandalwood	U	

Saxifragaceae

Boykinia richardsonii (Hook.) Gray	Richardson boykinia	U	
Chrysoplenium tetrandrum (Lund) T. Fries	Northern water carpet	U	
Leptarrhena pyrolifolia (D. Don) Ser.	Leather-leaf saxifrage	U	
Parnassia palustris L.	Northern Grass-of-Parnassus	U	

Parnassia kotzebuei Cham. & Schlecht.	Kotzebue Grass-of-Parnassus	U	
Parnassia sp.	Grass of Parnassus		D
Ribes hudsonianum Richards.	Northern black currant	U	D
Ribes laxiflorum Pursh (may be *R. glandulosum*)	Trailing black currant		D
Ribes triste Pall.	Red currant	U	D
Saxifraga bronchialis L.	Spotted saxifrage	U	
Saxifraga davurica Willd.	Saxifrage	U	
Saxifraga foliolosa R. Br.	Foliose saxifrage	U	
Saxifraga hieracifolia Waldst. & Kit.	Hawkweed-leaf saxifrage	U	
Saxifraga lyallii Engler	Red-stem saxifrage	U	
Saxifraga oppositifolia L.	Purple mountain saxifrage	U	
Saxifraga punctata L.	Brook saxifrage	U	
Saxifraga serpyllifolia Pursh	Thyme-leaf saxifrage	U	
Saxifraga tricuspidata Rottb.	Three-tooth saxifrage	U	

Scrophulariaceae

Castilleja caudata (Pennell) Rebr.	Pale Indian paintbrush	U	
Pedicularis capitata Adams	Capitate lousewort	U	
Pedicularis kanei Durand	Kane lousewort	U	
Pedicularis labradorica Wirsing	Labrador lousewort	U	
Pedicularis parviflora J. E. Sm. var. *parviflora*	Lousewort	U	
Pedicularis sudetica Willd.	Lousewort	U	
Pedicularis verticillata L.	Whorled lousewort	U	
Veronica wormskjoldii Roem. & Schult.	Alpine speedwell	U	

Umbelliferae (Apiaceae)

Angelica lucida L.	Wild celery	U	
Heracleum lanatum Michx.	Cow parsnip	U	D

Valerianaceae

Valeriana capitata Pall.	Capitate valerian	U	

Violaceae

Viola epipsila Ledeb.	Marsh violet	U	
Viola langsdorffi Fisch.	Violet	U	

Nonvascular Plant Species

Lichens

Cetraria cucullata (Bell.) Ach.		U	
Cetraria islandica (L.) Ach.		U	
Cetraria nivalis (L.) Ach.		U	
Cetraria richardsonii Hook.		U	

Cetraria spp.	U	
Cladonia alpetris (L.) Rabenh.	U	
Cladonia mitis Sandst.	U	
Cladonia rangiferina (L.) Web.	U	
Cladonia spp.	U	
Dactylina arctica (Hook.) Nyl.	U	
Haematomma sp.	U	
Lobaria linita (Ach) Rabh.		D
Nephroma spp.	U	
Peltigera aphthosa (L.) Willd.	U	
Peltigera canina (L.) Willd.	U	
Rhizocarpon geographicum (L.) DC.	U	
Stereocaulon paschale (L.) Hoffm.	U	D
Thamnolia vermicularis (Sw.) Schaer.	U	
Umbilicaria sp.	U	
Mosses		
Aulocomium sp.	U	
Climacium sp.	U	
Dicranum sp.	U	
Hylocomium sp.	U	
Hypnum spp. and other feather mosses	U	
Paludella squarrosa (Hedw.) Brid.[d]	U	
Pleurozium sp.	U	
Polytrichum spp.	U	D
Ptilium crista-castrensis (Hedw.) DeNot.	U	
Rhacomitrium spp.	U	D
Sphagnum spp.	U	D

[a] Vascular plant species nomenclature according to Hulten (1968) except where noted. Lichen nomenclature according to Thomson (1979). Moss nomenclature according to Conard (1979).

[b] Nomenclature according to Welsh (1974).

[c] Nomenclature according to Viereck and Little (1972).

[d] Nomenclature according to Crum (1976).

APPENDIX B

List of scientific and common names of plants by life form measured or tabulated in the middle Susitna River Basin and Alphabet Hills during summer, 1982.

Tree:

Betula papyrifera	Paper birch
Picea glauca	White spruce
Picea mariana	Black spruce
Populus balsamifera	Balsam poplar
Populus tremuloides	Quaking aspen

Tall Shrub:

Alnus crispa	American green alder
Alnus sinuata	Sitka alder

Low Shrub:

Betula glandulosa	Resin birch
Betula nana	Dwarf arctic birch
Echinopanax horridum	Devil's club
Potentilla fruticosa	Shrubby cinquefoil
Ribes triste	Red currant
Rosa acicularis	Prickly rose
Salix fuscescens	Alaska bog willow
Salix glauca	Glaucous willow
Salix lanata	Richardson willow
Salix pulchra	Diamond leaf willow
Shepherdia canadensis	Soapberry
Spiraea beauverdiana	Beauverd spiraea
Viburnum edule	High bush cranberry

Dwarf shrub:

Arctostaphylos alpina	Alpine bearberry
Arctostaphylos rubra	Red-fruit bearberry
Arctostaphylos uva-ursi	Bearberry
Cassiope stelleriana	Alaska moss heath
Cassiope tetragona	Four-angle mountain heather
Diapensia lapponica	Diapensia
Empetrum nigrum	Crowberry
Ledum decumbens	Northern labrador tea
Ledum groenlandicum	Labrador tea
Loiseleuria procumbens	Alpine azalea
Salix polaris	Polar willow
Salix reticulata	Netleaf willow
Vaccinium uliginosum	Bog blueberry
Vaccinium vitis-idaea	Mountain cranberry

Forb:

Aconitum delphinifolium	Monkshood
Artemesia spp.	Wormwood
Astragalus spp.	Milk-vetch
Chrysosplenium tetrandrum	Northern watercarpet
Cornus canadensis	Bunchberry
Dryopteris spp.	Shield fern
Epilobium angustifolium	Fireweed
Epilobium latifolium	Dwarf fireweed
Equisetum arvense	Meadow horsetail
Equisetum silvaticum	Woodland horsetail
Eriophorum spp.	Cottongrass
Luetkea pectinata	Luetkea
Linnaea borealis	Twin-flower
Lycopodium spp.	Clubmoss
Mertensia paniculata	Tall bluebell
Petasites frigidus	Arctic sweet coltsfoot
Polemonium spp.	Jacob's ladder
Polygonum bistorta	Meadow bistort
Pyrola spp.	Wintergreen
Rubus arcticus	Nagoon berry
Rubus chamaemorus	Cloud berry
Rumex spp.	Dock
Sedum rosea	Roseroot
Solidago multiradiata	Northern goldenrod
Trientalis europaea	Arctic starflower
Valeriana capitata	Capitate valerian
Viola spp.	Violet

Graminoid:

Calamagrostis canadensis	Bluejoint
Carex spp.	Sedge
Eriophorum spp.	Cottongrass
Hierochloe alpina	Alpine holygrass

Lichen:

Cetraria spp.
Cladonia spp.
Nephroma spp.
Peltigera spp.
Stereocaulon paschale

LEGEND

OS	OPEN SPRUCE	LW	LOW WILLOW	L	LAKE
WS	WOODLAND SPRUCE	MGH	MESIC GRAMINOID HERBACEOUS	▬ ▪ ▬	BOUNDARY OF PRIMARY BURN AREA
LS	LOW SHRUB	DS	DWARF SHRUB	− − −	BOUNDARY OF SECONDARY BURN AREA

ALPHABET HILLS BURN AREA

Agricultural Experiment Station
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SCALE: 1 : 24,000
1 INCH = 2000 FEET

DATE 1982
FIGURE 4