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SUSITNA HYDROELECTRIC PROJECT

ENVIRONMENTAL STUDIES - SUBTASK 7.12

PLANT ECOLOGY STUDIES

PHASE II DRAFT FINAL REPORT

MARCH, 1983

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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 pre-burn inventory and assessment study in the Alphabet Hills of southcentral Alaska.

A total of 47 sites were sampled from July 27 to August 20, 1982, to measure canopy cover shrub stem density, browse utilization, browse availability, and current annual growth biomass for the browse inventory study. The 47 sites were classified and grouped into 10 vegetation types based on Level IV of Viereck et al.'s (1982) vegetation classification system. Five of the sampled vegetation types were forests: Open White Spruce, Open Black Spruce, Woodland Spruce, Open Birch Forest, and Open Spruce-Birch Forest. Five of the sampled vegetation types were scrublands: 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. *Betula papyrifera* and mixed *Picea glauca* - *B. papyrifera* were the dominant trees 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 and stem density in the Dwarf Birch vegetation type of all vegetation types sampled. *Salix pulchra* had low canopy cover and scattered distribution in the Dwarf Birch Type. The Dwarf Birch-Willow vegetation type was only 1 of 2 typ[illegible] [illegible]pled where the low shrub *S. pulchra* had greater canopy cover [illegible]imates than *B. glandulosa*, although stem density estimates remained lower. 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 highest canopy cover and stem density of the vegetation types sampled.

The phenology studies were initiated to evaluate forage availability for cow moose during parturition along the canyon slopes above the middle Susitna River. If this spring forage were 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 herbaceous species from grazing. These exclosures were sampled and the corresponding north-facing slopes were observed at 7-day intervals for phenological development of the vegetation and evidence of moose utilization. These observations were made from 31 May to 2 July 1982. Some general observations were made on a reconnaissance survey 15 and 16 May. Samples were also obtained at the end of the growing season 31 August to 3 September 1982.

Elevation within transect and transect location had a significant effect on soil temperatures, plant canopy cover and current growth during the spring period. However, the effects of elevation were not consistent among transects. On some transects vegetation developed earlier at the bottom-elevation site while on others it matured faster at the middle-slope or at the highest elevations. Vegetation along 1 of the transects developed much later than along any other transect. Timing of vegetation development resulted from an interaction of climate, topography, and site history. Plant species at the same site grew at different rates. Most of the early-developing sites that were studied were above the level of the potential impoundment, but could be influenced by mesoclimatic effects 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 also 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. It was determined that fire could 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.

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2 - INTRODUCTION

During spring, summer, and fall 1982 (31 May through 20 September) the range ecology team of the Agricultural Experiment Station, University of Alaska, Palmer Research Center was involved in 3 studies concerning the Susitna Hydroelectric project. All 3 studies were designed to examine specific parameters of vegetation types as they related to habitat for Alaskan moose (Alces alces gigas) in the middle Susitna River Basin of southcentral Alaska (Fig. 1). Mr. Warren B. Ballard and Dr. Wayne L. Regelin (ADF&G) provided essential information in developing the scope and objectives of these studies. The 3 studies were: 1) a plant phenology - moose utilization study, 2) 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 Institute of Northern Forestry (INF), Fairbanks, and 3) an inventory of available browse and its utilization by moose in the middle Susitna River Basin.

2.1 - Browse Inventory

Browse production and utilization by moose 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 annual standing crop biomass of shrubs, graminoids and forbs. Utilization of shrubs that are presumably the major foods of moose in the middle 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 channel when calving (Ballard et al. 1982) to take advantage of any late winter - early spring growth by herbaceous plants. Energy reserves of moose are probably near depletion by this time. Parturition and lactation further increases 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 (Kcal) 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). However, Tieszen (1974) and Archer and Tieszen (1980) have shown that in arctic areas of Alaska herbaceous plants initiate growth sooner than shrubs. In addition, shrubs such as _Salix_ spp. and _Ledum_ spp. allocate nearly 75% of their nonreproductive, above ground biomass to nonphotosynthetic supportive tissue, whereas graminoids and forbs do not produce any nonphotosynthetic support tissue (Archer and Tieszen 1980). Thus, herbaceous plant production could be critical to moose reproductive success. The plant phenology - moose utilization study was designed to gather information concerning this theory and suggest possible hypotheses for future study. The primary objective of the phenology study was to document use of herbaceous plants by cow moose during spring. A secondary objective was to monitor vegetation development and soil temperature during early spring to determine if plant growth and development in different areas occurred at different times. It was suspected that an elevational gradient in snowmelt, soil temperature, and plant development might exist.

2.3 - Alphabet Hills Pre-burn Inventory and Assessment

The Bureau of Land Management (BLM) proposed a 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) lended support to the need for some type of habitat improvement measure. The fire team of the BLM and USFS was a cooperative effort throughout all phases of planning. The management goal was a discontinuous burn that would create several types of new habitat for moose and could be easily controlled. The area was surrounded by natural water boundaries in most sections that eliminated the need for fire lines. Several points had been selected for ignition by heli-torch. Because of the natural bounderies, little, if any, ground support would be required at the time of the fire. If the fire did not spread as intended, the fire boss would have the option of additional ignition points. Fluorescent pink panels were placed near our study sites so that an ignition could be made near them and insure that some study plots would be burned.

Initially, a secondary burn area was circumscribed by the BLM-USFS fire team. This was the area surrounded by other natural boundaries. Any area in it could conceivably be burned. Later, the fire boss delimited the primary burn area. This was the area expected to carry the fire. Study sites within this area would have a high probability of some impact if the fire burned as expected. Based on similarities in vegetation as determined from color infrared U-2 imagery, the range ecology team delimited a control area that was outside the burn areas. Control sites were placed here since there was little probability of them burning. Most study plots were positioned within the primary burn area because it had the highest probability of being burned. The secondary burn area was intermediate in probability of being burned; thus, only minor work was performed there.

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 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.

The purpose of the Alphabet Hills study was to obtain pre-burn data on composition, distribution, and abundance of the vegetation, litter, and soils in the proposed burn area. The long term objectives of the study are to monitor changes in the vegetation, litter, and soils proceeding the burn and the subsequent response of moose to those changes in vegetation following completion of the burn.

3 - ACKNOWLEDGEMENTS

Dr. Jay D. McKendrick is thanked for his efforts in initiating these studies and completing all the necessary administrative tasks and procurement of supplies. Dr. Wayne L. Regelin and Mr. Warren B. Ballard provided needed information on moose ecology and assisted in determining the objectives of these studies. L. Werner and R. Crane assisted in summer field sampling. G. Covey and O. Logsdon organized logistic support for field operations while at Watana base camp. Helicopter pilots J. Connor, J. Abshire and J. 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. D. Murray of the University of Alaska for his help with species identification and verification of some 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 McLaren 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 McLaren 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 receded. 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 (Picea glauca) forests on well-drained slopes, and black spruce (Picea mariana) forests at the wettest sites. Alpine tundra exists at the highest elevations.

4.1.1 - Plant Phenology Transect, Specific Site Descriptions

4.1.1.1 - Watana Creek Transect

The bench location upstream from the Watana Creek transect (Fig. 2) 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 dominated the low shrub layer while Ledum groenlandicum, Vaccinium uliginosum, and V. vitis-idaea 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.

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. Moss provided about 65% ground cover. The mean age of 3 P. 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 important at the south-facing exclosure while B. glandulosa was more important on the west-facing exclosure. Moss formed 90% of the ground cover. Trees averaged 62 years (4 individuals) 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 549m (1000 ft) placed it in the potential impoundment zone. The most important understory vegetation included L. groenlandicum and V. vitis-idaea, but Rosa acicularis 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. It was the only bottom site positioned on a slope and it had the warmest soil temperatures of any transect. These three facts (younger, greater degree of slope, and warmer) are probably related more to disturbance due to fire at this site than bottom sites on other transects. The ages of these bottom locations may have been biased by transect location since we chose areas where helicopters could land near the river.

4.1.1.2 - Jay Creek Transect

The Jay Creek transect started at a higher elevation than any other transects at 884 m (2900 ft) (Fig. 2). The bench location was actually on a slope below an almost barren outcropping. It was a low birch shrub scrub type with a 10° slope and 176° aspect. The low shrub layer was formed by B. glandulosa and the dwarf shrub layer by L. decumbens and V. vitis-idaea.

Caribou were observed browsing in the area, and B. glandulosa had been browsed. 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. It was at 792 m (2600 ft) on a 5° slope with 144° aspect. It contained a low shrub layer of B. glandulosa and a dwarf shrub layer of L. decumbens and V. vitis-idaea. Betula glandulosa usually occurred on mounds with other species growing beneath the shrub layer. Most trees at this site averaged 31 years of age although 1 tree 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 microclimatic changes associated with the reservoir. The exclosures were placed on either side of an open, grassy area but were 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 old, making it one of the youngest sites. It also appeared to be the warmest site, as indicated by plant species composition and the time at which growth was initiated.

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 was facing south-southeast and the other was facing 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, E. nigrum, and graminoids. Moss cover was variable. Mean age of 4 trees was 146 years, the oldest average of any site.

4.1.1.3 - Switchback Transect

The bench location along the Switchback site (Fig. 2) 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. decurbens, 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 just before it broke toward the river at an elevation of 762 m (2500 ft), 96 m above the potential Watana impoundment. It 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 outcropping. 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 individual was estimated to be 210 years old. This was more evidence of disturbance, probably fire, in the area.

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 lost by inundation. This moist location had Alnus sinuata, Ribes triste, and several forb species. Mean age of 5 trees was 143 years, making it one of the oldest sites sampled.

4.1.1.4 - Tsusena Creek Transect

The transect downstream from Tsusena Creek was the only one in the potential Devil Canyon Impoundment area (Fig. 2). 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. Important vegetation consisted of B. 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 on other sites. Average age of 3 trees was 114 years while 1 individual was 56 years old. This site did not appear to have been disturbed as recently as other sites and appeared to be well above the current forest 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 as thick here as on the bench site. Average age of 4 trees was 87 years.

The bottom location was an open spruce type with 2° slope and aspects of 5° and 140° at an elevation of 512 m (1680 ft). The 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 tree individuals was 135 years.

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

McLaren and Susitna Rivers (Fig. 1). The Alphabet Hills are a gently sloping, elevated ridge (6400 m) surrounded by lowland areas with numerous lakes and ponds. Major vegetation types are shrub land 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 browse and herebaceous plant for vegetation types in the middle Susitna River Basin (Fig. 3). Thirty-nine sites were randomly selected by overlaying a grid on a vegetation map (McKendrick et al. 1982) of the area. Selection of sites was arbitrarily limited to those occurring within approximately 16 km (10 miles) of the proposed dam impoundments. However, because the immediate impoundment area was relatively small in relation to that portion of the middle Basin under consideration, 8 sites were sampled near the locations of the 4 1982 phenology transects (Fig. 2). A browse inventory site was also situated on opposing slopes of the phenology transects at approximately mid-slope, in the vegetation type representative of each area.

Browse inventory sites were occularly classified in the field to Levels IV or V of Viereck et al. (1982). Several sites were later adjusted to different, or new, Level V classifications based on results of preliminary analysis. Some vegetation types were sampled more intensively than others. This was based partially on land area occupied by that vegetation type and also on their suspected importance to moose. Several prospective sites originally selected using the grid overlay were omitted from the final selection of sites so as to not over-sample in vegetation types that were considered of lesser importance to moose: e.g. mat and cushion tundra, sedge grass tundra, mat and cushion-sedge grass tundra and alpine herbaceous tundra vegetation types.

At each browse inventory site, 3 parallel 50-m line transects were established from a randomly chosen point. The transects were spaced from 10 to 20 m apart; the distance between transects was adjusted from site to site in an effort to keep all transects within the confines of 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 perpendicular parallel to the direction of travel. Percent canopy cover of understory plant species and trees $\leq$1.13 m in height (breast height) was occularly estimated using 5% cover increments if plant cover was between 10 to 90% (10,15,20,...,90%) and 1% cover incremets in the 1 to 9% and the 91 to 100% 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 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 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. Most tree canopy estimates were taken from a combination of occular estimations using aerial photographs, aircraft overflight, 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 overlapping between quadrats that were spaced at 10 m intervals along the line transect and to expedite sampling time and decrease search time for shrubs with low densities.

Only shrubs with stems 40 cm or taller were considered for measurement. Again an arbitrary limit, that was determined by our observations to be the approximate lower limit of much of the browsing pressure incurred by the low shrubs during winter. This height limitation was designed to approximate "typical" snow cover during winter when most of the twigs below 40 cm would be unavailable for browsing.

The basal diameter at approximately 5 cm from ground level of each nearest shrub stem was also measured. 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 covered. 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 middle Susitna River Basin by randomly measuring twigs that had been previously browsed at a number of sites and locations over the study area.

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 1-2 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 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.

5.1.4 - 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° 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 biomass removed when twigs were browsed by moose. 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. 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.

5.1.5 - 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 determine dry weight biomass.

Estimates of dry weight biomass were for all 1982 growth to ground level of forb and graminoid life form totals. The dry weight biomass estimates of shrubs was CAG woody stems, and CAG leaves that were attached to CAG woody stems. CAG leaves attached to previous years' woody stems were not collected. CAG for shrubs was collected over the entire height of plants 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 in each vegetation type was also calculated. Estimated sample size to within 20% of the mean with 67% confidence was used as the criteria.

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

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 numbers 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.

Ecologically, it was felt that if we were right 2 times out of 3 that the error was acceptable, hence the 67% confidence level was chosen. Sampling to within 20% of the mean for small averages meant that if the calculated mean was 1% cover, we would sample for a confidence interval of 0.8 to 1.2%. Realistically, if the cover is 1%, we would probably be satisfied to know that it is 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. The several measurements, the upper limit selected for "small" values, and the absolute value for differences were as follows:

Canopy cover	%	25	5
DPB	mm	5	1
Twig counts	#	5	1
Utilization	%	5	1
Distance	m	5	1

Canopy cover was analyzed this way for all studies. Currently the other parameters are analysed this way only for the Alphabet Hills burn. Percent of the mean is used in these other cases.

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. 2). Locations were chosen to represent areas of use and non-use by radio-collared moose during April and May, the usual month of parturition (Ballard et al. 1982). It was recognized that nonradio-collared moose might be using areas not indicated as being used by radio-collarad moose as described by Ballard et al. (1982). However, this was the best approximation available for an experimental design. Areas of "usage" and "non-usage" were included in the design to attempt to identify differences in vegetation that might be attracting cow moose to the areas where they concentrate. 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 transects east of Jay Creek represented areas of little or no usage by radio-collared moose during parturition. Transects east of Watana Creek were used by radio-collared moose on the south slope but not on the north. 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.

Four elevations for each study area were selected along each of the 4 transects except transect 4 where only 3 elevations were selected. 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 (#4) prevented helicopter access either by landing or by dropping a sling load of fencing materials. Terrain was too rough and vegetation too dense to reasonably hand-carry the materials to an appropriate location, therefore no exclosures were constructed there.

Exclosures were constructed in vegetation typical of each elevation and transect. Some exclosures were located in pure vegetation types, such as low shrub scrub, while others were located along ecotones because moose frequently use these transition edges of vegetation types. The exclosures were always constructed at some distance away from the helicopter access area.

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 exactly 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 wildlife utilization. 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.

5.2.2 - 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 so that phenological development of plant species could be followed. Individual twigs of shrubs that were in a good photographic position were flagged and photographed each week outside some exclosures so development of an individual twig could be tracked. Species selected for individual tagging were Betula glandulosa, Ledum groenlandicum, and Rosa acicularis. Selection of particular individuals was arbitrary.

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 thermometer was allowed to equilibrate in the ground while plant canopy cover was estimated. Soil temperatures were used to monitor the warming of a site in the spring. Soil temperatures were used because daily ambient temperatures were extremely variable.

5.2.4 - Canopy Cover

Percent canopy cover was occularly 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. These 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 where possible, 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
	(2) leaf buds
	(3) leaves
anthesis	(4) flower buds
	(5) flowers
fruiting	(6) seeds
	(7) decadent
	(8) (unused)
quiesience	(9) dormant

In some evergreen species, such as *Vaccinium vitis-idaea*, it was extremely difficult to tell when the plant initiated new growth in the spring. Hence, some stages for some species were arbitrary.

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 CAG data set.

The scope of biomass estimations in the phenology study were 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 CAG 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 TCAG data set.

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

Statistical analysis of the plant current growth biomass data for the phenology study consisted of analysis of variance using a nested design for both CAG and TCAG data sets. Transect location was treated as the main effect. Elevation was nested within site, and exclosure as well as week were nested within elevation. This design applied to the CAG data, weeks 1 through 6 outside the exclosures. For data collected during week 6 (CAG and TCAG inside and outside) the nested design was similar as described above, except that inside - outside exclosure comparisons were nested within elevation. 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 present were clipped from the 0.5-m^2 plots of the phenology study. The twigs were clipped at the leafbud scale so as to only take 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 of sampling. The basal diameter and total length of each twig was measured to the nearest tenth millimeter with calipers.

A mean diameter and length was calculated for each species and tested for significant differences among species with t tests. Simple linear regression equations were calculated 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 10% of the mean with 95% 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. Some areas appeared to be more recently disturbed by fire than others. This data was collected to age the present plant community at each site. 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.

5.2.9 - Statistical Analysis

Data 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 represented something specific, rather than a random sample of a population. Each transect represented either presence or absence of moose. Each elevation was a particular location with respect to slope. Exclosures and plots were random since they 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.

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.

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 measures 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 as to protrude 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 to the top of the tripod was wired a metal tag identifying the site.

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, grasses and carices, bryophytes, and lichens as well as litter, dead wood, bare ground, and water were occularly 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.

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 occularly 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 and the appropriate counts made. 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 *Salix* spp., *Alnus* spp., and *Betula* 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. Shrubs had to be at least 40 cm in height (average snow depth) to be sampled. The number of live and dead browsed and unbrowsed 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 previously browsed at a number of sites and locations 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 diameter at point-of-browsing 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 diameter (mm) at point-of-browsing (DPB) (determined by measuring at least 100 browsed twigs of each species), 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 vegetation types of all the variables measured as was done for the Susitna Basin browse inventory study. 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 plant species or life form totals with a mean >1 were presented.

6 - RESULTS AND DISCUSSION

Average diameter at point-of-browsing (DPB) measurements for shrub species in the middle Susitna River Basin are shown in Table 2. A. sinuata, B. papyrifera and S. glauca DPB measurements all averaged 3.5 mm. Individual DPB measurements often exceeded these average values. This was particularly evident for some S. 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 highest for A. sinuata (Table 2). 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 well into winter.

Eleven new vascular plant species (Table 1) were added to the species list compiled by McKendrick et al. (1982) (Appendix A). Two were downstream species that have been identified since the last report. Eight new species were located upstream during the phenology study while 1 new species was found during the browse inventory study. At twelfth species, Ribes hudsonianum (northern black current), had been found downstream previously. It has now been identified upstream also. A total of 288 species have been found during vegetation studies on the Susitna River project. This includes a total of 57 families and 143 genera. Two hundred sixty-five species in 56 families and 136 genera have been identified upstream. Several of these species were not found previously because field work had not started as early as May in the past.

Range extensions for 2 more 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 Additonally, 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.

6.1 - Browse Inventory

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. Only plant species or life form totals with a mean ≥ 1 were presented.

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% of the 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 P. glauca (white spruce) or P. mariana (black spruce).

6.1.1.1.1. - Open White Spruce Vegetation Type

Six sites were sampled in the Open White Spruce vegetation type. The Open White Spruce type contained Picea glauca as the dominant overstory tree, although P. mariana was often present. The tall shrub layer was composed entirely of Alnus sinuata (Sitka alder) while the low shrub layer had small cover percentages of Betula glandulosa (resin birch), Salix pulchra(diamond leaf willow) and S. glauca (glaucous willow) (Tables 3 and 4). Canopy cover percentages for both tall and low shrubs were very similar between the 0.5-m^2 quadrat (Table 3) and the larger 4-m^2 quadrat (Table 4). The low shrubs Rosa acicularis (prickly rose) and Viburnum edule (high bush cranberry) were not sampled in the 4-m^2 quadrats (Table 4). The dwarf shrub layer totaled 34% cover, dominated by Vaccinium uliginosum(bog blueberry) and V. vitis-idaea (mountain cranberry) (Table 3). 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 3). 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 needleleaf forest types sampled in the middle Susitna River Basin (Table 5). Approximately 93% 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 6. 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 5). 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 6).

Total available biomass of twigs and leaves for shrub species in the Open White Spruce vegctation type is shown in Table 7. Total available woody twig biomass totaled 216 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, however, show slightly higher utilization for A. sinuata (5%) than for S. pulchra (4%) (Table 6), which was probably the most preferred browse species measured in the Open White Spruce type. The 3 Salix spp. composed 39% of the total available twig biomass and

44% of the total available leaf biomass (Table 7). Salix glauca had higher estimates of both available and utilized biomass than S. pulchra.

Average current annual growth (CAG) of forbs for the 6 sites in the Open White Spruce vegetation type was 136 kg/ha (Table 8). Leaf CAG was from 2 to 5 times higher in weight than the twig CAG to which they were attached. Alnus sinuata, R. acicularis and S. glauca produced from 10 to 22 kg/ha of leaf CAG biomass. Alnus sinuata also produced the greatest twig CAG biomass (13 kg/ha), while 7, 5, and 3 kg/ha of twig CAG biomass were produced by S. glauca, B. glandulosa, and S. pulchra, respectively (Table 8). Approximately 35 kg/ha of twig CAG and 76 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 9 and 10) was similar to the understory of the Open White Spruce vegetation type (Tables 3 and 4) for both species composition and percent canopy cover. Alnus sinuata was the only tall shrub sampled in the Open Black Spruce vegetation type (Tables 9 and 10). Betula glandulosa and S. pulchra had the highest canopy cover in the low shrub layer while V. uliginosum and E. nigrum (crowberry) had the highest 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 Picea 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 9 and 3).

Total average moss cover was higher in the Open Black Spruce type than in the Open White Spruce vegetation type (Tables 9 and 3). 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 9).

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 11). Over 97% of B. glandulosa stems and 62% of S. pulchra stems were ≤ 1 cm in basal diameter. Betula glandulosastem densities in this size class averaged approximately 4 stems/m^2 in the 10 sites samples 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 11 and 5).

The average basal diameter of B. glandulosa shrubs was smaller in the Open Black Spruce vegetation type (Table 12) than in the Open White Spruce vegetation type (Table 6). This was partially explained by the high density of 0-1 cm size class stems in the Open Black Spruce vegetation type (Table 11). Both S. glauca and S. pulchra twigs were utilized in the Open Black Spruce type utilizeu 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 13). Available woody biomass of S. pulchra was over 3 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 biomass use estimates in the Open Black Spruce vegetation type (Table 13). This difference was due largely to greater stem densities of Salix pulchra in the Open Black Spruce type (Tables 11 and 5). Betula glandulosa and S. pulchra produced the most biomass, together comprising 67% of the total available biomass.

Total forb CAG was approximately 18% lower in the Open Black Spruce type than the Open White Spruce type (Table 14). However, total graminoid CAG was 2.5 times greater in the Open Black Spruce type (Tables 14 and 8). Salix pulchra and B. glandulosa had the highest leaf CAG production (Table 14). Total leaf CAG for tall and low shrubs was 69 kg/ha and twig CAG totaled 34 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 closely 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. marian[illegible] [illegible] P. glauca in the overstory (Tables 15 and 16). The average pe[illegible]rt 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 15). 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 15 and 9). Canopy cover of lichens, particularly Cladonia spp., was higher 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 17). 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 this smallest basal stem size class (Table 17).

Percent utilization of S. pulchra, S. glauca and A. sinuata twigs was substantially greater in the Woodland Spruce vegetation type (Table 18) than either the Open White Spruce (Table 6) or Open Black Spruce (Table 12) 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 produced approximately 78% of the total available biomass in the Woodland Spruce vegetation type (Table 19). Salix pulchraproduced only 27 kg/ha of woody twig biomass which would be available as winter browse. Low stem densities (Table 17) and 30% utilization of S. pulchra twigs (Table 18) 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 20). 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) comprised 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 in the Open Birch Forest vegetation type (Tables 21 and 22). Below a B. papyrifera overstory, nearly 50% of the understory vegetation was composed of forbs (Table 21). 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 absent in the Open Birch Forest vegetation type (Tables 21,22 and 23). Very low densities of B. glandulosa, all with small basal diameters, were found in the 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 23). 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 24). 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 25). However, utilization of A. sinuata was almost non-existent for the 48 stems sampled in this type (Table 24), 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 21), averaging 578 kg/ha CAG biomass (Table 26). 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 21). 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 26).

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 P. glauca and B. papyrifera in the 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 L. groenlandicum were common understory shrub species (Table 27). These low shrub species were not sampled in the 4-m^2 quadrats (Table 28). Epilobium angustifolium, Mertensia paniculata, and Cornuscanadensis were the dominant forbs (Table 27). Linnaea borealis was found in the Open Spruce-Birch Forest vegetation type in approximately the same cover percentages as in the Open White Sprice 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 27 and 21). 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 29).

Total forb CAG biomass in the Open Spruce Birch Forest vegetation typewas approximately half as abundant in the Open Spruce Forest, averaging 284 kg/ha (Table 30). Populus balsamifera (balsam poplar) had 6 kg/ha and R. 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 30).

6.1.2 - Scrub

6.1.2.1 - Low Shrub Scrub

Low shrub scrub vegetation was composed of 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 18 sites sampled in the Dwarf Birch vegetation type (Tables 31 and 32). 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 31). Total lichen cover was 21%, 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 31).

The greatest density of B. glandulosa stems of all vegetation types sampled was in the Dwarf Birch vegetation type (Table 33). 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 76,435 stems/ha for all size classes combined yielded about 8 stems/m^2, most of which were about 60 cm in height. S. pulchra occurred as scattered shrubs subdominant to B. glandulosa.

Betula glandulosa occurred in 84% of 1,032 quadrants in the Dwarf Birch vegetation type but received only very light utilization (Table 34). Approximately 25% of the quadrants for the 18 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 (Tables 34 and 33) precluded an accurate assessment of the importance of that species as forage.

By far the dominant shrub species with browsable forage for moose in Dwarf Birch vegetation types was B. glandulosa, totaling 540 kg/ha in available twig biomass alone (Table 35). However, only an average of 2% of B. glandulosa twigs were utilized over the 18 sites samples in this type (Table 34). This low utilization of B. glandulosa as forage is probably due to the relatively large amount of area dominated by this species (33,549 ha) (McKendrick et al. 1982) and relatively low palatability of the species. However, B. glandulosa might function as back-up forage for 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 36). Total leaf CAG for the 2 low shrub species was 66 kg/ha while total twig CAG biomass was 37 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 2 sites sampled in the Dwarf Birch-Willow type were in wetter areas than the Dwarf Birch type. Salix pulchra was the dominant willow species (Tables 37 and 38). Low-growing B. glandulosa was also present in the Dwarf Birch-Willow vegetation type, ranging from 1 to 5% cover. Vaccinium *uliginosum* was the most important dwarf shrub, averaging 11% canopy cover (Table 37). Forbs and graminoids had higher cover percentages in this type than the Dwarf Birch vegetation type due mainly to the moisture conditions found in association with the Dwarf Birch-Willow vegetation type. Two percent of the area sampled was covered by free-standing water. Total moss cover was approximately equal to the total moss cover in the Dwarf Birch vegetation type (Tables 37 and 31).

Betula glandulosa and *S. pulchra* had similar stem densities in the Dwarf Birch-Willow vegetation type (Table 39), each with about 2 stems/1-m^2. All *B. glandulosa* stems were ≤ 1 cm in basal diameter. Approximately 72% of the *S. pulchra* stems were ≤ 1 cm in basal diameter.

Percent utilization of both *B. glandulosa* and *S. pulchra* was very low in the Dwarf Birch-Willow vegetation type (Table 40). Stem densities of both *S. glauca* and *A. sinuata* were low (Table 39), but utilization was higher than for *B. glandulosa* and *S. pulchra* (Table 40). The substantial number of shrubs sampled from 120 point-centered quadrants was further evidence of the low density of *S. glauca* and *A. sinuata* (Table 40).

Browsing of shrubs with low densities might inadvertently suggest that *S. glauca* and *A. sinuata* were preferred 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 plants that occur in higher 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 studied (Johnson 1980).

The number of unbrowsed twigs for *B. glandulosa* was nearly double that for *S. pulchra* although available leaf, twig and total biomass of the 2 species was approximately equal in the Dwarf Birch-Willow vegetation type (Table 41). Available twig biomass for S. pulchra was higher in the Dwarf Birch-Willow type than for all other vegetation types sampled. The possible exception may have been for the Low Willow vegetation type, for which data on percent utilization and number of twigs was unavailable. Total available biomass in the Dwarf Birch-Willow vegetation type was 514 kg/ha, of which approximately half was twig and half was leaf biomass (Table 41).

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 42). Salix pulchra had 1.7 times as much leaf CAG as B. glandulosa but only 1.2 times as much twig CAG biomass. In contrast to the Dwarf Birch vegetation type, the wetter soil moisture conditions predominating the Dwarf Birch-Willow type averaged 76 kg/ha of forb CAG biomass (Table 42). The forb CAG biomass was composed of Petasites frigidus, Cornus canadensis, and Rubus chamaemorus (Table 37). Graminoid CAG was composed primarily of Calamagrostis canadensis and Carex spp. (Table 37). Total leaf and twig CAG biomass for tall and low shrubs was 58 kg/ha and 28 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 43 and 44). The predominant shrubs in this type were the ericaceous dwarf shrubs V. uliginosum, E. nigrum, L. groenlandicum and V. vitis-idaea(Table 43). 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 45). Stem densities of B.

glandulosa were similar to those found in the Woodland Spruce (Table 17) and Dwarf Birch-Willow (Table 39) vegetation types. Percent utilization of shrubs in the Open Ericaceous Shrub Tundra vegetation type was very low (Table 46).

Betula glandulosa averaged 84 kg/ha leaf biomass and 111 kg/ha twig biomass (Table 47). Shrubs in this vegetation type were low-growing, and would offer little forage when snow cover exceeded 0.5 m in depth.

The Open Ericaceous Shrub Tundra vegetation type had 87 kg/ha and 99 kg/ha CAG biomass of forbs and graminoids, respectively (Table 48). Salix pulchra had the highest CAG biomass estimates, contributing 25 kg/ha and 12 kg/ha to leaf and twig CAG biomass in this vegetation type (Table 48). Total leaf and twig CAG biomass was 37 kg/ha and 19 kg/ha, respectively, for tall and low shrubs.

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 49 and 50). 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 49). The forb Rubus chamaemorus and graminoid 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 49). 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 51) approximated those found in the Open Black Spruce vegetation type (Table 11).

Utilization of low-growing B. glandulosa shrubs was very low (Table 52).

Similar to the Open Ericaceous Shrub Tundra type, B. glandulosa was the only low shrub in the Ericaceous Shrub-Sphagnum Bog vegetation type. Betula glandulosa averaged only 40 cm in height (Table 52), so snow depths exceeding 0.4 m would inhibit utilization of these shrubs by moose. Twig biomass available above 40 cm was 67 kg/ha for B. glandulosa (Table 53). Utilization of B. glandulosa for forage in the Ericaceous Shrub-Sphagnum Bog vegetation type was almost non-existent (Tables 53 and 52). Forb CAG biomass totaled 203 kg/ha in the Ericaceous Shrub-Sphagnum Bog vegetation type (Table 54). Leaf and twig CAG biomass of B. glandulosawas very low in relation to stem densities totaling 45,550 stems/ha (Table 51) and 67 kg/ha available twig biomass (Table 53).

6.1.2.2 - Dwarf Shrub Scrub

Dwarf shrub scrub vegetation is 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 55 and 56). 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 55).

The highest density of S. pulchra stems in the vegetation types sampled was found in the Low Willow Tundra vegetation type (Table 57). These low growing shrubs were relatively random in their distribution as noted by the small estimated sample size. Average 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 211 kg/ha and 126 kg/ha in the Low Willow Tundra vegetation type (Table 58). Salix pulchra had 28 kg/ha of leaf CAG biomass and 5 kg/ha of twig CAG biomass. Salix pulchra and B. glandulosa together had 33 kg/ha and 8 kg/ha of leaf and twig CAG biomass, respectively, in this vegetation type.

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). These 27 Level V vegetation types combined 1 to 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 utilized by 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 Alnus 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 (Sphagnum spp.), lichens (Peltigera spp., 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 hiding cover, shade during warm ambient temperatures, protection from the elements and 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.) comprised 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 forst 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 marianaalso 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 the 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 Shrub-Willow vegetation type, the Dwarf Shrub type had little forb cover. The Dwarf Shrub vegetation type was situated on well-drained 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 unavailable as winter forage for moose when snows exceeded 40 cm in depth unless cleared by wind, or moose digging into the snow.

In the 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. Average percent utilization of S. glauca was equal to or greater than S. lanata in 1 out of 2 vegetation types. In a study designed to determine the relative preference of 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 growing together. In all 4 study areas where both S. pulchra and S. glauca existed, Milke (1969) ranked S. pulchra as the preferred species. Salix lanata was preferred over S. pulchra at 2 out 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 study areas, 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 was as follows: S. pulchra, S. lanata, and 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. Machida (1979) ranked S. alaxensis (felt leaf willow) as forage most preferred by moose at an Interior Alaska study area near Fairbanks.

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 (4167 to 5417 stems/ha) in the Open White Spruce vegetation type, where percent utilization ranged from 4 to 5%. 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 35% 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 the shrubs with higher stem densities.

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) found that *S. glauca* was poorly utilized on study areas where it was abundant, and also 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 was not correlated with species density (Milke 1969). Milke (1969) concluded that neither relative abundance nor density of *Salix* spp. observably affect the degree to which moose utilize the plants. Rather, the inherent palatability of a species overrides the effects of relative abundance or density on browsing intensity.

One other solution as to 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 one place, would briefly browse nearby S. *glauca* or S. *lanata* plants that w..e 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 (caribou (*Rangifer tarandus*), rodents, leporids, 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 moose.

Average diameter at point-of-browsing (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 diameter at point-of-browsing 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 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 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 occassional 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.

Based on our available twig biomass estimates, if all twig biomass was browsed in any given year the plant might have decreased vigor the following year in many cases. It is suspected that this degree of utilization over several years would definitely result in decreased vigor. Removal of all 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 major portion of the plants 2-yr, 3-yr, and/or 4-yr-old stem growth. These effects are probably ameliorated by the browsing occurring during plant dormancy.

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. were located on 2-yr-old stems and about 1% on 3-yr-old stems (Archer and Tieszen 1980). The average Salix plant initiated growth of leaves and lateral twigs from less then 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 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 Tiesen's (1980) work on S. pulchra demonstrated that removal of terminal growth back to 5- to 7-yr-old growth stimulated development of terminal long-shoots from suppressed lateral buds buried in the cambium. That growth far exceeded terminal long-shoots under non-defoliation conditions (Archer and Tieszen 1980). However, it is evident that the energy reserves of a plant would be rapidly 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 extent of browse utilization 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 (108 kg/ha) would support 8.3 moose/ha for 1 day. It follows that 1 moose could survive for 8.3 days on each hectare, or 8.3 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, presumably, too high. Certain broad assumptions must be made in order to use the foregoing technique:

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

Although preference and/or browsing intensity on different species of shrubs may vary 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: 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, _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 that 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, loafing, 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 of the vegetation types sampled in this study for moose. 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 in the middle Susitna River Basin to moose.

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 completely snow-free at that time, although the Watana area contained some snow patches in depressions between shrubs, and Vaccinium uliginosum (bog blueberry) 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 been reduced. Vaccinium vitis-idaea (mountain cranberry) was abundant at the base of trees in the area between Devil and Tsusena Creeks. Snow was melting around Ledum groenlandicum (Labrador tea) at the highest elevations of the Switchback transect.

General observations between Watana Base Camp and Talkeetna River on 15 and 16 May indicated snow was about half melted from forested south-facing slopes while it had only melted 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 connecting the open areas. Apparently these shallower areas are important to wildlife at this time of year. Shallower snow occurred in wet, boggy sites as well as dry, windy areas that had no trees. These areas may be as important to moose as south-facing slopes, primarily during winter and early spring.

6.2.2 - Soil Temperature

Temperatures varied significantly by transect, elevation within transect, and time within elevation within transect (Table 59). 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 (prickly rose) 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 Betula papyrifera (paper birch) had been hedged so that they resembled large B. glandulosa (resin birch) - 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 had gentle, west-facing slopes and were not shaded by higher elevations 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 59). The bench location was well above the current forest line although a few surviving old trees were present.

The coldest transect was Tsusena Creek. Minimun temperature separation 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. These 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. These colder temperatures were probably caused by the thick insulating layer of moss as well as colder climatic 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.

Most of the elevations along the Tsusena Creek transect appeared less recently disturbed by fire than 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 some other sites. Whether the lower soil temperatures along the Tsusena Creek site result from a possibly different climatic regime alone or the deeper moss layer alone is a matter of conjecture, but it seems very likely that the associated delayed phenological development is an interdependence of climate, burn history, and resultant moss layer.

The warmest area consistly was the middle elevation on the Jay Creek site. The vegetation 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 it 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 (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 ($P < 0.05$) among elevations and transects. This was primarily due to a difference in vegetation type rather than a difference related to phenological development. Only species that consistently occurred in most sites would give reasonable statistical results. The major species were _Betula glandulosa_, _Vaccinium vitis-idaea_, _V. uliginosum_, and _Empetrum nigrum_ (crowberry).

6.2.3.2 - Week 1

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

60).

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. Vaccinium uliginosum had some leaf buds whereas it was still dormant at the higher elevations.

The Jay Creek transect had several species already leafed out on 1 June (Table 61). At the bench and top-slope positions leaves had emerged on V. vitis-idaea exhibited leaf emergence while V. uliginosum had more 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 lot of standing dead from last year's growth of Equisetum silvaticum and Calamagrostis canadensis, but little (< 1% cover) had started this year. 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* (diamond leaf willow) generally occurred along small runoff rills while the second species, *Salix glauca* (grayleaf willow) grew on the small ridges between these drainages. One lower elevation area had a 13° north-facing slope with 4°C soil temperature. This appeared to be 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 leaved-out *B. nana*. This area appeared to be 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: *Salix pulchra*, *Ribes triste* (red current) *Ledum groenlandicum*, and *L. decumbens* (Northern Labrador tea) (Table 62). Most *V. vitis-idaea* was still dormant while some *V. uliginosum* had leaf buds.

Some *Carex* spp. on the bench position was beginning to emerge while most other species, except *B. glandulosa*, appeared 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 location. *Ribes triste* had leaves and flower buds. *Alnus sinuata* was mostly 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 reaching 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 initiating leaf buds (Table 63). 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 here more than on some other transects. Rosa acicularis also appeared to be more developed. Ledum groenlandicum had new leaves at the bottom location whereas Cornus canadensis (bunchberry) was dormant and B. glandulosa only had leaf buds. The corresponding north-facing slope was utilized less than most other areas visited.

6.2.3.3 - Week 2

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 cages. 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. It was not obvious if these were biological differences or artifacts of sampling and statistical analysis.

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 64). Vacciniumuliginosum 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 apparent major differences in phenological development at different elevations at this time.

Plant species on the Jay Creek transect had also advanced phenologically by 8 June (Table 65). *Betula glandulosa* and *B. acicularis* were now 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 cones 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 did not lag behind that on the south-facing slope and appeared 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 leaved 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 probably *B. papyrifera* while those in pure blocks might have been *Populus tremuloides* (quaking aspen) although this was never ground-truthed. *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*.

Almost all important plant species on the Switchback site advanced a full phenological state from 2 June to 9 June (Table 66). *Alnus sinuata*, *B. glandulosa*, *B. acicularis*, and *V. uliginosum* had leaves at this time. Average height of *Equisetum silvaticum* had increased from 2 to 10 cm tall (Tables

62,66). Ribes triste was in flower at the bottom elevation. Vaccinium vitis-idaea had flower buds at the middle-slope location. No new observations of 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 (Table 63,67). On the north-facing slope B. glandulosa buds appeared a little more advanced but were still very immature.

6.2.3.4 - Week 3

Cover values of all the major species, B. glandulosa ($P < 0.005$), V. vitis-idaea ($P < 0.08$), V. uliginosum ($P < 0.02$), and Empetrum nigrum ($P < 0.02$) varied 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.

The Watana Creek transect showed no major phenological advances between the second and third week (14 June) except that Rosa acicularis was now in leaf and Empetrum nigrum had some terminal buds at the bottom and top elevations, respectively (Table 68). Vaccinium uliginosum had flower buds at the top-slope elevation, where flower buds of Ledum decumbens were first 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 69). 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 65,69).

Epilobium angustifolium did not increase in size significantly. Mertensia paniculata, a perennial, appeared to start growth earlier than E. angustifolium, an annual, since it was present during the first week. However, it appeared to grow more slowly. Epilobium angustifolium seemed to start growth later but grew more rapidly, reaching its maximum a week earlier than M. paniculata. Hence, M. paniculata might be available earlier for forage.

A few plant species progressed phenologically along the Switchback transect as was observed on 16 June (Table 70). Vaccinium uliginosum had flower buds, Empetrum nigrum just had terminal buds, and many Ribes triste had lost their flowers. Equisetum silvaticum appeared 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 71). 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

Betula glandulosa ($P < 0.03$), V. uliginosum ($P < 0.000$), and Empetrum 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 ($P < 0.001$), and Empetrum nigrum ($P < 0.001$) cover values were different among transects at this time. Vaccinium vitis-idaea did show trends with respect to elevational variation ($P < 0.14$) and B. glandulosa with respect to transects ($P < 0.18$). Hence, most ubiquitous species had different cover values among transects and elevations within transects.

The only new development on the Watana Creek transect in the fourth week was that V. vitis-idaea and V. uliginosum developed flower buds (Table 72). Some individuals of Ledum decumbens flowered at the top-slope elevation although most were still only in bud.

Developments along the Jay Creek transect in week 4 (22 June) included flower buds on V. vitis-idaea and V. uliginosum and some flowers on Cornus canadensis (Table 73). Most of the forbs appeared to have slowed their growth although the average height of Equisetum silvaticum increased slightly.

Several advances occurred on the Switchback transect during the fourth week, 23 June: Empetrum nigrum, Arctostaphylos uva-ursi (bearberry), and grasses entered the leaf stage (Table 74). Although much V. vitis-idaea was still in the leaf stage, some individuals acquired flower buds. Valeriana capitata was flowering at the bottom elevation while Mertensia paniculata had leaves. Thus 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 24 June. Some Cornus canadensis leafed out while some grass expanded leaves (Table 75). Rubus chamaemorus and V. uliginosum were flowering at the top-slope location.

6.2.3.6 - Week 5

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

The last week of 28 June to 2 July had few changes because most species had at least expanded leaves at all sites by this time. Watana Creek transect had only a few minor changes during the last week 28 June: Rosa acicularis and Spiraea beauverdiana (beauvered spiraea) developed flower buds (Table 76) and some Cornus canadensis and V. vitis-idaea started flowering.

Several changes occurred on the Jay Creek transect by this last week (Table 77). Ledum groenlandicum and L. decumbens had flowered. Most Mertensia paniculata was in flower, rather than being restricted to the most advanced individuals. Epilobium angustifolium, Mertensia paniculata, and Equisetum silvaticum all increased their average height. Empetrum nigrum berries were observed at the top-slope elevation.

Changes along the Switchback transect during week 5 (30 June) included some V. vitis-idaea flowering at the middle slope location as well as Ledum decumbens flowering at higher elevations (Table 78). The average height of Equisetum silvaticum increased by 10 cm while the mean grass height remained about the same.

During the fifth week (1 July) some V. vitis-idaea and Cornus canadensis flowered along the Tsusena Creek transect (Table 79). Average height of grasses increased slightly. Some individuals of Ledum groenlandicum and L. decumbens 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 1 ubiquitous species during 1 week. The average cover, height, and phenological state for B. glandulosa are reported in Table 80. This species was more abundant at the higher elevations than at the 2 lower elevations, but did not vary significantly by transect. This 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, taller individuals of B. glandulosa grew at the higher elevations except along the Switchback transect where heights were similar (Table 80). The higher elevations, especially the bench position, along Tsusena Creek appeared to have much taller shrubs (86 cm versus overall mean of 55 cm). Whether this was related to edaphic, climatic, or site history factors or a combination was not known.

Phenological state was not different for the Watana Creek, Jay Creek, and Switchback transects (Table 80). However, B. glandulosa along the Tsusena Creek transect was in the leaf bud stage while plants along the other transects had already expanded many of their leaves. Watana and Jay Creek transects had some variation in phenological state with respect to elevation. The bench location appeared to lag 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 81 presents cover, height, and phenological development of Mertensia paniculata over time for the middle slope elevation of the Jay Creek transect. Cover increased slowly during the first 2 weeks, then increased during the third week and remained the same during the fourth week. Cover values almost doubled (8.5 versus 14.4%) 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. However, Mertensia paniculata may normally exhibit a slowing of growth at this stage, as resources are directed toward flower development.

6.2.6 - Summary and Discussion of Plant Phenology

Early greenup of herbaceous plant species could be important for moose in the spring on south-facing slopes, 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 certain 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.

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 offering 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 they were producing some forage but other forage was not abundant. Later in the spring we observed no evidence of grazing, presumably because there was such an abundance of forage available at that time.

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 forage available depended on the transect location. Effects of elevation were probably confounded with vegetation type to some degree. Hence, disjunct patches of vegetation may become available for foraging at the same time. Forage availability appeared to be dependent on the climatic environment in a particular area as modified by elevation, aspect,and site history, especially with respect to fire.

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 development 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 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 and affect spring temperatures 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 problems. Regardless, sites that warmup relatively early would still be available in the Switchback area.

6.2.7 - Biomass Estimations

Forbs and graminoids were the most abundant plants measured in terms of current annual growth biomass (Table 82). 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 produced 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 ($P < 0.1$) in biomass over time.

Graminoid biomass was greatest ($P < 0.05$) at transects 2 and 3, elevation 4 when compared to all other locations (Table 82). Forb biomass was greatest ($P < 0.05$) at transect 2, elevation 3 and transect 3, elevation 4. 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 transect 3, elevation 4 averaging 24 g current growth of leaves and stems per 100 twigs. Betula papyrifera biomass was greatest ($P < 0.05$) at transect 2, elevation 3 averaging 8 g current annual growth of leaves and twigs per 100 twigs (Table 82).

During week 1 (31 May - 3 June), B. glandulosa current twig biomass (100 twigs) was significantly greater ($P < 0.05$) at transect 1, elevation 1 than any other location (Table 82). Current twig biomass per 100 twigs of A. sinuata was greatest ($P < 0.05$) at transect 3, elevation 4. Site 2, elevation 3 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 transect 2, elevation 3 than any other location.

Graminoid standing crop was greatest ($P < 0.05$) at transects 1 and 2, elevation 4.

Betula glandulosa average leaf and twig biomass per 100 twigs was greatest ($P < 0.05$) at transect 1, elevation 2 during week 3 (14-17 June). Graminoid biomass was greater ($P < 0.05$) at transect 3, elevation 4, and *B. papyrifera* leaf biomass per 100 twigs at transect 2, elevation 3, than any other location.

During the 4th week (21-25 June), *B. glandulosa* leaf biomass per 100 twigs was greatest ($P < 0.05$) at transects 3 and 4 and *B. papyrifera* biomass at transect 2, elevation 3.

For week 5 (28 June - 1 July), *B. glandulosa* leaf biomass per 100 twigs was greatest ($P < 0.05$) at transect 2, elevation 1. Forb biomass was greater ($P < 0.05$) at transect 2, elevation 3, and graminoid biomass at transect 2, elevation 4 than any other location.

By week 6 (31 August - 3 September), forb biomass was greatest ($P < 0.05$) at transect 2, elevation 3 and transect 3, elevation 4, *A. sinuata* at transect 3, elevations 3 and 4, and *B. glandulosa* leaf biomass per 100 twigs at transects 1 and 3, elevation 1 (Table 82).

Comparisons inside and outside the exclosures during week 6 indicate that forb biomass was significantly greater ($P < 0.05$) inside the exclosures at transect 1, elevations 2 and 3, and transect 3, elevation 4 (Table 82). Current growth biomass per 100 twigs of *A. sinuata* was greatest ($P < 0.05$) inside the exclosures at transect 3, elevation 4. 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 82). *Betula* *glandulosa* leaf and twig biomass per 100 twigs was highly variable when comparisons between inside and outside the exclosures were made (Table 82).

Total current annual growth biomass (TCAG data) of shrubs was similar ($P > 0.05$) inside and outside of the exclosures (Table 83). However, twig and leaf biomass of *B. papyrifera* was greater ($P < 0.05$) outside the exclosures at transect 3, elevation 4.

Transect and elevation differences in TCAG data were similar to those in CAG data for all plants measured (Tables 82 and 83).

6.2.7.1 - 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 elevations 3 and 4 at all transects, which were located at the middle and bottom of the slope respectively (Table 82). Shrub current growth biomass per 100 twigs was greatest at elevations 1 and 2 which were located on the bench above the slope and where the bench breaks into the slope of the river valley, respectively (Table 82). These results would be expected as the plant communities change with elevation grading from shrubland-open forest types on the bench above the river channel, into a mixed deciduous-coniferous forest on the slope of the river valley, to various plant communities at the bottom of the slope, reflecting successional stage of the site. Generally, these bottom-slope sites were mature, open forest communities. Moisture regimes and soil communities also played a part in these elevational trends. However, site history also provided an important modifying influence.

Over the period of this study, forb and graminoid biomass steadily increased at all sites (Fig. 5). 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 82).

Comparisons of plant current growth biomass inside and outside the exclosures (week 6, both data sets) reveal few significant differences (Tables 82 and 83). Forb biomass was greater inside the exclosures, indicating possible utilization of 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 of many of the sites sampled in the middle basin. Biomass of A. sinuata per 100 twigs was greater inside the exclosures than out (Tables 82 and 83). This may also reflect utilization by large herbivores.

Total current annual growth biomass of plants sampled during week 6 outside the exclosured indicates 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 valley, 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 later spring did not lend itself to examination of this hypothesis. However, greater biomass of forbs inside than outside the exclosures at week 6 supported the hypothesis that forbs were eaten at some time during the growing season. To provide a definitive answer as to the validity of the moose-forb hypothesis, 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.

6.2.8 - 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 84). 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 84).

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 84).

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 r values 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. 6) and was generally linear. Only A. sinata differed noticeably from the other species along the y-axis. These data indicate a nearly 1:1 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 84).

Basal diameter was least variable of the two measurements (coefficients of variation ranging form 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.

6.2.9 - Larger Exclosures

Larger exclosures were construced for the 1983 spring field season shortly after 1982 exclosures were disessembled. These 5 x 5-m exclosures were construced 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 tall. These exclosures were arranged in clusters of 2 to 4 in areas where moose were known to congregate during parturition (Fig. 7). W. B. Ballard (ADF&G) provided information on moose locations and assisted in the general positioning of the clusters of exclosures. Emplacement 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). Descriptions of individual sites are more meaningful following their treatment by fire. 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 85. The outer boundary surrounding the control burn area was arbitrary being based primarily on the similarity of the vegetation in the burn and control areas (Fig. 8). 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. Hence, most study sites were located in the primary burn and control areas. The primary and secondary burn areas were defined by USFS 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 86 . *Salix glauca* had the largest DPB measurements, averaging 3.5 mm. The smallest DPB's of the shrub species was on 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 86). Mean weight of leaves was 0.74 g for S. glauca while B. glandulosa averaged only 0.30 gm. Salix pulchra had the greatest twig weights, averaging 0.51 g/twig (Table 86). Species of Salix invariably 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 87).

Density of P. glauca averaged 455/ha, while A. crispa, B. glandulosa, and S. pulchra had the greatest density of the shrubs sampled (Table 88). 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 89). 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 90).

Sample sizes needed for adequate cover estimates ranged from 1 to 13 plots per site. 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 87 and 89).

6.3.2 - Open Black Spruce Vegetation Type

Seven sites were examined in the Open Black Spruce vegetation type. Basal tree cover 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 91).

Stem densities were greatest for P. mariana B. glandulosa, and S. pulchra. The oldest trees in 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 92).

Basal diameter of shrubs fell within the <1 - 2 cm range, and utilization based on twig counts ranged from 3% to 27% (Table 93).

Available and utilized browse biomass in the Open Black Spruce type totaled 540 and 135 kg/ha, respectively (Table 94). This represents approximately 20% utilization of the total biomass of the shrubs sampled. Salix pulchra was the major producer and received 22% utilization of the total biomass produced. Betula glandulosa was second in biomass production with 16% utilization. Salix glauca accounted for only 3 kg/ha, but received 25% utilization of the biomass produced. (Table 94).

Required 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 91 and 93).

6.3.3 - Woodland White Spruce Vegetation Type

Five sites were sampled in the Woodland White Spruce vegetation type. Basal tree cover averaged only 6%, low shrub cover 25%, dwarf birch 45%, forbs

8%, moss 46%, and lichens 21% (Table 95). 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 95).

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 highest density (Table 96).

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 97 and 98).

Total available biomass of shrub stems was 411 kg/ha (Table 97). Betula glandulosa and S. pulchra provided the greatest biomass and received 23% and 26% utilization of the biomass produced, respectively. However, every individual of S. glauca and S. lanata that was sampled at these sites had been browsed (Table 97). One individual of S. pulchra at site #23 in the Woodland White Spruce vegetation type had 208 browsed stems and 332 unbrowsed stems due to severe hedging.

Estimated sample sizes followed the same pattern as for the 2 previous vegetation types (Tables 95, and 98).

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 99). 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 100). The few trees present were younger in age then 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 19%, and ranked similar to utilization based on biomass (Table 101).

Browse availability totaled 1,822 kg/ha with only 16% utilization of the total biomass produced. Betula glandulosa and S. pulchra provided the most biomass and 15% and 20% of the total biomass produced had been utilized, respectively (Table 102).

Plot sample sizes needed for cover estimates and twig counts showed the same trends as for the other vegetation types discussed previously (Tables 99 and 101).

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 103). 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 99 and 103). 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 104). 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 the 1 - 2 cm size class (Table 105). 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 produced having been utilized (Table 106). Betula glandulosa and S. pulchra were the most abundant of the shrubs sampled in terms of available biomass (Table 106). 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 103) 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 103 and 105).

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, 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, 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, P > 0.15). Litter cover increased (r_s = 0.98, 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 highest of tree densities, dominated by P. mariana. Shrub cover was low, and forb and graminoid cover was relatively high. 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 high. 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 higher than other vegetation types, presumably 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 difference 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.

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. Shrub cover was greatest in 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 high 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 of plots 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 - 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 compared directly between the 2 studies. 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 were used for comparative purposes.

6.3.7.1 - Open White Spruce Vegetation Type

Percent canopy cover and species composition in the Open White Spruce vegetation type was not significantly correlated ($r=0.29$, $P > 0.05$) between the 2 study sites. 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 studies. However, as indicated previously by canopy cover estimates, S. pulchra was much more predominant 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 only 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.

6.3.7.2 - 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. Species composition and percent canopy cover were highly correlated ($r=0.98$, $P < 0.01$) between the 2 studies. 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 15,5000 stems/ha for the Susitna Basin and Alphabet Hills Open Black Spruce vegetation types, 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 Open Black Spruce vegetation type. In both studies the bulk of total available shrub biomass was produced by S. pulchra and B. glandulosa.

6.3.7.3 - Woodland White Spruce Vegetation Type

Species composition and canopy cover in the Woodland White Spruce type was highly correlated (r=0.89, P < 0.01) between sites sampled in the Susitna Basin and Alphabet Hills studies. Canopy cover of B. glandulosa, S. pulchra, V. uliginosum and L. groenlandicum were all greater in the sites sampled in the Alphabet Hills. Cover of lichens was also higher in the Alphabet Hills, particularly of Peltigera spp. Stem densities of B. glandulosa and S. pulchra were 200% and 11 times higher 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 studies. 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 higher for the Alphabet Hills.

6.3.7.4 - 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 more canopy cover in the Alphabet Hills. Total forb, graminoid, and lichen cover was similar between the 2 studies. Sites in 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 ($r=0.90$, $P < 0.01$) 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 higher 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 studies. Betula glandulosa was the major component of total available biomass for both the Alphabet Hills and Susitna Basin studies. Total available biomass of B. glandulosa in the Alphabet Hills exceeded that for the Susitna Basin; the opposite was true for S. pulchra in the Dwarf Birch vegetation type.

6.3.7.5 - Dwarf Birch - Willow Vegetation Type

Species composition and percent canopy cover were significantly correlated ($r=0.85$, $P < 0.01$) between the 2 study areas for in the Dwarf Birch-Willow vegetation type. Canopy cover of the low shurbs B. glandulosa and S. glauca as well as the dwarf shrubs E. nigrum and V. uliginosum was substantially greater in the Alphabet Hills sites. Total forb and graminoid cover was comparable between the 2 studies 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 in the Dwarf Birch-Willow vegetation type. Stem densities of B. glandulosa and S. pulchra were both greater in the Alphabet Hills study sites. Percent utilization of S. glauca twigs was higher in the Susitna Basin, while percent utilization of both S. pulchra and B. glandulosa were both higher in the Alphabet Hills. Total available biomass was approximately 2 times greater in the Alphabet Hills than in the Susitna Basin.

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TABLE 1

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 magellanica Lam. subsp. irrigua (Wahlenb.) Hult.	Bog sedge	U	
Orchidaceae			
Platanthera obtusata (Pursh) Lindl.	Small bog-orchis	U	
Dicotyledoneae			
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.	Marsn marigold	U	
Rosaceae			
Potentilla villosa Pall.	Villous cinquefoil	U	
Saxifragaceae			
Chrysosplenium tetrandrum (Lund) T. Fries	Northern water carpet	U	
Ribes hudsonianum Richards	Northern black currant	U	

TABLE 2

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

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

TABLE 3

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 90 - 1-m^2 quadrats from 6 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	1.3	7
Alnus sinuata	3	1.3	7
Total low shrub	12	1.8	13
Betula glandulosa	3	1.0	4
Rosa acicularis	1	0.3	1
Salix glauca	2	0.9	4
Salix lanata	1	0.5	1
Salix pulchra	1	0.3	1
Viburnum edule	1	0.2	1
Total dwarf shrub	34	2.4	12
Arctostaphylos rubra	1	0.4	1
Empetrum nigrum	2	0.4	1
Ledum groenlandicum	6	0.8	3
Salix reticulata	1	0.3	1
Vaccinium uliginosum	17	1.8	12
Vaccinium vitis-idaea	10	1.4	8
Total forb	12	1.8	12
Cornus canadensis	3	1.0	4
Epilobium angustifolium	1	0.3	1
Linnaea borealis	1	0.1	1
Mertensia paniculata	1	0.2	1
Petasites frigidus	2	0.5	1
Rubus chamaemorus	1	0.2	1
Total graminoid	2	0.3	1
Carex spp.	1	0.3	1
Grass spp.	1	0.2	1
Total moss	40	3.5	18
Total lichen	5	1.1	5
Cladonia spp.	1	0.3	1
Peltigera spp.	2	0.5	1
Stereocaulon paschale	1	0.7	2
Litter	13	1.3	6
Dead wood	1	0.3	1
Bare ground	1	0.4	1

TABLE 4

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 90 - 4-m^2 quadrats from 6 sites in the Open White Spruce vegetation type, middle Susitna River Basin.

Life Form/Species	Mean	Standard Error	Estimated Sample Size
Total tree	11	2.0	14
Total basal tree	1	0.3	1
Total tall shrub	3	1.2	5
Alnus sinuata	3	1.2	5
Total low shrub	14	1.6	9
Betula glandulosa	4	0.7	2
Salix glauca	3	0.7	2
Salix lanata	1	0.4	1
Salix pulchra	2	0.3	1

TABLE 5

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 90 - 4-m^2 quadrats at 6 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	1361	890	962
	1-2	1361	890	962
	2-3	694	411	787
	3-4	111	88	1397
	Total	3527	1010	489
Betula glandulosa	0-1	11056	2559	121
	1-2	694	209	205
	2-3	83	62	1239
	Total	11833	2693	117
Salix glauca	0-1	3111	868	175
	1-2	1389	476	265
	2-3	278	150	658
	Total	4778	1422	177
Salix lanata	0-1	5361	1807	256
	1-2	56	39	1113
	Total	5417	1826	251
Salix pulchra	0-1	3250	725	112
	1-2	861	250	191
	2-3	56	39	1113
	Total	4167	844	93

TABLE 6

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 6 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	<0.1	191	6	8
	Salix pulchra	11	<0.1	160	6	5
	Salix glauca	12	<0.1	149	6	6
	Salix lanata	14	0.3	10	2	9
	Alnus sinuata	18	0.1	120	5	8
Height (cm)	*Betula glandulosa*	60	0.2	191	6	5
	Salix pulchra	60	0.1	160	6	2
	Salix glauca	70	0.2	149	6	4
	Salix lanata	80	1.8	10	2	14
	Alnus sinuata	110	0.5	120	5	6
Utilization (%)	*Betula glandulosa*	6	0.9	191	6	134
	Salix pulchra	4	0.7	160	5	108
	Salix glauca	5	0.8	149	5	100
	Salix lanata	5	2.6	10	2	65
	Alnus sinuata	5	1.4	120	4	228

TABLE 7

Total 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
Alnus sinuata	63133	84	80	164	8818	12	11	23
Betula glandulosa	100581	39	51	90	31949	12	16	29
Salix glauca	43958	38	37	75	10512	9	9	18
Salix lanata	47670	27	17	45	21668	12	8	20
Salix pulchra	41253	30	31	60	7917	6	6	12
Total Biomass		218	216	434		51	50	102

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

TABLE 8

Average total current annual growth[a] (kg/ha) and number of plots required to sample within 20% of the mean with 67% confidence by life form and shrub species for 6 sites in the Open White Spruce vegetation type, middle Susitna River Basin.

Life Form/Species	Category	Mean	Standard Error	Estimated Sample Size
Total forb		136	19.6	47
Total graminoid		30	5.4	77
Tree				
Betula papyrifera	leaf	3	2.7	1995
Betula papyrifera	twig	2	1.5	2108
Tall shrub				
Alnus sinuata	leaf	22	8.9	382
Alnus sinuata	twig	13	6.1	460
Low shrub				
Betula glandulosa	leaf	7	2.3	285
Betula glandulosa	twig	5	1.8	343
Rosa acicularis	leaf	10	2.3	118
Rosa acicularis	twig	2	0.5	176
Salix fuscescens	leaf	1	0.9	2251
Salix fuscescens	twig	<1	0.1	2251
Salix glauca	leaf	18	7.8	438
Salix glauca	twig	7	3.1	475
Salix lanata	leaf	4	2.6	1126
Salix lanata	twig	1	0.5	1194
Salix pulchra	leaf	7	2.7	377
Salix pulchra	twig	3	1.3	509
Viburnum edule	leaf	4	1.6	443
Viburnum edule	twig	1	0.6	467

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

TABLE 9

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 - 1-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 10

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	12
Total basal tree	1	0.1	1
Total tall shrub	2	0.7	3
Alnus sinuata	2	0.7	3
Total low shrub	15	1.3	11
Betula glandulosa	7	0.8	4
Salix glauca	1	0.2	1
Salix pulchra	6	0.9	5

TABLE 11

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	801
	1-2	1233	570	801
	2-3	700	223	382
	3-4	633	313	917
	Total	3799	1041	571
Betula glandulosa	0-1	39467	2993	22
	1-2	1000	271	275
	2-3	50	50	3751
	Total	40517	3092	22
Salix glauca	0-1	883	480	1108
	1-2	367	156	677
	2-3	117	83	1901
	Total	1367	648	843
Salix lanata	0-1	400	340	2702
	Total	400	340	2702
Salix pulchra	0-1	7200	982	70
	1-2	3883	717	128
	2-3	383	102	268
	3-4	83	44	1032
	Total	11549	1560	67

TABLE 12

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	<0.1	510	10	3
	Salix pulchra	11	<0.1	372	10	4
	Salix glauca	13	0.1	64	9	5
	Alnus sinuata	18	0.1	123	6	8
Height (cm)	*Betula glandulosa*	50	0.1	510	10	2
	Salix pulchra	60	0.1	372	10	2
	Salix glauca	60	0.3	64	9	4
	Alnus sinuata	120	0.5	123	6	6
Utilization (%)	*Betula glandulosa*	2	0.3	510	9	586
	Salix pulchra	9	0.8	370	9	70
	Salix glauca	12	1.8	64	6	34
	Alnus sinuata	2	0.6	123	6	259

TABLE 13

Total 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 14

Average total current annual growth[a] (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		112	14.0	53
Total graminoid		76	7.8	36
Tall shrub				
Alnus sinuata	leaf	12	7.3	1245
Alnus sinuata	twig	8	5.3	1363
Low shrub				
Betula glandulosa	leaf	24	6.6	245
Betula glandulosa	twig	12	1.8	81
Spiraea beauverdiana	leaf	1	0.4	1201
Spiraea beauverdiana	twigs	1	0.4	1518
Salix glauca	leaf	1	1.3	3376
Salix glauca	twig	1	0.9	3376
Salix pulchra	leaf	31	6.8	162
Salix pluchra	twig	12	2.9	188

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

TABLE 15

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 - 1-m² 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 16

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	7
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	1

TABLE 17

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	1126
	1-2	111	111	1126
	2-3	56	56	1126
	3-4	111	111	1126
	Total	389	251	84
Betula glandulosa	0-1	26278	4154	29
	1-2	1778	494	87
	2-3	111	78	550
	Total	28167	4143	25
Salix glauca	0-1	1222	769	446
	1-2	56	56	1126
	Total	1278	820	464
Salix pulchra	0-1	1444	772	322
	1-2	389	251	468
	2-3	278	278	757
	3-4	56	56	1126
	Total	2167	828	165

TABLE 18

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	<0.1	139	3	5
	Salix pulchra	16	0.1	32	3	3
	Salix glauca	10	0.1	9	3	3
	Alnus sinuata	16	0.2	19	3	8
Height (cm)	*Betula glandulosa*	70	0.2	139	3	4
	Salix pulchra	60	0.4	32	3	3
	Salix glauca	50	0.2	9	3	1
	Alnus sinuata	110	1.2	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 19

Total 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 20

Average total current annual growth[a] (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	7	4.9	633
Alnus sinuata	twig	4	3.0	694
Low shrub				
Betula glandulosa	leaf	6	2.2	134
Betula glandulosa	twig	3	0.9	149
Rosa acicularis	leaf	1	0.6	660
Salix pulchra	leaf	6	5.0	714
Salix pulchra	twig	3	2.8	852

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

TABLE 21

Average percent canopy cover and number of plots required to sample within 20% of the mean wi... ι7% confidence by life form and plant species in 15 - 1-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	26
Alnus sinuata	15	6.5	26
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.	,3	7.2	19
Linnaea borealis	4	2.0	3
Lycopodium spp.	3	1.7	3
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 22

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 23

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
<u>Alnus sinuata</u>	0-1	2000	1658	258
	1-2	2000	1658	258
	2-3	500	500	376
	3-4	333	227	175
	Total	4833	2338	153
<u>Betula glandulosa</u>	0-1	500	362	197
	Total	500	362	197

TABLE 24

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	0.3	8	1	11
	Alnus sinuata	29	0.2	48	1	7
Height (cm)	*Betula glandulosa*	100	1.1	8	1	3
	Alnus sinuata	230	2.0	48	1	10
Utilization (%)	*Betula glandulosa*	0	0	8	1	--
	Alnus sinuata	1	1.1	48	1	1151

TABLE 25

Total 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 26

Average total current annual growth[a] (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	8	6.4	265
Alnus sinuata	twig	2	2.2	336

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

TABLE 27

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 - 1-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 28

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	26
Total basal tree	4	2.7	4
Total low shrub	2	1.3	1
Betula glandulosa	2	1.3	1

TABLE 29

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	0.1	4	1	5
	Alnus sinuata	14	0.2	11	1	7
Height (cm)	Betula glandulosa	60	4.8	4	1	1
	Alnus sinuata	40	10.8	11	1	19
Utilization (%)	Betula glandulosa	32	11.8	4	1	14
	Alnus sinucta	33	11.6	10	1	31

TABLE 30

Average total current annual growth[a] (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	54.3	15
Total graminoid		64	23.9	53
Tree				
Populus balsamifera	leaf	6	6.0	375
Populus balsamifera	twig	6	5.5	376
Low shrub				
Rosa acicularis	leaf	42	14.8	46
Rosa acicularis	twig	5	1.7	43
Shepherdia canadensis	leaf	4	3.6	376
Shepherdia canadensis	twig	1	1.1	376
Viburnum edule	leaf	9	6.0	179
Viburnum edule	twig	1	0.9	172

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

TABLE 31

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 - 1-m^2 quadrats from 18 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	17	1.0	11
Salix pulchra	2	0.4	2
Total dwarf shrub	40	1.5	9
Empetrum nigrum	15	1.1	12
Ledum groenlandicum	8	0.7	5
Loiseleuria procumbens	1	0.3	1
Salix reticulata	1	0.2	1
Vaccinium uliginosum	16	0.9	8
Vaccinium vitis-idaea	5	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	22
Total lichen	21	1.5	22
Cetraria spp.	2	0.3	1
Cladonia spp.	12	1.0	12
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	7	0.6	4
Bare ground	1	0.3	1

[a] Site 61 had only 3 plots.

TABLE 32

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 242 - 4-m^2 quadrats from 17 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	1
Total low shrub	24	1.2	13
Betula glandulosa	22	1.1	12
Salix pulchra	2	0.3	1

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

TABLE 33

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 242 - 4-m^2 quadrats at 17 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	67169	3600	18
	1-2	8388	672	39
	2-3	857	212	370
	3-4	21	15	3013
	Total	76435	3627	14
Salix glauca	0-1	610	407	2693
	1-2	217	104	1394
	Total	827	491	2132
Salix pulchra	0-1	3802	1054	465
	1-2	661	137	260
	2-3	52	23	1190
	Total	4515	1078	345

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

TABLE 34

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 18 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)	*Betula glandulosa*	11	<0.1	870	18	5
	Salix pulchra	12	<0.1	259	14	5
	Salix glauca	12	0.1	71	11	5
	Salix lanata	9	0.1	4	4	3
Height (cm)	*Betula glandulosa*	70	0.2	869	18	11
	Salix pulchra	60	0.2	260	15	7
	Salix glauca	50	0.2	71	11	2
	Salix lanata	50	0.5	4	4	1
Utilization (%)	*Betula glandulosa*	2	0.3	869	11	373
	Salix pulchra	9	1.1	257	10	101
	Salix glauca	11	2.2	71	8	75
	Salix lanata	26	9.2	4	4	13

[a] Site 61 had only 3 plots.

TABLE 35

Total 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 18 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	1062447	410	540	950	252236	97	128	226
Salix glauca	6864	6	6	12	2150	2	2	4
Salix pulchra	56438	40	42	83	19415	14	15	28
Total Biomass		456	588	1045		113	145	258

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

TABLE 36

Average total current annual growth[a] (kg/ha) and number of plots required to sample within 20% of the mean with 67% confidence by life form and shrub species for 18 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	100
Total graminoid		60	10.1	182
Low shrub				
Betula glandulosa	leaf	45	3.4	36
Betula glandulosa	twig	23	1.7	35
Salix pulchra	leaf	21	4.5	304
Salix pulchra	twig	14	3.8	487

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

[b]Site 61 had only 3 plots.

TABLE 37

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 - 1-m^2 quadrats from 2 sites in the Dwarf Birch-Willow vegetation type, middle Susitna River Basin.

Life Form/Species	Mean	Standard Error	Estimated Sample Size
Total tall shrub	1	0.7	1
Alnus sinuata	1	0.7	1
Total low shrub	13	2.8	10
Betula glandulosa	3	1.0	2
Echinopanax horridum	3	2.7	9
Salix glauca	1	0.7	1
Salix pulchra	8	2.5	8
Total dwarf shrub	20	3.4	14
Empetrum nigrum	3	1.0	2
Ledum groenlandicum	3	0.8	1
Spiraea beauverdiana	2	1.1	2
Vaccinium uliginosum	11	2.2	6
Vaccinium vitis-idaea	2	0.8	1
Total forb	18	3.2	12
Cornus canadensis	3	0.8	1
Petasites frigidus	4	1.1	2
Rubus chamaemorus	3	0.6	1
Rumex spp.	1	0.5	1
Total graminoid	10	2.5	8
Calamagrostis canadensis	6	2.5	8
Carex spp.	4	0.8	1
Eriophorum spp.	1	0.9	1
Total moss	31	6.2	30
Total lichen	2	0.7	1
Cladonia spp.	1	0.4	1
Peltigera spp.	1	0.5	1
Litter	11	1.7	4
Dead wood	1	0.8	1
Water	2	1.2	2

TABLE 38

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 30 - 4-m^2 quadrats from 2 sites in the Dwarf Birch-Willow vegetation type, middle Susitna River Basin.

Life Form/Species	Mean	Standard Error	Estimated Sample Size
Total tree	1	0.6	1
Total tall shrub	1	0.4	1
Alnus sinuata	1	0.4	1
Total low shrub	13	1.7	4
Betula glandulosa	4	1.0	1
Salix glauca	1	0.5	1
Salix pulchra	7	1.6	3

TABLE 39

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 30 - 4-m^2 quadrats at 2 sites in the Dwarf Birch-Willow vegetation type, middle Susitna River Basin.

Species	Size Class (cm)	Mean	Standard Error	Estimated Sample Size
Alnus sinuata	0-1	250	184	406
	1-2	250	184	406
	2-3	333	333	751
	3-4	167	167	751
	Total	1000	438	297
Betula glandulosa	0-1	23833	5005	34
	Total	23833	5005	34
Salix glauca	0-1	500	422	535
	1-2	583	353	275
	Total	1083	631	255
Salix pulchra	0-1	14250	2956	33
	1-2	4417	1370	73
	2-3	1250	746	268
	Total	19917	3936	30

TABLE 40

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 2 sites 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	<0.1	94	2	4
	Salix pulchra	11	0.1	75	2	5
	Salix glauca	11	0.1	23	2	5
	Alnus sinuata	15	0.1	26	2	4
Height (cm)	*Betula glandulosa*	60	0.2	95	2	3
	Salix pulchra	50	0.2	75	2	2
	Salix glauca	60	0.3	23	2	2
	Alnus sinuata	90	0.5	26	2	3
Utilization (%)	*Betula glandulosa*	1	0.6	94	1	401
	Salix pulchra	4	1.3	75	1	240
	Salix glauca	15	5.4	23	2	71
	Alnus sinuata	11	3.2	26	2	59

TABLE 41

Total 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 2 sites 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
Alnus sinuata	10000	13	13	26	3800	5	5	10
Betula glandulosa	259780	100	132	232	45283	17	23	41
Salix glauca	10938	10	9	19	2491	2	2	4
Salix pulchra	161328	115	121	237	95602	68	72	140
Total Biomass		238	275	514		92	102	195

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

TABLE 42

Average total current annual growth[a] (kg/ha) and number of plots required to sample within 20% of the mean with 67% confidence by life form and shrub species for 2 sites in the Dwarf Birch - Willow vegetation type, middle Susitna River Basin.

Life Form/Species	Category	Mean	Standard Error	Estimated Sample Size
Total forb		76	18.5	46
Total graminoid		79	18.5	42
Low shrub				
Betula glandulosa	leaf	20	5.5	57
Betula glandulosa	twig	12	3.5	67
Rosa acicularis	leaf	2	1.4	468
Rosa acicularis	twig	<1	0.4	532
Salix glauca	leaf	2	2.3	751
Salix glauca	twig	1	1.1	751
Salix pulchra	leaf	34	21.5	293
Salix pulchra	twig	14	8.2	253

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

TABLE 43

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 - 1-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 44

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 45

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	139
	Total	23166	5864	72

TABLE 46

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	<0.1	108	3	3
	Alnus sinuata	28	0.7	5	3	9
Height (cm)	*Betula glandulosa*	50	0.4	108	3	19
	Alnus sinuata	130	2.4	5	3	5
Utilization (%)	*Betula glandulosa*	1	0.5	108	1	377
	Alnus sinuata	0	0.0	5	3	--

TABLE 47

Total 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
Betula glandulosa	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 48

Average total current annual growth[a] (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		87	23.2	81
Total graminoid		99	31.1	111
Tall shrub				
Alnus sinuata	leaf	4	2.6	582
Alnus sinuata	twig	2	1.4	560
Low shrub				
Betula glandulosa	leaf	5	1.4	95
Betula glandulosa	twig	2	0.7	109
Salix glauca	leaf	3	2.8	1126
Salix glauca	twig	1	1.2	1125
Salix pulchra	leaf	25	7.3	96
Salix pulchra	twig	12	3.6	96

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

TABLE 49

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 - 1-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
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 50

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	4
Total basal tree	1	0.3	4
Total low shrub	6	1.1	1
Betula glandulosa	6	1.1	1

TABLE 51

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 52

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	1075

TABLE 53

Total 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 54

Average total current annual growth[a] (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		203	64.6	38
Total graminoid		8	7.0	323
Low shrub				
Betula glandulosa	leaf	2	0.9	78
Betula glandulosa	twig	1	0.5	81

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

TABLE 55

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 - 1-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
Luetkea pectinata	3	1.9	3
Lycopodium spp.	1	0.6	1
Rubus arcticus	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 56

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	4
Salix pulchra	12	3.0	5

TABLE 57

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 58

Average total current annual growth[a] (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		126	18.8	9
Total graminoid		211	37.8	13
Low shrub				
Betula glandulosa	leaf	5	2.0	65
Betula glandulosa	twig	3	1.1	75
Salix pulchra	leaf	28	15.0	112
Salix pulchra	twig	5	2.6	121

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

TABLE 59

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

	Position	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 60

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 (%)		Height (cm)			Phenological State[a]
	Mean	Standard Error	Mean	Standard Error	No. of Plots	
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 or first signs of new growth or dormant for evergreens, (2) leaf buds, (3) leaves, (4) flower buds, (5) flowers, (6) seeds, (7) decadent.

TABLE 61

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	9
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	9
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 or first signs of new growth or dormant for evergreens, (2) leaf buds, (3) leaves, (4) flower buds, (5) flowers, (6) seeds, (7) decadent.

TABLE 62

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 or first signs of new growth or dormant for evergreens, (2) leaf buds, (3) leaves, (4) flower buds, (5) flowers, (6) seeds, (7) decadent.

TABLE 63

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).

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	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 or first signs of new growth or dormant for evergreens, (2) leaf buds, (3) leaves, (4) flower buds, (5) flowers, (6) seeds, (7) decadent.

TABLE 64

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 (%)		Height (cm)			Phenological State[a]
	Mean	Standard Error	Mean	Standard Error	No. of Plots	
Low Shrub						
<u>Betula glandulosa</u>	8	1.8	51	3.8	17	3
<u>Rosa acicularis</u>	<1	0.1	33	13.3	3	2
Dwarf Shrub						
<u>Vaccinium vitis-idaea</u>	8	1.5	8	0.5	27	1
<u>Vaccinium uliginosum</u>	7	2.1	22	2.0	20	3
<u>Ledum groenlandicum</u>	10	1.8	29	2.2	23	4
<u>Ledum decumbens</u>	6	1.5	18	2.1	15	4
<u>Empetrum nigrum</u>	2	1.1	7	0.9	7	1
<u>Arctostaphylos uva-ursi</u>	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 or first signs of new growth or dormant for evergreens, (2) leaf buds, (3) leaves, (4) flower buds, (5) flowers, (6) seeds, (7) decadent.

TABLE 65

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^2quadrats).

Life form/Species	Cover (%) Mean	Cover (%) Standard Error	Height (cm) Mean	Height (cm) Standard Error	Height (cm) 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 or first signs of new growth or dormant for evergreens, (2) leaf buds, (3) leaves, (4) flower buds, (5) flowers, (6) seeds, (7) decadent.

TABLE 66

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).

Life form/Species	Cover (%) Mean	Cover (%) Standard Error	Height (cm) Mean	Height (cm) Standard Error	Height (cm) 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 or first signs of new growth or dormant for evergreens, (2) leaf buds, (3) leaves, (4) flower buds, (5) flowers, (6) seeds, (7) decadent.

TABLE 67

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	Height (cm) 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 or 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 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 or 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 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	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 frut'cosa			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 or 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 14 June to 18 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	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 or 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 14 June to 18 June, 1982, at Tsusena Creek transect (transect #4) (24 - 0.5-m^2 quadrats).

Life form/Species	Cover (%)		Height (cm)			Phenological State[a]
	Mean	Standard Error	Mean	Standard Error	No. of Plots	
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 or 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 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 or 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 21 June to 25 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	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 or 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 21 June to 25 June, 1982, at Switchback transect (transect #3) (32 - 0.5-m2 quadrats).

Life form/Species	Cover (%) Mean	Cover (%) Standard Error	Height (cm) Mean	Height (cm) Standard Error	Height (cm) 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 or 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 21 June to 25 June, 1982, at Tsusena Creek transect (transect #4) (24 - 0.5-m^2 quadrats).

Life form/Species	Cover (%) Mean	Standard Error	Height (cm) Mean	Standard Error	No. of Plots	Phenological State[a]
Low Shrub						
Betula glandulosa	19	2.9	80	6.5	22	3
Dwarf Shrub						
Vaccinium vitis-idaea	6	1.1	9	0.8	19	2
Vaccinium uliginosum	7	1.6	24	2.3	16	4
Ledum groenlandicum	12	3.4	25	2.7	14	4
Ledum decumbens	5	1.9	24	3.1	5	4
Empetrum nigrum	15	4.6	10	1.0	14	4
Arctostaphylos uva-ursi	6	1.1				
Forb						
Cornus canadensis	<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 or 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 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 or 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 28 June to 2 July, 1982, at Jay Creek transect (transect #2) (32 - 0.5-m^2 quadrats).

	Cover (%)		Height (cm)			
Life form/Species	Mean	Standard Error	Mean	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 or 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 28 June to 2 July, 1982, at Switchback transect (transect #3) (32 - 0.5-m^2quadrats).

Life form/Species	Cover (%) Mean	Standard Error	Height (cm) Mean	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 or 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 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 or 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 *Betula glandulosa* during week of 7 June to 11 June, 1982, at each elevation within each tansect.

Position	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 or 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 *Mertensia paniculata* during each week at the mid-slope elevation of the Jay Creek transect, 1982.

Date	Cover (%)	Height (cm)	Phenological State[a]
1 June	2.5	7.5	2.8
8 June	3.6	13.2	3.8
15 June	7.8	22.7	4.2
22 June	8.5	18.9	3.6
29 June	14.4	38.2	4.6

[a] Phenological state: (1) just emerging from ground or 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

Mean (±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 major shrubs sampled inside and outside exclosures during weeks 1 through 6 (5/82 - 8/82) in the middle Susitna River Basin.

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
[illegible]	[illegible]	[illegible]	[illegible]				[illegible]								
		[illegible]	[illegible]				[illegible]								
		[illegible]	[illegible]		[illegible]		[illegible]								
		[illegible]	[illegible]		[illegible]						[illegible]				
	2	1					6.40±1.00								
		2			1±1		6.87±1.04								
		3		15±12	28±22			3.95±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	10±7										35.25±7.25
	4	1					4.63±0.63								
		2					5.13±0.35								
		4					2.88±1.69								
2	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	0.88±0.09	9.30±1.23								
		4			70±23	3.25±1.91	2.30±1.38								
	3	1				2.63±0.68	3.88±0.09								
		2				2.63±0.55	3.63±0.38								
		3			4±4	3.95±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

TABLE 82 (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
		1					[illegible]								
		[illegible]					[illegible]								
		4					[illegible]								
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	4.90±0.75								
		4		18±18											
	2	1				3.05±1.39	4.00±1.08								
		2		9±9		3.63±1.33	3.00±1.48			1.63±1.63	2.55±2.50				
		3		67±67	32±32			10.00±0.90	8.12±1.49						
		4			83±30										
	3	1				2.25±0.41	1.05±0.35								
		2		1±1		2.95±1.00	2.30±0.81								
		3			9±5	3.30±1.20	2.75±0.96								
		4		75±37	121±63					4.00±4.00	1.50±1.50			1.00±1.00	1.25±1.25
	4	1					2.63±0.99								
		2				0.95±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±1.50	4.00±1.54								
		3		3±3		3.30±1.94	2.30±1.38								
		4		50±29	15±7										
	2	1				2.75±1.07	2.63±0.94								
		2			13±13	2.00±1.13	2.25±0.86								
		3		140±72	117±60			9.95±5.74	4.38±2.63						
		4		13±10	95±32	1.95±1.64	1.30±1.00								
	3	1		2±2		4.43±1.71	3.13±1.15								
		2		4±3	35±31	4.00±2.05	2.00±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

TABLE 62 (continued 3)

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
	4	1				3.30±0.09	4.30±0.21								
		2				3.95±1.51	4.63±1.03			5.00±5.00	4.30±4.30				
		4		2±2		5.37±0.00	4.00±0.00								
5	1	1				4.15±1.46	3.92±1.63								
		2		2±2		5.30±3.06	3.00±2.34								
		3			0±3										
		4		2±2	31±24										
	2	1			1±1										
		2			6±3	16.95±4.85	10.57±3.10								
		3		152±63	119±00			3.13±3.13	1.00±1.00						
		4			210±30	3.30±1.94	3.43±2.00								
	3	1				4.95±0.95	3.05±0.74								
		2		7±7	15±9	1.75±1.75	2.00±2.00								
		3		34±22	0±2	4.75±3.14	3.43±2.60								
		4		6±2	114±49										
	4	1			1±1	6.00±1.23	5.50±1.18								
		2		91±51	91±63	6.50±1.16	6.95±1.00								
		4				5.75±1.18	5.62±1.13								
6	1	1	in		5±6	6.25±0.76	2.77±1.19								
			out	6±6	11±9	3.13±1.00	3.92±2.30								
		2	in	13±7	1±1	2.00±0.19	3.25±1.21								
			out	1±1	1±1	9.30±3.00	8.05±0.63			9.95±5.95	3.95±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	1.95±1.95								
		4	in	35±14	11±7										
			out	34±17	167±154										

TABLE 82 (continued 4)

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
	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	6.30±2.01								
			out	30±8	6±4	4.68±1.89	4.63±1.72								
		3	in	1170±345	579±310										
			out	316±85	281±209										
		4	in	94±31	78±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	5.00±1.41	7.05±1.81								
			out	5±5	1±1	7.30±3.48	9.00±4.86			0.64±0.63	1.00±1.00				
		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±67	30±10	5.30±0.35	6.05±0.33								6.00±6.00
			out	42±22	4±3									6.67±6.67	
		4	in	121±49	230±82									30.67±4.88	23.37±5.74
			out	16±2	411±270			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±1.30								
		2	in	54±23	2±1	5.25±1.71	3.60±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								

* Elevation 3 not established at transect 4.

TABLE 83

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.

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
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 83 (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
[illegible]	[illegible]	in		[illegible]±100	[illegible]±20	20±[illegible]								
[illegible]	[illegible]	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 84

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 85

Hectares and percentage of each the Primary, Secondary and Control burn areas covered by vegetation types 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 86

Average diameter at point-of-browsing (DPB) for browsed twigs, weight/twig, and weigh- of leaves attached to clipped twigs in the Alphabet Hills.

Species	DPB (mm)	Leaf (g)	Twig (g)
Betula glandulosa	2.4	0.30	0.35
Salix glauca	3.5	0.74	0.46
Salix lanata	3.0	0.58	0.36
Salix pulchra	2.8	0.65	0.51

TABLE 87

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.[illegible]	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 88

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 89

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	*Betula glandulosa*	1	0	64	2	1
	Salix pulchra	2	0	80	2	1
Utilization (%)	*Betula glandulosa*	12	2.5	64	2	77
	Salix pulchra	12	2.0	80	2	54

[a] Site #23 heavily browsed, data missing

TABLE 90

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

Species	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 91

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 92

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	1500	11				
Rosa acicularis	33786	1143				
Salix glauca	357	—				
Salix lanata	643	250				
Salix pulchra	15500	1857				

[a] 4-m^2 quadrat

[b] Point-centered quarter

TABLE 93

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	*Betula glandulosa*	1	0	261	7	1
Diameter	*Salix glauca*	1	0	13	2	1
Class	*Salix lanata*	2	0	22	1	1
	Salix pulchra	2	0	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 94

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

Species	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 95

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 96

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						
Picea glauca			361	15	95	200
Picea mariana			87	1	48	200
Tall shrub						
Alnus sinuata	150	—				
Low shrub						
Betula glandulosa	57950	4300				
Rosa acicularis	3200	—				
Salix glauca	100	—				
Salix lanata	100					
Salix pulchra	25400	4150				

[a] 4-m^2 quadrat

[b] Point-centered quarter

TABLE 97

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

Species	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	1060	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 98

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	Betula glandulosa	1	0	178	5	1
	Salix glauca	2	0	164	5	1
	Salix lanata	2	0	2	2	1
	Salix pulchra	2	0	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 99

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
Hierochloe 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 100

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 101

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	2	0	276	7	1
Diameter	Salix glauca	2	0	36	5	1
Class	Salix pulchra	2	0	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 102

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

Species	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 105

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 104

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 105

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	_Betula glandulosa_	2	0	120	3	1
Diameter	_Salix glauca_	2	0	14	3	1
Class	_Salix pulchra_	2	0	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 106

Total available and utilized leaf, twig and total biomass (kg/ha) estimated from number of unbrowsed and browsed twigs/ha[a] and stem densities (number/ha) from 3 sites in the Dwarf Birch - Willow vegetation type, Alphabet Hills.

Species	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.

FIGURE 1

Location of Susitna River Basin and Alphabet Hills study areas in southcentral Alaska.

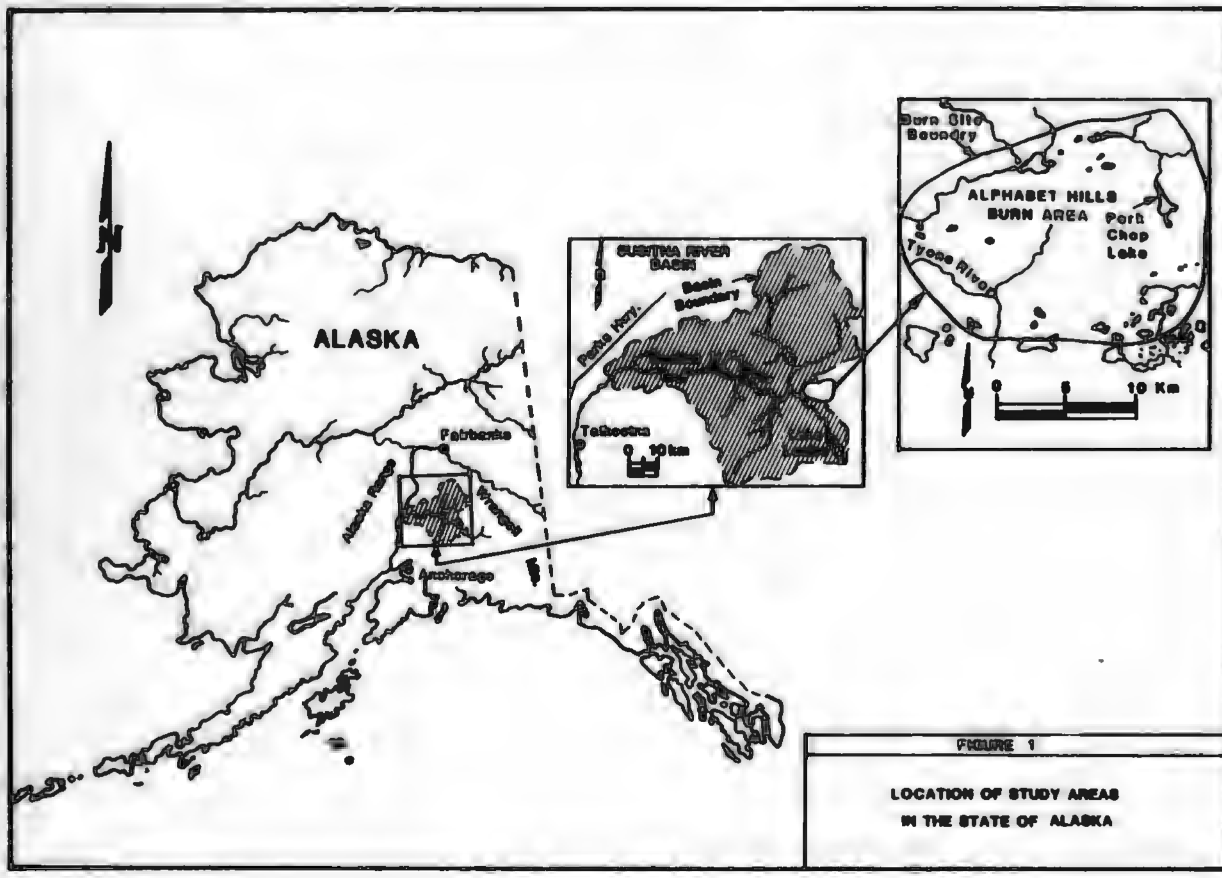

FIGURE 1

LOCATION OF STUDY AREAS IN THE STATE OF ALASKA

FIGURE 2

Location of transects for 1982 plant phenology study, middle Susitna River Basin.

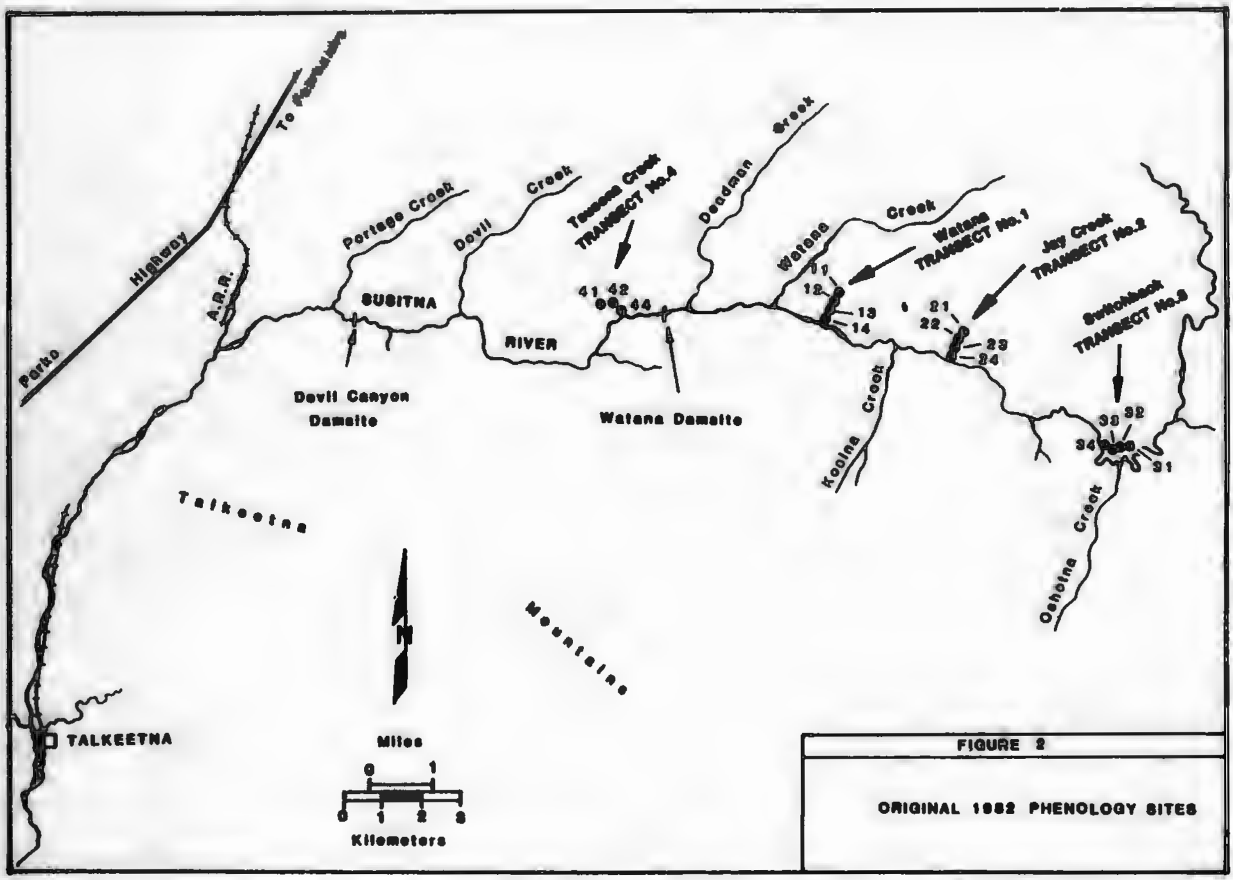

FIGURE 2

ORIGINAL 1982 PHENOLOGY SITES

FIGURE 3

Location of individual sites from 1982 browse inventory study, middle Susitna River Basin.

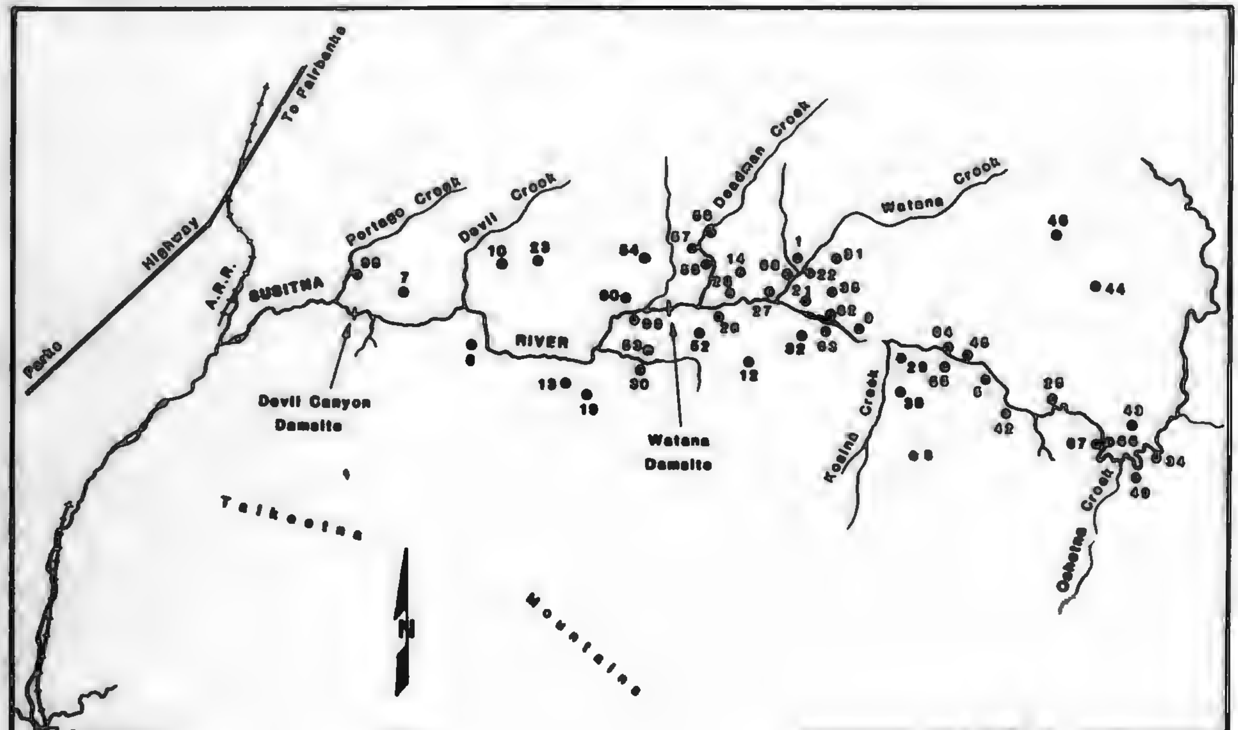

FIGURE 3

1982 BROWSE INVENTORY LOCATIONS

FIGURE 4

Vegetation map (1:24,000) of 1982 Alphabet Hills pe-burn inventry and assessment study (back pocket) showing primary, secondary, and control burn boundaries, southcentral Alaska.

FIGURE 5

Mean biomass of forbs and graminoids (kg/ha current annual growth) by week, plant phenology study, middle Susitna River Basin.

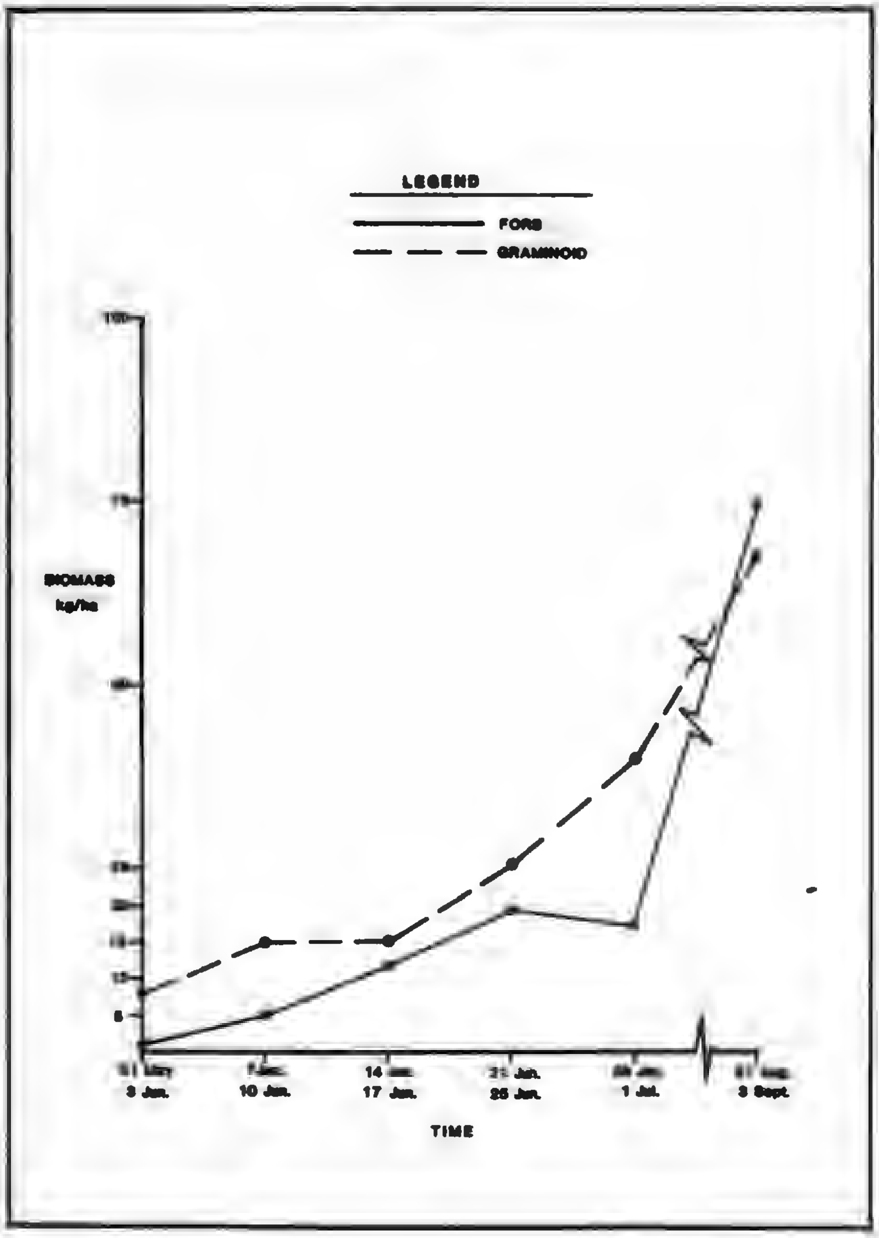
LEGEND
FORB
GRAMINOID
BIOMASS
kg/ha
5
3 Jun.
10 Jun.
14 Jun.
17 Jun.
21 Jun.
25 Jun.
1 Jul.
3 Sept.
TIME

FIGURE 6

Plot of basal diameter and length of twigs of current annual growth for 5 shrubs, plant phenology study, middle Susitna River Basin.

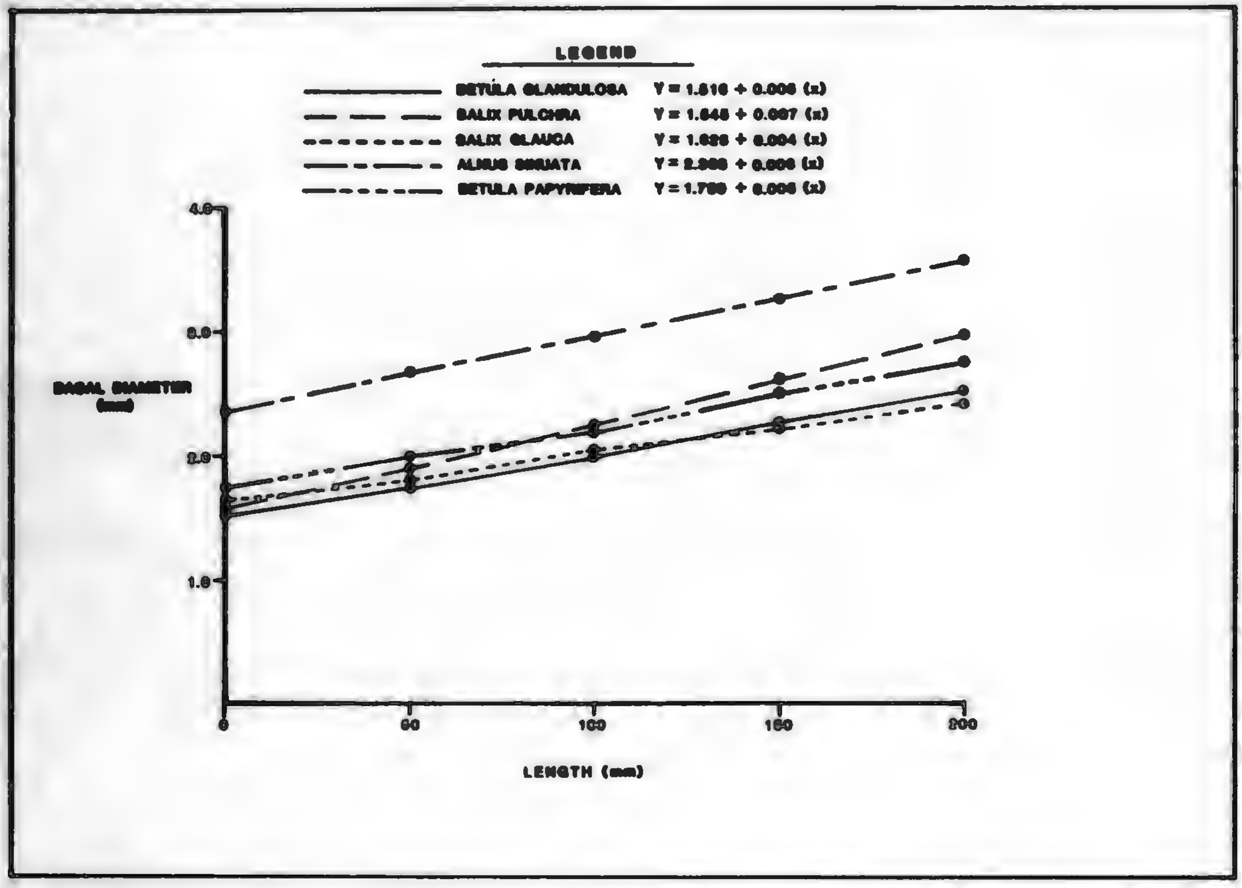
LEGEND
BETULA GLANDULOSA
SALIX PULCHRA
SALIX GLAUCA
ALNUS SINUATA
BETULA PAPYRIFERA
4.0
3.0
2.0
1.0
BASAL DIAMETER (mm)
0
50
100
150
200
LENGTH (mm)

FIGURE 7

Individual sites of relocated exclosures following 1982 plant phenology study, middle Susitna River Basin.

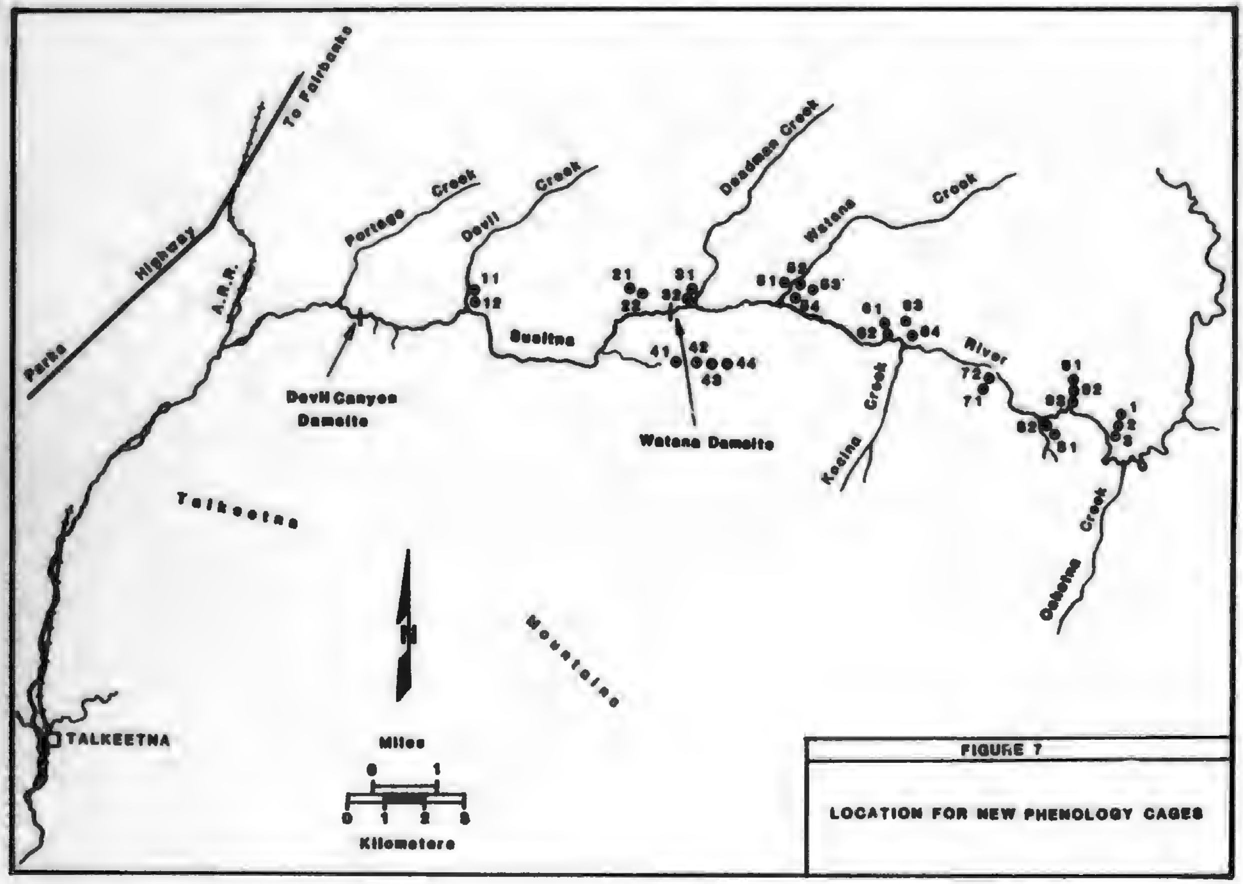

FIGURE 7

LOCATION FOR NEW PHENOLOGY CAGES

FIGURE 8

Location of individual sites from 1982 Alphabet Hills pre-burn inventory and assessment study.

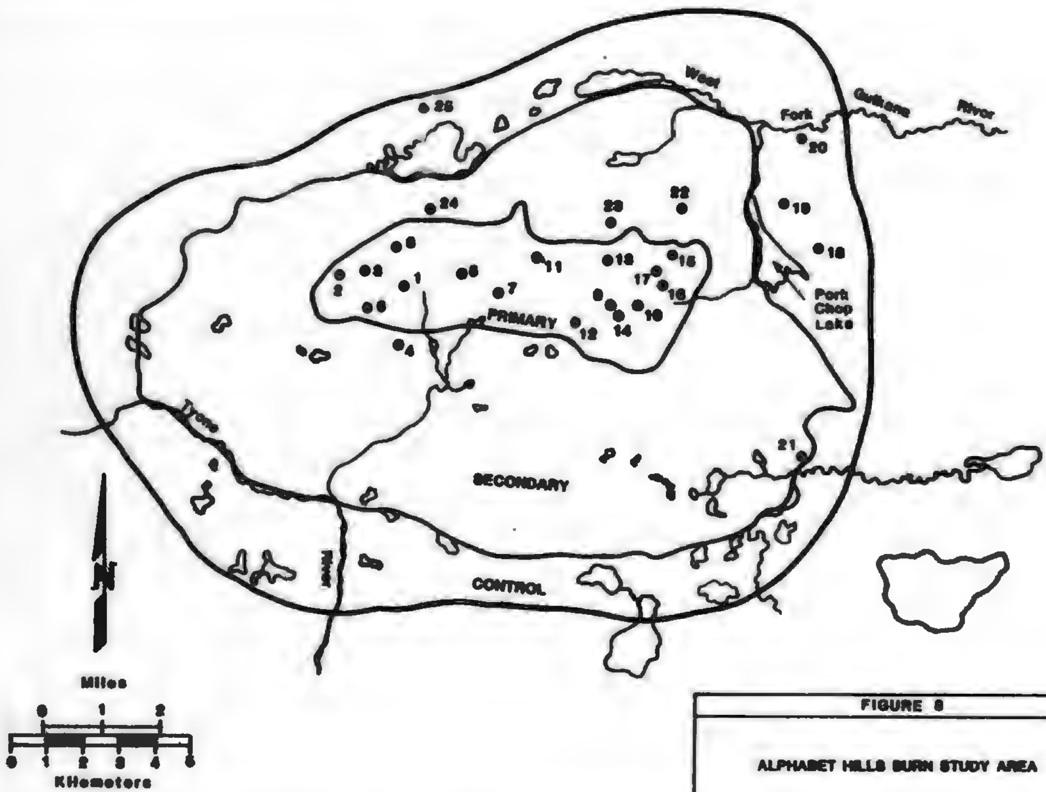

FIGURE 8

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 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 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 Pallas	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		
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

Potamogetonaceae

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

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 sp.	Dandelion	U

Cornaceae

Cornus canadensis L.	Bunchberry	U D

Crassulaceae

Sedum rosea (L.) Scop.	Roseroot	U

Cruciferae (Brassicaceae)

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 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 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
Arctostaphylosuva-ursi	Bearberry
Cassiope stellariana	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

APPENDIX B (continued)

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
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 spp.