SUSITNA HYDROELECTRIC PROJECT

FEDERAL ENERGY REGULATORY COMMISSION
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PLANT PHENOLOGY STUDY

PREPARED BY

UNIVERSITY OF ALASKA
PALMER

FINAL REPORT

UNDER CONTRACT TO
HARZA-EBASCO
SUSITNA JOINT VENTURE

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ENVIRONMENTAL STUDIES
PLANT PHENOLOGY STUDY

Prepared by

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Under Contract to
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Prepared for
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Final Report
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NOTICE

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

SUMMARY

Movements of radio-collared moose (<u>Alces alces</u>) in the potential impoundment area of the Susitna Hydroelectric Project during spring prior to parturition prompted questions of why moose were using these areas at this time of year (Ballard et al. 1982). The 1982 phenology study emphasized a few areas of the impoundment zones where moose seemed to concentrate at this time of year and nearby areas where they did not concentrate. Marked locations were studied each week for 5 weeks, however, the investigation did not start until early June, past the critical period. The phenology study was expanded in 1983 to obtain data over a wider area, at the cost of using fixed locations and gathering environmental data, and was initiated earlier in the season. Additionally, since bear (<u>Ursus</u> spp.) movements were believed to be affected by availability of horsetail (<u>Equisetum</u> spp.) and overwintered berries in these areas (Miller and McAllister 1982, Miller 1983), abundance of horsetail and berries were also measured.

The initial hypothesis suggested by the Alaska Department of Fish and Game (ADF&G) was that moose were consuming forbs during this time period, and might be eating them to ground level. Exclosures were constructed in late May 1982 at four elevations along four transects on south-facing slopes to protect plants from grazing and to provide a fixed location where plant development could be studied over time. The general areas of study were based on areas of moose concentration on south-facing slopes, and concentrations sometimes occurred on the north-facing slopes. This theoretically permitted an evaluation of why moose used certain south-facing slopes and not others, but sometimes used north-facing slopes. Exclosures were visited each week to measure vegetation and soil temperatures.

Elevation within transect and transect location had a significant effect on soil temperature, plant canopy cover, and current growth biomass during the spring period. However, the effects of elevation were not consistent among transects. On some transects vegetation matured faster at the bottom-elevation site while on others it matured faster at the middle-slope or at the highest elevations. Vegetation along one of the transects matured much later than along any other transect. Timing of vegetation development resulted from an interaction of climate, topography, and site history. Recent fire (last 40 - 70 years) appeared to be the common factor among early developing areas. Maturation rates differed among species at the same site. Most early-developing sites that were studied were above the level of the potential impoundments.

Nine areas of moose concentration were selected for sampling during 1983 after consultation with the ADF&G: Devil Creek, Tsusena Creek, Fog Creek, Watana Slide, Watana Creek, Fish Creek, Kosina Creek, Clarence Creek, and Switchbacks. Four areas had north- and south-facing transects that began on benches above the potential impoundment and descended to the Susitna River. The other transects were either completely above or below the impoundment, had only one aspect, or were along a tributary stream.

Transects were sampled each period at 10-m intervals with observers recording a coded value for elevation, aspect, slope, vegetation type, snow depth, and species identification, phenological stage and utilization of the closest shrub, forb, or graminoid within a 0.5-m radius of the snowshoe or

boot tip. Coded values for abundance of over-wintered berries and horsetail were also recorded. The transects were flagged so the same approximate stops were sampled each week. However, it was not possible to sample the exact stop in different sample periods or to obtain consistent values for the various parameters. Data were analyzed using 2-way contingency tables and log-linear models on reduced data. This methodology permitted sampling more areas than the 1982 study when detailed methods with relatively fixed locations were used. Variables that affected phenological development or snow melt could not be confidently isolated although some trends were noted for south-facing slopes, usually greater than 3° in closed forest or low shrub types. Sample sizes in the various cells limited the confidence placed in these generalizations.

Berries were too scarce to conclude anything about locations with this methodology. However, in areas with abundant berries, they were available during sample period 1. Horsetail, however, was found on 0-3° slopes in open forests below the impoundment zone. It frequently was not visible until the second sample period. Phenological development data for horsetail were available only where it was the closest forb to the boot tip. Hence, it could not be tracked over time, although the latest observations were that it was half grown. A large percentage of areas where overwintered berries were concentrated in 1983 probably will not be inundated by the project, but a large percentage of the horsetail sites probably will be flooded.

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1 INTRODUCTION

The plant phenology - moose utilization study was initiated because it was suspected that pregnant cow moose concentrated along south-facing slopes and some north-facing slopes of the Susitna River valley during calving (Ballard et al. 1982) to take advantage of any late winter - early spring growth by herbaceous plants. Energy reserves of moose are probably near depletion by late winter. Parturition and lactation further increase energy demands of cow moose.

Graminoids and forbs that are breaking quiescence and actively photosynthesizing immediately prior to and during moose calving would have relatively greater energy content than many of the shrubs present (Cook 1971). Shrubs, graminoids, and forbs all have high energy content when in vegetative stages, far beyond what is needed for gestation and lactation in domestic large ungulates (Cook 1971). Archer and Tieszen (1980) have shown that at Atkasook, Alaska, 2 graminoid species initiated growth sooner than the shrub species diamondleaf willow (*Salix pulchra*) and northern Labrador tea (*Ledum decumbens*). Graminoids and forbs produce only photosynthetic tissue while these 2 shrub species may allocate 75-84% of their total nonreproductive, above ground biomass to stems (Archer and Tieszen 1980). Thus, herbaceous plant production in late winter-early spring could be critical to moose reproductive success.

The original objective of the phenology study was to determine if early spring growth of forbs on the slopes of the impoundment areas were providing forage for cow moose prior to parturition. Since the possibility existed that the moose could completely remove the forbs, exclosures were built to protect the vegetation and provide an area of "intensive" sampling. Hence the study was relatively intensive in a few locations and relatively cursory in other locations to cover the areas needed to explore this hypothesis. As implemented the second year, the objective was broadened to monitor vegetation development during early spring to determine if early forage availability occurred in some areas before others and why these differences occurred. It had been hypothesized that herbaceous vegetation development would occur first on the south-facing slopes.

The 1982 results indicated no conclusive evidence of specific forb removal by moose during the spring from south-facing slopes as had been hypothesized originally. Early green-up areas were also located on north- as well as south-facing slopes.

The specific inclusion of horsetail and berries in the second study (1983) was an attempt to assess their influences on early spring bear movements. Information on radio-collared brown (*Ursus arctos*) and black bears (*U. americanus*) indicated many sightings below the potential impoundment level during early spring, possibly related to the early appearance of horsetail in the lower lying areas (Miller 1983). Hence, another phenology study was initiated in April 1983 to monitor snow melt, to cover a broader area than the 1982 study, and to evaluate relative abundance of overwintered berries and horsetail. Methods, which will be described later, were those desired by the Alaska Department of Fish and Game (ADF&G).

Many studies have investigated the phenological development of plant species, particularly as it related to range readiness or forage availability and its relationship to environmental variation. Clary and Kruse (1979) discussed the use of forbs as indicator species for range readiness for deer in southwestern states. Halls (1973) evaluated flowering and fruiting of browse species with respect to weather information. Komonov (1981) used multiple regression analysis to quantify important environmental factors affecting plant development. McGee (1976) reported that shade in the previous year affected budbreak on oak seedlings. Hoefs (1979) observed that vegetation on mid-slope elevations tended to develop earlier than higher or lower elevations on Sheep Mountain in the Kluane Lake area, Yukon Territory. Pearcy and Ward (1972), however, found that individuals of tufted hairgrass (Deschampsia caespitosa) responded differently in phenological development based on their original elevation. However, their elevation ranges were much larger than ours. Stewart et al. (1976) evaluated phenological development and energy relationships for browse in Saskatchewan, which were related to moose energy requirements and snow depth. Some of these studies supported the belief that spring plant development was related to topographic factors, but the information was needed for specific areas in the Susitna basin.

2 OBJECTIVES

Objectives of the 1982 phenology study were to:

1. Identify any forbs that might be grazed by moose prior to parturition.
2. Monitor species development weekly during the spring.
3. Monitor soil temperatures weekly to have a parameter that could be compared across sites. Different plant species common to the various vegetation types initiated growth under different conditions so did not make good standards for comparisons of several locations.
4. Determine if grazing had a significant effect on vegetation during the spring.

Objectives of the 1983 phenology study were to:

1. Identify what areas became snow free first in relation to aspect, elevation, slope, and vegetation type.

2. Identify where forage became available for moose first.

3. Identify where overwintered berries were most abundant and when they were available.

4. Identify where horsetail occurred most abundantly and when it became available.

5. Identify utilization of early growth vegetation.

The overall objective was to evaluate snow and plant species development as they might relate to moose and bear movements during snowmelt.

3 SITE DESCRIPTION

3.1 1982 Site Descriptions

3.1.1 Watana Creek Transect

The bench location upstream from the Watana Creek transect (Figure 1) 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. Resin birch (Betula glandulosa) dominated the low shrub layer while Labrador tea (Ledum groenlandicum), bog blueberry (Vaccinium uliginosum), and mountain cranberry (V. vitis-idaea) dominated the dwarf shrub layer. Moss covered almost 90% of the ground. The average age of four large trees in the areas was 94 years, making it a relatively old site. Methodology describing the aging technique used for tree cores is contained in the Methods section.

The exclosure at the top of the slope was in an ecotone between low birch shrub scrub and woodland spruce. It was at an elevation of 683 m (2240 ft) with a 5°slope and 150° aspect. This would be 17 m above the potential impoundment water surface. Vegetation consisted of resin birch in a low shrub layer with a dwarf shrub layer of Labrador tea, mountain cranberry, and crowberry. Moss provided about 65% ground cover. The mean age of three white spruce (Picea glauca) individuals was 82 years.

The middle-slope location along the Watana Creek transect was in open white spruce forest located on the side 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 low shrub layer dominated by resin birch with Labrador tea, bog blueberry, and mountain cranberry in the dwarf shrub layer. Bog blueberry was more abundant in the south-facing exclosure while resin birch was more abundant in the west-facing exclosure. Moss formed 90% of the ground cover. Trees averaged 62 years (N=4) making it a medium-aged site. Old snags were present but not aged.

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

3.1.2 Jay Creek Transect

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

The second elevation, top position, was another low birch shrub scrub type located on a gentle break in the 15° slope. Elevation was 792 m (2600 ft) on a 5° slope with 144° aspect. The low shrub layer was composed of *B. glandulosa* and a dwarf shrub layer of northern Labrador tea and mountain cranberry. Resin birch usually occurred on mounds, and other shorter species grew beneath the shrub layer. Most trees at this site averaged 31 years of age although one was 100 years old and a dead tree was 157 years old.

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

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

3.1.3 Switchback Transect

The bench location at the Switchback transect (Figure 1) 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 resin birch low shrub layer and a dwarf shrub layer of northern Labrador tea, mountain cranberry, and lichens. The average age of three trees was 35 years, although one tree was 91 years old. Hence, the area was probably disturbed by fire within the last 40 to 50 years.

The top-slope elevation (762 m, 2500 ft) was located on the bench just above where the terrace sloped toward the river, and was 96 m above the potential Watana impoundment. This site was in an ecotone between low birch shrub scrub and woodland white spruce forest with an average slope of 1° and aspect of 275°. Important species included resin birch, bog blueberry and lichens. Average age of three trees was 56 years while a fourth individual was 163 years old. Fire scarred snags were present, again indicative of disturbance.

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

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

3.1.4 Tsusena Creek Transect

The transect downstream from Tsusena Creek was the only one in the potential Devil Canyon impoundment area (Figure 1). 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 two exclosures were 232° and 86° at this site which was on top of a knoll. Abundant vegetation consisted of resin birch over a layer of Labrador tea and crowberry. Resin birch was much taller at this site than at other sites. Moss covered about 85% of the area and was about 8 cm deep, much deeper than at any other location. Average age of three trees was 114 years while one individual was 56 years old. Trees were rare at this location. This site had not been disturbed as recently as other sites and was well above present timber line.

The top-slope position on the Tsusena Creek transect was another low birch shrub scrub type at an elevation of 635 m (2086 feet) on a 7° slope with aspects of 110° and 20°. Vegetation consisted of a low shrub layer of resin birch and a dwarf shrub layer of Labrador tea and crowberry. Moss covered about three-fourths of the ground and was about 8 cm deep. Average age of four trees was 87 years.

No middle-elevation exclosure was constructed because of difficulties getting equipment there with tree cover. The bottom location was in an open spruce type with 2° slope and aspects of 5° and 140° at an elevation of 512 m (1680 ft). This site was on a level, forested area by the Susitna River. Vegetation consisted of resin birch, Labrador tea, and mountain cranberry. Moss covered 90% of the ground. Mean age of four trees was 135 years.

3.2 1983 Site description

Vegetation along the 1983 transects cannot be described in as much detail as the 1982 transects since descriptive data were not collected and time limitations did not permit taking sufficient field notes. Nomenclature for vegetation types follows Viereck et al. (1982). General descriptions of these vegetation types in the middle Susitna basin are found in McKendrick et al. (1982).

3.2.1 Devil Creek

The area that had been indicated as a moose concentration area extended from above Devil Creek's first tributary up the Susitna River to the second bend above Devil Creek (Figure 2). Devil Creek transects started in low shrub types dominated by resin birch, bog blueberry, some willows, and other shrub species on the benches on each side of the river, upstream from Devil Creek. The south-facing transects passed through open to closed mixed forest with an understory of bluejoint and mountain cranberry on slopes that were occasionally steep. The north-facing transects descended through alternating sections of low shrub and open and woodland spruce forest types with typical shrub understories. The last portion, approximately 50 m in elevation, was relatively steep. Alder were more common at the bottom of this transect than on the south-facing slope. Ice jams had deposited ice at the bottom of both transects during period 2 (week of May 1). Bears were observed at the top of the south-facing slope. Some utilization of resin birch, alder, and sedges was noted, presumably by moose.

3.2.2 Tsusena Creek

The area of moose concentration around Tsusena Creek extended from the stream below Tsusena Creek, including some upper stretches, up beyond Deadman Creek about one third the distance to Watana Creek (Figure 2). The Tsusena Creek transects started in a well-drained, somewhat disturbed opening and descended through mixed birch-spruce forests which contained bluejoint and mountain cranberry in the understory until poorly-drained black spruce types were entered on a flat lowland. The transects traversed this until they reached a strip of riparian forest and riparian low shrub types near the river. This area was relatively well advanced even when first visited.

This contrasted greatly with a transect sampled in 1982, located downstream a short distance. The 1982 site was a relatively cold area that was late developing. Deep moss layers were common. The 1983 site seemed to have younger vegetation and seems to have been disturbed more recently.

3.2.3 Fog Creek

The Fog Creek area of moose concentration paralleled the stream near the Fog Lakes area and involved less than 100-m elevation difference. The south-facing transects started in a low shrub-dwarf tree scrub area and proceeded across some wet areas. They then climbed a well-drained ridge covered with spruce and descended to a willow stand along a feeder stream. Many moose pellets were found in this area. The north-facing transects started in a low shrub type then proceeded over a hillside covered with spruce. They descended into a creek bottom area that was hummocky and contained large spruce trees.

3.2.4 Watana Slide

An area of moose concentration had been indicated by ADF&G on the north side of the Susitna River and extended up Watana Creek. The Watana Slide transects were up Watana Creek a short distance from a mud slide that occurred sometime between summers 1982 and 1983. They included elevations above and below the impoundment. The east-facing slopes had a number of old earth slides and some areas that looked like they might slide if conditions were right. Silt was deposited by wind on litter and low-growing vegetation just above the first of two sets of bluffs, which were probably old slide scars. This silt appeared to inhibit growth since the dust-covered plants were shorter than adjacent dust-free plants. The east-facing transects started in a woodland forest-dwarf tree scrub area with many snags from old fires. They descended among some very old slides then followed a small stream over flat terrain. They reached a more recent set of slides then descended into a flat area vegetated with willows and horsetail.

The west-facing transects began in a low shrub type abundant with bog blueberry, resin birch, and crowberry, then passed through shorter spruce (< 6 m tall), and finally taller spruce (> 6 m tall) on the floodplain. Robust feltleaf willow (Salix alaxensis) had been browsed heavily at the bottom of these transects and moose pellets were abundant. The last snow to melt along these transects was on the floodplain.

3.2.5 Watana Creek

Watana Creek transects were located on both sides of the Susitna River just upstream from the mouth of Watana Creek. Their highest elevations were still beneath the level of the potential impoundment. The south-facing transects began in a wet low shrub area, then passed through spruce vegetation. One transect ended in mature mixed balsam poplar-white-spruce type along Watana Creek. The other passed through a stand of willows near the Susitna River. The north-facing transects started in a woodland spruce area, descended gradually through spruce, then entered a flat woodland forest-dwarf tree scrub area with relatively poor drainage. They then descended over another steeper slope covered with thick moss. Alders were arranged in a band of vegetation above where the transects entered the open strip of shrubs and herbaceous species by the river. The 1983 Watana Creek transects were considerably downstream from the 1982 Watana Creek transects, which were called Fish Creek in 1983.

3.2.6 Fish Creek

Another moose concentration area was observed only on the north side of the river from Fish Creek to Kosina Creek with elevations ranging from the river to the benches. Hence, comparisons of the north- and south-facing slopes for Fish and Kosina Creeks might indicate why moose occurred mainly on south-facing slopes rather than north-facing slopes in the area.

Fish Creek transects were located just downstream from a small feeder stream and were the locations called Watana Creek in 1982. They were about half-way between Watana and Jay Creeks. The south-facing transects began in a wet low shrub area, passed through woodland and open white spruce types, then descended gently through more white spruce vegetation.

Phenology

Black spruce was growing on a poorly-drained area above where the transects made a final, steeper descent through birch-spruce with some aspen (Populus tremuloides) and a fringe of willows along the floodplain. The south-facing transects were relatively long. The north-facing transects originated on a gently sloping low shrub site then descended gently through black spruce and a small drainage. There was a steep descent through spruce before encountering the open strip of riparian vegetation along a slough by the river. High water levels sometimes inundated this vegetation so the stops parallel to the river were moved downstream a little. Iris (*Iris* sp.) and sweet-vetch (*Hedysarum* sp.) had been utilized on an island across the slough.

3.2.7 Kosina Creek

Kosina Creek transects were located a short distance downstream from Kosina Creek. Concentrations of moose had been reported on the south-facing slopes in the past (W.B. Ballard, personal communication) and were observed during this study. The south-facing transects began on a gentle slope covered with low shrub vegetation dominated by resin birch and bog blueberry then went downhill through combinations of aspen, paper birch, and white spruce. White spruce in the understory in some of the aspen-dominated portions of the transects were only 2-3 m tall and apparently were invading the site since they appeared younger than the aspen. One closed aspen area had living and dead trees the same size and a lot of dead fall. Apparently two disturbances had occurred, resulting in much growth of young trees. Green bark was stripped from willows, and mountain cranberry had been browsed near the bottom of these transects, hence the area was apparently used in the spring.

The north-facing transects descended through alder and spruce on steep slopes. South-facing slopes occurred near the bottom of the transect where dips occurred. A strip of alder occurred above a narrow band of willows by the river. Many animal signs were found on both slopes, although most tracks on the north-facing transects occurred in the relatively flat areas where travel was easier. The animal trails appeared to be transitting areas, rather than connecting snow-free areas where animals could utilize shrubs.

In other words, although animals apparently travelled through the area, they were not eating much.

3.2.8 Clarence Creek

The moose concentration area around Clarence Creek, a small stream draining Clarence Lake, extended up Clarence Creek and down the south side of the Susitna River. This area was unusual in that it faced north, but few moose locations occurred on the south-facing slopes. Most other moose concentration areas either faced south or contained both aspects. The transects started in dwarf spruce scrub, descended through spruce, then alder in a draw, to a dry, open knoll. They then passed through more spruce, and then a strip of alder before reaching the river. This was also the site of a spectacular ice jam which covered most of the shrub and herbaceous vegetation by the river. Snow occurred later here than most sites.

3.2.9 Switchbacks

The concentrations of moose in the switchback area were on the north side of the river on the benches, much of which was covered by low shrub or dwarf spruce scrub, and contained many fire-scarred areas. The benches on the south side also contained many old burn areas, but were drier. The south-facing transects started in some moist low shrub sites which contained scattered spruce trees and snags and which were dominated by resin birch and willow. They descended through scattered, disturbed sites near a stream, through alder thickets, over a dry, open knoll, and through wet willow vegetation before reaching the shore. The north-facing transects descended from a low shrub-woodland white spruce area through a wide strip of alder, into some small, relatively flat areas with willow near small drainages. A variety of open areas were passed until a large poorly drained area of cottongrass (Eriophorum spp.) tussocks with scattered dwarf black spruce trees was encountered. A final descent was made through alder to the strip of small shrubs at the bottom.

4 METHODS

4.1 1982 Methods

4.1.1 Site Selection

Transect locations were selected based on concentrations of radio-collared moose in the impoundment zone during parturition periods (Figure 1). Locations were chosen to represent areas of use and non-use by radio-collared moose during April-June, the usual period of parturition (Ballard et al. 1982). It was recognized that nonradio-collared moose might be using areas that were not being used by radio-collared moose. However, this was the best approximation available for an experimental design. Areas of "use" and "non-use" were included in the design to attempt to identify differences in vegetation that were attractive to cow moose.

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

Transects were generally about 1.5 km long, although one was 2 km. The "transects" were lines used for qualitative, non-structured observations, especially on the north-facing slopes. Transects generally followed the easiest path down, which was usually along animal trails which permitted more observations of animal signs. Exclosures were constructed at discrete points along the transects on the south-facing slopes.

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

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

Transects were sampled at 7-day intervals beginning 31 May and ending 2 July, 1982. The south-facing slope exclosures were sampled in the morning for all transects except Watana Creek. The corresponding north-facing slope without exclosures was examined in the afternoon for general observations on vegetation composition and phenological development as well as utilization by wildlife. The north-slope at Watana Creek was visited at the end of each week for logistical reasons. Sampling was not begun until after snowmelt because of project delays.

4.1.2 Photographic Points

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

4.1.3 Soil Temperature

Soil temperature at the 1-cm depth was taken inside each exclosure using a bimetallic thermometer with a dial scale. The temperature was always measured in a "typical" location in the shade to avoid daily heating effects of the sun. Hence, the thermometer location varied slightly from week to week because the sun angle as well as our arrival time would vary. The thermometer was allowed to equilibrate in the ground while plant canopy cover was estimated. Soil temperatures were used to monitor the warming of sites because daily ambient temperatures were extremely variable. Phenological development of plant species could not be used to monitor these trends since no species occurred at all sites and some species develop more rapidly.

4.1.4 Canopy Cover

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

4.1.5 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 states were as follows:

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

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

4.1.6 Tree Ring Analysis

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

This study was not included in the original proposed methodology. During the early phases of the phenological study, it was noted that the sites with the earliest maturing forage appeared to have been burned relatively recently (last 50 years) whereas the latest maturing sites had a deep moss layer and little evidence of fire. Cores of living and dead trees were obtained in an attempt to determine the fire history of each site. Field time did not permit an intensive collection of cores. The intention of coring snags was to match tree ring patterns of living and dead trees in an attempt to determine when the trees had died and hence when the fire occurred, assuming the trees died during the fire. Limited laboratory time and poor quality cores did not permit this analysis.

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

4.1.7 Statistical Analysis - Cover

Cover 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 was unique, rather than a random sample of a population. Each transect also represented either documented presence or absence of radio-collared moose. Each elevation was a particular location with respect to slope. Exclosures and plots represented random locations from the population of exclosures and plots.

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

4.2 1983 Methods

4.2.1 1983 Field Methods

Thirty-two line transects were established in the proposed Devil Canyon and Watana impoundment zones during April 26 to May 5, 1983 (Figure 2). Four transects were located at each of 7 areas and 2 transects located at each of 2 areas. Two parallel line transects spaced approximately 100 m apart were positioned so they began on the benches above the impoundment zones and extended downslope to the Susitna River if terrain and distance permitted. The transects turned at right angles and paralleled the river at the bottom.

Two transects were placed on each side of the Susitna River valley at the Devil Creek, Watana Creek, Fish Creek, Kosina Creek, and the Switchback areas (Figure 2). Two transects were also placed on either side of Watana Creek in the area designated Watana Slide (Figure 1). Two transects were positioned on the north side of the Susitna River at Tsusena Creek and on the south side at Clarence Creek (Figure 2). Access and time limitations prevented the establishment of paired transects for the Tsusena Creek and Clarence Creek areas. Two transects, which did not terminate at the Susitna River were also placed on either side of Fog Creek (Figure 2).

Placement of transects was based primarily on identification of areas known to have local concentrations of moose during spring. ADF&G biologists were consulted during early April 1983 to determine where snow was melting most rapidly and the location of concentrations of moose. Slope, aspect, elevational gradients, and helicopter access at top and bottom of transects were also considered in the placement of transects on opposite slopes.

Each line transect followed a compass bearing to minimize observer bias, but sometimes directions were altered for topographical reasons. Some stops along the transects were flagged with surveyor's tape tied to shrubs or trees so the transect could be approximately relocated during later time periods. Beginning and ending elevations were recorded for each transect.

Transects were walked at 7-day intervals over 5 consecutive periods encompassing 6 weeks. The 5 periods were as follows: Period 1, April 26-May 5; Period 2, May 6-May 12; Period 3, May 13-May 19; Period 4, May 20-May 26; and Period 5, May 27-June 2. The four observers were regularly rotated among the transects. The same observer walked the same transect only during periods 1 and 5.

The transect number, stop number, date, and level IV vegetation type (Viereck et al. 1982) were recorded at 10-m intervals along the transect. Coded values for elevation, slope, and aspect were also recorded (Table 1). Elevation was estimated with hand-held altimeters. Slope and aspect were estimated using a clinometer or Abney level and compass, respectively.

At each 10-m stop the coded value for the snow depth at the tip of the observer's snowshoe or boot was recorded during periods 1 through 4 (Table 1). A coded number of berries and horsetail stems within a 0.5-m radius in front of the boot or snowshoe was recorded. Species (Table 3), phenological state (Table 2), and utilization codes (1 = not used, 2 = used) of the nearest shrub, forb, and graminoid within a 0.5-m radius were also recorded. A coded value for the Level IV vegetation type was also recorded (Table 4). A qualitative estimate of phenological advancement (late, middle, early) was recorded during the fifth period when no snow was present. Other observations such as utilization signs, general transect description, observation of animals and animal signs, general description of phenological development, and other notes of interest were recorded in field notebooks by individual observers.

One 50-m to 100-m line transect was also established on the riverbanks, parallel to the Susitna River (or Watana Creek), at the lower terminus of each downslope transect. These transects were needed to observe the development of horsetail near the river for possible bear usage. These riparian transects were located approximately midway between the water and the alder or forest vegetation, whichever was closer to the water. The same information described in the preceding paragraphs was recorded for the riparian transects as for the downslope transects, but at 5-m rather than 10-m intervals.

4.2.2 1983 Data Analyses

The hypotheses to be tested were that phenological advancement, overwintered berries, and horsetail densities were a function of elevation, aspect, slope, and vegetation type. Log-linear models and 2-way contingency tables were used to test the hypotheses and obtain an understanding of what factors interacted. The hierarchical log-linear model used an additive function of main effects and interactions to predict the logarithm of the expected cell frequency. This was similar to an analysis of variance, but all variables were treated equally with no variable considered as the dependent, or response variable. Another technique, logistic regression, treated one qualitative variable as a response or dependent variable and the others as qualitative, independent variables. This may be a more appropriate method of analysis, but lack of knowledge or adequate documentation of the technique and difficulty in interpreting the computer outputs resulted in the use of log-linear models.

Aspect (8 directions), elevation (17 30-m bands), slope (7 categories), vegetation type (approximately 30 level IV categories, Table 1) and transect location (9 areas) defined the cells of interest in a log linear model. This was initially considered across all transects during one time period. Several problems with this approach led to its abandonment. The river near the Switchbacks was slightly lower than the highest elevation of Devil Creek transects. Numerous missing cells would occur since the higher elevations were not present at Devil Creek, but lower elevations were not present near the Switchbacks. This would invalidate the results. Some transects had few, if any, east or west-facing slopes while others had few south-facing slopes resulting in more missing cells or structural zeroes. Additionally, certain combinations of aspect and elevation did not have all slopes or vegetation types present. Most of the above would be considered structural zeroes. Aside from such structural zeroes, insufficient data were collected to represent all cells that might exist with these narrow definitions. Inaccuracies in elevation, slope, and aspect estimates could lead one to question the narrowness of these categories. However, broader categories that were justifiable could not be established initially. Finally, computer statistical packages could not handle this many cells at one time. Hence, the following procedures were developed to reduce the data to a meaningful form.

The data for a time period were divided according to transect groupings and analyzed one group at a time. The first analysis consisted of 2-way contingency tables for each response variable (phenological advancement, berries, horsetail) and each independent variable (aspect, elevation, slope, vegetation type). Aspect and elevation were treated in their original coded form. Slope categories were combined into 0-3°, 3-10°, and greater than 10° intervals since these had reasonable interpretations. Slopes greater than 10° were eliminated when they only accounted for a small fraction ($<$ 10%) of the observations. They accounted for 20% of the observations for some transects and were included because that much information could not be eliminated. These steeper slopes were considered marginal wildlife habitat. Vegetation types were grouped according to crown closure and growth form: closed, open, and woodland forest; dwarf tree scrub, tall shrub, low shrub;

and herbaceous. More detailed classification levels should be used for such phenological studies, but techniques were insufficient to handle the information. Berry and horsetail abundance were reduced to presence or absence, or frequency, since most of the with more abundant berries (code $\geq$ 3)cells were empty.

Computer printouts included observed frequency, percentages of row totals, standardized deviates, and marginal subtotals. The marginal subtotals indicated which categories for a variable were missing or poorly represented for each independent variable. The observed frequency and percentages of row totals enabled assessment of which categories had similar responses and could be combined. Combining categories was needed to reduce the number of 0 cells in multi-way contingency tables.

The standardized deviates were the differences between observed and expected values divided by the square root of the expected value. The value of this in each cell was similar to a z-statistic and indicated if significantly more or fewer responses occurred in a specific cell than would be expected by chance. These 2-way contingency tables provided an estimate of how each independent variable (slope, aspect, elevation, vegetation type) affected each response variable (phenology, berry, and horsetail frequency) without considering interactions.

The previous analysis was used to combine categories in a meaningful way so that multi-way contingency tables could be analyzed using a log-linear model. Elevation was reduced to above and below the estimated impoundment levels where possible. This reduced the biological information, but it directly tested the hypothesis of potential loss of spring forage by inundation. The 450-m band was the top of the Devil Canyon impoundment, and the 660-m band was considered the top of the Watana impoundment. Where all locations within a group of transects were either above or below the impoundments, elevation was not considered in the models. Similarly, aspect was not used when transects were only sampled on one side of the river.

Contingency tables were constructed for (1) phenological advancement, aspect, elevation, and slope or vegetation type and (2) berries or horsetail, aspect, elevation, and vegetation type. Slope and vegetation type information were considered to be redundant, but it was uncertain which was more important for phenology; hence, each was included separately. Berry and horsetail densities were believed to be more related to vegetation type, so slope was never considered in those models. A table was also produced for vegetation type, aspect, elevation, and slope to investigate independence among these variable and to see if the assumption of interrelation of vegetation type and slope was reasonable. This was used as an interpretation aid rather than an actual test of hypotheses.

Each table of observed frequencies was accompanied by partial and marginal tests of association. These tests were used to determine what factors and interactions affected the model or indicated which factors affected the response variable. Partial association tests indicated if a term could be removed from the full model without affecting it's meaningfulness. Significance on this test meant that the term was needed. Marginal association tests indicated if a term added information to a model consisting only of lower order terms. If a third order term improved the model produced by the first and second order terms, then the term was significant.

Tables of standardized deviates for the full log-linear model indicated which cells had significantly more positive responses than would be expected. A cell in this context referred to the interaction of levels of independent variables (aspect, elevation, slope, vegetation type). The "dependent" variables were considered to have responses in these cells. Reduced models were not considered because of the additional expense.

The berry and horsetail frequencies were sometimes low enough that no models after the first were considered. Observation of the observed frequency table would indicate where the concentration occurred.

5 RESULTS

5.1 1982 Results

5.1.1 Reconnaissance Observations

Some general observations on late winter snow conditions were made on a reconnaissance trip on 15 and 16 May, 1982. The Watana and Jay Creek transects were almost snow-free at that time, although the Watana area contained some snow patches in depressions between shrubs, and 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 decreased. Mountain cranberry was abundant at the base of trees in the area between Devil and Tsusena Creeks, while snow was melting around 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 that snow cover had been reduced by approximately 50% on forested south-facing slopes while it had only decreased around trees on north-facing slopes. The immediate area around shrub stem bases was relatively snow-free on the benches. Snow depths were greatest between shrubs and contained many animal tracks connecting these relatively snow-free areas. Apparently these areas of less snow cover surrounding shrub stems are important to wildlife at this time of year. Snow depths were least in wet, boggy sites as well as the dry, windy areas that had no trees.

5.1.2 Soil temperature

Temperatures varied significantly by transect, elevation within transect, and date within elevation within transect (Table 5). 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) and it was located in a mixed birch-spruce stand on a well-drained slope (12°) whereas other bottom elevations were flat (<20°) and poorly drained.

The warmest location on the Jay Creek transect, and the warmest overall, was mid-slope in an open birch-spruce stand 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 rose (1 m or taller) as well as abundant bluejoint, woodland horsetail, and 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 one other tree was 124 years old. Several individuals of paper birch had been hedged so that they resembled large resin birch-paper birch hybrids and caused species identification problems through the early weeks of the study. However, this area was not heavily used by radio-collared moose (Ballard et al 1982).

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

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 4). The bench location was well above the current forest-line although a few surviving old trees were present.

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

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

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

5.1.3 Canopy Cover, Height, and Phenological State

Results and discussion of the statistical analysis of phenological development of the vegetation were confined to dominant species. Because some species only occurred at one or a few sites, they frequently showed significant differences ($P < 0.10$) among elevations and transects. This was primarily because of differences in vegetation type rather than a difference related to phenological development. Only species that consistently occurred in most sites would give reasonable statistical results when comparing elevations and transects. The major species were resin birch, mountain cranberry, bog blueberry, and crowberry.

5.1.3.1 Week 1; 31 May - 4 June, 1982

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. Mountain cranberry had significantly different cover values for elevation within transect ($P < 0.1$) and for transects ($P < 0.01$). Cover values for resin birch ($P < 0.01$) and bog blueberry ($P < 0.02$) varied among elevations within transect while crowberry ($P < 0.02$) differed among transects.

Most plant species were either dormant or had just initiated leaf buds during the first week. Bog blueberry on the Watana transect was generally dormant or had some leaf bud development whereas most resin birch plants had developed at least to the bud stage (Table 6). Mountain cranberry appeared dormant; however, new growth was sometimes difficult to identify. The bottom elevation at Watana Creek contained an individual of rose with leaves and mountain cranberry with flower buds. Some individuals of bog blueberry were in leaf bud stage whereas individuals of the same species were still dormant at the higher elevations.

The Jay Creek transect had several species already leafed out on 1 June (Table 7). At the bench and top-slope positions, leave had emerged on mountain cranberry while more individuals of bog blueberry had leaf buds than on the Watana transect. Some resin birch individuals were starting to leaf out at the Jay Creek transect, although most were still in the bud stage. Alpine bearberry (Arctostaphylos alpina) already had leaves and flowers.

Paper birch on the middle position of the Jay Creek transect had begun leaf expansion, but had been severely hedged in the past. There was a substantial amount of woodland horsetail and bluejoint (standing dead from the previous year's growth), but little growth (< 1% cover) had started this year by week one. Ground cover might inhibit initial soil warm-up in the spring. Tall bluebell 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 willow observed on the south-facing slopes.

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

The Switchback transect had several species already in the leaf stage by 2 June: diamondleaf willow, American red currant, Labrador tea, and Northern Labrador tea (Table 8). Most mountain cranberry was still dormant while some bog blueberry had entered leaf bud stage.

Individual sedges on the bench position were beginning to emerge while most other species, except resin birch, were dormant. The top elevation was similar to the bench position during this time period. The middle location contained bog blueberry in leaf bud, while woodland horsetail was just emerging. Resin birch was in the advanced bud stage with many starting to break open. Diamondleaf willow already had exerted some leaves. Shrubby cinquefoil (Potentilla fruticosa) and mountain cranberry had leaves at the lowest elevation. American red currant had leaves and flower buds. Most Sitka alder were in the bud stage, but some had started to leaf out.

The corresponding north-facing slope across from the Switchback transect contained very hedged willow, with dpb's (diameter-at-point-of-browsing) of 10 mm. Sitka alder had been noticeably browsed. This area contained the only bog blueberry which had been observed as browsed.

The Tsusena Creek transect contained bog blueberry in leaf on 3 June, but most other species were dormant or entering leaf bud state (Table 9). The two highest elevations were similar with resin birch just starting to form leaf buds. Observations between the top and bottom positions indicated that graminoids were greening up sooner here than on some other transects. Rose also was more developed. Labrador tea had new leaves at the bottom location whereas bunchberry was dormant and resin birch had leaf buds.

5.1.3.2 Week 2; 7 June - 11 June

The second week of 7 to 11 June had no significant differences ($P > 0.10$) for major species cover values between inside and outside the exclosures. All major species had significant ($P < 0.03$) differences with respect to elevation while only mountain cranberry and crowberry (*Empetrum nigrum*) had different cover values among transects ($P < 0.01$). The previous week, crowberry cover varied only with transect, and resin birch and bog blueberry varied with elevation.

Several changes occurred along the Watana Creek transect by the second week. Resin birch and bog blueberry had leafed out in many places and had rose leaf buds (Table 10). Bog blueberry tended to have leaf buds at the two highest elevations while at the lower two elevations plants were leafed out. Changes in leaf area like this could account for elevational differences in cover for this species. When fully leafed out, there may be no differences in cover values among elevations for this species. There were not major differences in phenological development at different elevations at this time at this site.

Plant species on the Jay Creek transect had also advanced phenologically by 8 June (Table 11). Resin birch and rose were in leaf as were bog blueberry, netleaf willow (*Salix reticulata*) and alpine bearberry. As in week one, the top two elevations were similar. At the middle elevation tall bluebell was still in the flower bud stage but had grown from 8 to 13 cm, while fireweed (*Epilobium angustifolium*) had acquired leaves. Field horsetail had strobili on many individuals and had almost doubled in height. Sedge and crowberry had acquired leaves at the bottom location.

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

Almost all major plant species on the Switchback site advanced a full phenological state from 2 June to 9 June (Table 12). Alder, resin birch, rose, and bog blueberry had leaves at this time. Average height of field horsetail had increased from 2 to 10 cm (Tables 8 and 12). Currant was in flower at the bottom elevation. Mountain cranberry had flower buds at the middle-slope location. No new differences in phenological development were noted on the north-facing slope.

The Tsusena Creek transect sampled on 10 June was almost identical to the previous week with most species in the leaf bud stage or still dormant

(Tables 9 and 13). On the north-facing slope resin birch buds were more advanced but were still immature.

5.1.3.3 Week 3; 14 June - 18 June

Cover values of all major species including resin birch ($P < 0.001$), mountain cranberry ($P < 0.08$), bog blueberry ($P < 0.02$), and crowberry ($P < 0.02$) were different across elevations within transects during week three. Only mountain cranberry ($P < .04$), bog blueberry ($P < 0.06$), and crowberry ($P < 0.06$) were different among transects.

Vegetation on the Watana Creek transect exhibited no major plant phenological advances between the second and third week (14 June) except that prickly rose was now in leaf and crowberry had some terminal buds at the bottom and top transect elevations, respectively (Table 14). Bog blueberry had flower buds at the top-slope elevation, where flower buds of Northern Labrador tea were starting to break. The north-facing slope at this transect had flowers on diapensia (*Diapensia lapponica*) and four-angle mountain-heather (*Cassiope tetragona*) 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 15). However, bunchberry acquired new leaves and fireweed and tall bluebell had flower buds. The average height of tall bluebell increased 10 cm while that of field horsetail increased 8 cm (Tables 11 and 15). Fireweed did not significantly increase in height. Tall bluebell, a perennial, appeared to initiate growth earlier than fireweed, an annual. However, it appeared to grow more slowly. Fireweed started growth later but grew more rapidly, reaching its maximum height a week earlier than tall bluebell. Tall bluebell would be available earlier as forage.

Few plant species progressed phenologically along the Switchback transect by 16 June (Table 16). Bog blueberry had flower buds, crowberry had only terminal buds, and many American red currant plants had lost their flowers. Field horsetail was more abundant since six observations on height were made this time, as opposed to one 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: capitate valerian (Valeriana capitata), northern watercarpet (Chrysosplenium tetrandrum), and milk-vetch (Astragalus spp.)

Many plant species had not leafed out until 17 June on the Tsusena Creek transect (Table 17). Resin birch, bog blueberry, crowberry all developed leaves by this time, Cornus canadensis at the bottom elevation was dormant.

5.1.3.4 Week 4; 21 June - 25 June

Resin birch ($P < 0.03$), bog blueberry ($P < 0.01$), and crowberry ($P < 0.01$) had significant cover differences during the fourth week with respect to elevations within transects. Mountain cranberry ($P < 0.02$), bog blueberry ($P < 0.01$), and crowberry ($P < 0.01$) cover values were different among transects at this time. Mountain cranberry did show trends with respect to elevation ($P < 0.14$) and resin birch with respect to transects ($P < 0.18$). Most ubiquitous species had different cover values among transects and elevations within a transect.

The only new development on the Watana Creek transect in the fourth week was that mountain cranberry and bog blueberry had developed flower buds

(Table 18). Some Labrador tea had flowered at the top-slope elevation although most were still in bud.

Developments along the Jay Creek transect during week 4 (22 June) included flower buds on mountain cranberry and bog blueberry and flowers on bunchberry (Table 19). Most of the forbs slowed their growth although the average height of field horsetail increased slightly.

Several phenological advances occurred on the Switchback transect during the fourth week. Crowberry, bearberry (Arctostaphylos uva-ursi), and grasses entered the leaf stage (Table 20). Although most mountain cranberry were in the leafed state, some had acquired flower buds. Capitate valerian was flowering at the bottom elevation while tall bluebell had leaves. Phenological development on this site was delayed relative to the Jay Creek site.

Only minor changes were evident on the Tsusena Creek transect during the fourth week. Bunchberry leafed out while grass expanded leaves (Table 21). Cloudberry and bog blueberry were flowering at the top-slope location.

5.1.3.5 Week 5; 28 June - 2 July

Cover values of resin birch ($P < 0.001$, $P < 0.04$), bog blueberry ($P < 0.01$, $P < 0.02$), and crowberry ($P < 0.01$, $P < 0.01$) during the fifth week differed with both elevation and transect. Mountain cranberry cover did not differ with either elevation or transect ($P > 0.10$)

The last week of 28 June to 2 July had few changes as most species had at least expanded leaves at all sites by this time. Watana Creek transect had only minor changes during the last week. Prickly rose and beauverd spiraea

(Spiraea beauverdiana) developed flower buds (Table 22) and some C. canadensis and mountain cranberry started flowering.

Several changes occurred on the Jay Creek transect by the last week (Table 23). Northern Labrador tea and Labrador tea had flowered. Most tall bluebell was in flower, rather than being restricted to the most advanced individuals. Fireweed, tall bluebell, and field horsetail all increased their average height. Crowberry at the top-slope elevation had set fruit.

Changes along the Switchback transect during week 5 (30 June) included some mountain cranberry flowering at the middle slope location as well as Labrador tea flowering at higher elevations (Table 24). The average height of field horsetail increased by 10 cm while the mean grass height remained the same.

During the fifth week (1 July) some mountain cranberry, bunchberry, northern Labrador tea, and Labrador tea had flowered along the Tsusena Creek transect (Table 25). Average height of grasses increased slightly.

5.1.4 Spatial Variation in Phenological State of Resin Birch

An evaluation of the effect of transect and elevation might be better accomplished by discussing a single ubiquitous species during one week. The average cover, height, and phenological state for resin birch during week of 7 June to 11 June are reported in Table 26. This species was more abundant at the higher elevations than at the two lower elevations, but did not vary significantly by transect. This trend was consistent with the fact that low birch shrub scrub vegetation types occurred at higher elevations while several different vegetation types occurred at lower elevations depending on the transect.

Generally, resin birch grew taller at the higher elevations except along the Switchback transect where heights were similar among elevations (Table 26). The higher elevations, especially the bench position, along Tsusena Creek had much taller shrubs (85 cm versus overall mean of 55 cm). Whether this was related to edaphic, climatic, topographic, or site history factors or a combination of factors was not known.

Phenological state of resin birch was not different for the Watana Creek, Jay Creek, and Switchback transects during week of 7 June to 11 June (Table 26). However, resin birch along the Tsusena Creek transect was in the leaf bud state while plants along the other transects had already developed leaves. Watana and Jay Creek transects had some variation in phenological state with respect to elevation. The bench location appeared to lag behind the other elevations in plant development (2.4 versus overall mean 2.7 and 2.6 versus overall mean 2.9). The Switchback and Tsusena Creek transects were not different in phenological state with respect to elevation.

5.1.5 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 27 presents cover, height, and phenological development of tall bluebell over time for the middle slope elevation of the Jay Creek transect. Cover increased slowly during the first two weeks, then increased at a faster rate during the third week and remained the same during the fourth week. Cover values almost doubled (9 versus 14%) between 22 June and 29 June. Height followed a similar pattern with rapid growth through the first three weeks, slowing in the fourth week, and almost doubling in the fifth. The phenological state of tall bluebell exhibited a similar pattern. Most individuals had leaves on 1 June but had progressed to the flower bud state by 8 June. A few had begun flowering on 15 June.

Phenological development slowed on 22 June but advanced to the flowering state for many plants by 29 June. All parameters showed a slowing of growth during the fourth week. This could have resulted from colder air temperatures and snow flurries that occurred at the higher elevations the previous week or could have been an artifact of sampling. However, tall bluebell may normally exhibit a slowing of growth at this stage, as resources are directed toward flower development.

5.1.6 Transect Effects

The effect of transect location on phenological development of four common species can be seen graphically by maintaining the elevation approximately constant and comparing observations through time (Figure 3). Since plots were not repositioned in the same placed each week, the phenological development sometimes appeared to regress. In addition, it was sometimes difficult to distinguish between old and new growth in evergreen species such as northern Labrador tea and mountain cranberry because of similar coloring of old and new growth. If a leaf was partly emerged, it was obvious that the leaf was new growth. Otherwise an actively growing plant might mistakenly be listed as dormant. For comparison, the bench elevation on the two transects farthest downstream (Tsusena and Watana Creeks) and the top slope elevation was selected on the upstream transects (Jay Creek and Switchbacks) so that mean sea level elevations would be similar between transects.

Resin birch was at the leaf bud stage on the selected transects during the first week (Figure 3). During the second week, most leaves had expanded on the Jay Creek transect while most were still in the bud stage along the Tsusena Creek transect. The other two transects were intermediate in development for resin birch. By the third week, plants at this elevation along all transects except Tsusena Creek had leafed out. Plants on Tsusena Creek site developed leaves during the fourth week.

Bog blueberry developed earlier than resin birch under some conditions, as evidenced by the presence of leaves during the first week at the Switchback site (Figure 3). During the second week bog blueberry plants on the Jay Creek site had developed leaves. By the third week bog blueberry had developed leaves at this elevation on all transects. Differences in leaf development of bog blueberry after the third week were probably not significant.

Northern Labrador tea initiated early growth at this elevation on the Switchback and Jay Creek transects, with the leaves having been expanded by the firs week (Figure 6). By the second week northern Labrador tea on all the transects were in the flower bud stage. These plants on the Jay Creek transect were in flower by the fifth week. The flower bud stage appeared to last longer in this species than in other species. The retrogression between weeks 3 and 4 on the Switchback transect probably resulted from variability, unless flowers had actually fallen off.

Mountain cranberry initiated growth later than other species since the first new leaves did not appear on the plants until the third week, and then only at the Jay Creek site (Figure 3). Mountain cranberry on most other transects did not develop leaves until week 5, by which time the plants on the Jay Creek transect were already in flower.

5.1.7 Elevation Effects

The effect of elevation on phenological development of four common species was examined by selecting a single transect and examining its four elevations. The Watana Creek transect (named Fish Creek in 1983) was selected because the vegetation was the least patchy and had a relatively continuous gradient along the entire slope. The other transects all had level areas at the bottom slope site. The Watana Creek transect was the only transect where elevation would not be excessively confounded with old burns or other disturbances.

Resin birch showed slightly earlier development at the mid-slope elevation than at higher elevations during the second week (Figure 4). During the third and fourth weeks the differences in development of resin birch along the elevational gradient were minor or nonexistent. Resin birch did not occur in an open birch-spruce site at the bottom-slope elevation.

Bog blueberry exhibited slight differences in development during week two (Figure 4). Plants on the lower two elevations were slightly earlier in leaf development than the higher two elevations on this transect. Following week 2 the pattern of leaf development of bog blueberry appeared random.

Northern Labrador tea showed differences in phenological development at different elevations during week 1 (Figure 4). Plants at the lowest elevation were in the flower bud stage during week one while northern Labrador tea at the highest elevation was still dormant. Differences in phenological development during and after the second week were minor, although the bottom-slope elevation was slightly more advanced since a number of individual plants were flowering. The top slope elevation for Jay Creek, which was at a higher elevation than the same position on the Watana Creek transect, was even more advanced (full flower).

The bottom-slope elevation had the earliest development of mountain cranberry on the Watana Creek transect and had some individuals in the flower during the fifth week (Figure 4). The bench position was the last of the four elevations to develop leaves on mountain cranberry during week 4.

Slight overall trends with respect to elevation could be observed with plants at the bottom elevations developing first and plant phenology being late at higher elevations. However, as results on other transects show, site burn history may modify the effects of elevation. Many areas have flat areas along the river that would have a different cold air drainage regime than the Watana Creek transect. The birch-spruce forest, where the bottom exclosure was located was also an indicator of disturbance.

5.1.8 Summary and Discussion of Plant Phenology

Early development of herbaceous plant species could be important for moose in the spring on south-facing slopes of the potential impoundment areas, however, numerical data for cover, height, and phenological stage collected during spring 1982 did not support this hypothesis. In contrast, visual observations indicated that herbaceous species and possibly some shrubs such as mountain cranberry or willow bark might provide early spring forage in localized areas. Contents of moose pellets collected in 1983 indicated willow, resin birch, mountain cranberry, and mosses were important diet components. There does not appear to be a specific type of location, such as bottom-slope elevation, that was a consistently good source of early growth of vegetation. However, sites with recent (< 75 years) disturbance tended to green up earlier regardless of vegetation type.

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

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

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

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

Some species such as mountain cranberry 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) and was a major portion of late-winter diet of moose in 1983 as determined by fecal analysis. Some species, such as tall bluebell and fireweed started later but developed more quickly. Thus, fireweed could avoid grazing at the earliest times. Similarly, quaking aspen appeared to develop leaves later than paper birch.

Fireweed at the middle-slope Jay Creek site and cottongrass (Eriophorum spp.) at the bottom of the north-facing slope opposite the Switchback site had been grazed at a time when other forage was not abundant. A moose and her calf (the presumed grazers) were observed on the cottongrass site while no clues as to the grazer at Jay Creek were observed. Later in the spring we observed no evidence of grazing, presumably because there was an abundance of forage available at that time.

If one assumes a maximum reservoir elevation of 666 m for the potential Watana impoundment, then several of the "warmer" areas that developed early forage would be above the level of the impoundment while some would be inundated. Some of the warmest and earliest developing areas (middle-slope Jay Creek and bench and top positions on the Switchback transect) would not be flooded. However, the bottom two elevations along the Watana Creek transect would be flooded. The top location of Watana would be only 17 m above the surface of the impoundment, while the middle-slope elevations of Jay Creek and Switchback transect would be 35 m above the surface. Sites that warm up relatively early would also be available in the Switchback area.

5.2 1983 Results

5.2.1 Phenological Advancement - Period 5 - 22 May-2 June

The general phenological advancement of vegetation at a stop was recorded during period 5 instead of recording snow depth. The following sections summarize spatial variation of this parameter within each transect. Insufficient observations of utilization were made to analyze it statistically. Hence, it is discussed as qualitative observations at the start of each transect.

5.2.1.1 Devil Creek

Devil Creek transects were important to the study since digging for sweet-vetch roots (presumably by bear) was noted at the bottom, similar to that found at Fish Creek and Watana Creek. Sedge was utilized approximately one-fourth of the way down this transect during period 5. This was usually a very phenologically advanced area for period 3 - 5. "Phenologically advanced" means that the stops had larger values recorded for phenology than other stops did during that time period.

Devil Creek was an early-developing area with 53% of the stops being considered as advanced stops during period five. Southeast and southwest slopes were the most phenologically advanced during this time period (Table 28). The north and northeast slopes were later-developing than would be expected by chance alone. The earliest-developing sites occurred at the lower elevations by the river (Table 29). The highest elevation (660 m) also greened up earlier than would be expected by chance alone (Table 29) Although overall slope had a significant effect, no category of slope was statistically more advanced than other categories. There was, however, a trend for gentler slopes to develop earlier (Table 30). Closed forest and tall shrub vegetation types were associated with early development at this time (Table 31).

The full log-linear model for Devil Creek using phenology, aspect, elevation, and slope was unbalanced for the three independent parameters, as indicated by the large chi-square and low probability for aspect x elevation x slope interactions (Appendix Table P1-1). Aspect had the largest influence on phenology when considering single factors interacting with phenology (Table P1-1). Significant ($P < .10$) cells included 0 - 3° and 10 - 30°

east-south slopes below the Devil Canyon impoundment, 0 - 3° east-southeast above, 3 - 10° southwest slopes below, and southwest slopes greater than 30° above and below the impoundment (Appendix Table P1-2). The term "cell" will be used to refer to a combination of treatment levels for a particular log-linear model. In other words, a cell might have an early phenology state, aspect south, elevation below impoundment, and 0 - 3° slope. Appendix Table P1-3 indicates the number of observations in each cell for this model.

Third order interactions were significant in the full log-linear model for phenology, aspect, elevation, and vegetation type except for phenology x elevation x vegetation type. Aspect appeared to have the most effect of any parameters on phenological advancement and significantly affected the vegetation type distribution. In other words, vegetation on south-facing slopes along the Devil Creek transects developed earlier, but different vegetation types occurred on the different aspects. Elevation appeared to have the least effect according to the size of the chi-squares and the standardized deviates (Appendix Table P1-4). In the forest types the more southerly aspects above and below the impoundment had significantly more stops phenologically advanced than would be expected. Shrub types below the impoundment on more southerly aspects also developed early.

5.2.1.2 Tsusena Creek

A small bunch of grass had been utilized during period two along the Susitna River near the end of this transect. Numerous moose tracks were located in the vicinity. Hence, the area was used by moose during spring 1983.

Tsusena Creek was the most advanced site with 57% being reported as "early" in period 5 which was partly attributable to its southern exposure. It contained mixed forests along its slope and a broad flat area of black spruce at the bottom. The elevation bands, or intervals, with the earliest developing vegetation were mid-slope from 480 m to 470 m (Table 29). The highest (630 m) and the lowest (450 m) portions of the transects were the only bands with fewer early stops than would be expected by chance (Table 29). However, the bottom had more early greenup stops than other elevations, partly because it had five times as many observations as other elevation bands (Table 29). The 10 - 30° slopes had the largest number of early greenup stops as well as the largest percentage (Table 30). Number is important since it indicates that many early greenup stops exist, but this may be the result of many stops existing for those slopes. Percentage is important since it indicates what fraction of its stops are early greenup. Open forest types developed earlier than expected, while woodland forest types greened up later than expected by chance (Table 31).

This was one example where confounding of slopes and vegetation types might have produced misleading results. The open forests were usually birch-spruce on steeper, well-drained slopes while the woodland forest types were generally black spruce on level, poorly-drained locations. Hence, the timeliness of growth initiation was probably related more to drainage than to crown cover as one might expect, although an open birch-spruce forest may have less crown cover during spring than a woodland black spruce forest because the birch leaves have not developed.

The log-linear model for phenological advancement on Tsusena Creek was analyzed using elevation, slope, and vegetation type since the aspect had little variation. The transects were on a south-facing slope with few microsites. The simultaneous tests indicated that only interactions up to the third order were significant. All of the 2-way interactions were significant with the elevation x slope and slope x vegetation type being highly significant (Appendix Table P2-1). This was an artifact of the steeper slopes being almost exclusively above the 450-m band and flat areas occurring below that elevation. Similarly slopes steeper than 10° contained only open forests, while the woodland forest, dwarf tree scrub, and low shrub types occurred almost exclusively on the flat portions of the transects. This might account for the lack of significance for the elevation x slope x vegetation type interaction.

None of the 3-way interactions were significant by the partial association tests (Table P2-1). That meant that any one of those terms could be removed from the full model without losing any information. However, the phenology x elevation x vegetation type and phenology x slope x vegetation type terms were significant in the marginal association tests. That meant that each of these terms could be added to the second order model, and the model would be improved. The phenology x elevation x slope interaction added no information. In other words, phenology was related to the elevation x vegetation type and slope x vegetation type interactions, but not to elevation x slope. This resulted from the interdependence of slope and elevation.

The standardized deviates from the above model indicated that the following cells had higher frequencies of stops with advanced phenology; open forests on 3 - 30° slopes above the potential Devil Canyon impoundment and low shrub types on 0 - 3° slopes below the impoundment (Appendix Table P2-2).

This corresponded to the well-drained hillsides and the shrub area adjacent to the river. Groups of stops with later-developing vegetation occurred in forest types on flat positions below the impoundment and low shrub types on 0 - 10° slopes above the impoundment. These corresponded to the poorly-drained bottomlands and the low shrub observations on top.

The number of 0 cells that resulted because certain slopes, elevations, and vegetation types occurred together (Appendix Table #P2-3) might make some of the analysis questionable. A log-linear model was run to investigate the dependencies of these three parameters. The main effect of elevation was not significant. The most significant 2-way interactions were elevation x slope and vegetation x slope, but vegetation x elevation was also significant. Hence, slope elevation, and vegetation type were related to each other as discussed in preceding paragraphs.

5.2.1.3 Fog Creek

Fog Creek transects were late initiating growth with only 7% of the stops being labeled as having phenologically advanced vegetation. Much of the area was on shallow, poorly-drained sites, which sometimes had a shade-producing tree canopy over the understory vegetation. The north-facing slopes were more phenologically advanced than the south-facing slopes (Table 28), but this may be partially because of better drainage of the north-facing slopes. The lower elevations (660 m) had earlier green up (Table 29), but all elevations were above potential impoundment levels. The 0 - 3° slopes had the most phenologically advanced vegetation (Tables 30, 31). The forested stops were usually on better drained soils than the low shrub and herbaceous types. Some of the stops with herbaceous vegetation occurred on a very wet site.

The log-linear model for Fog Creek was analyzed using vegetation type (closed-open forest, low shrub), slope, and aspect (E-S-W, NW-NE). All elevations were above the Watana impoundment and little change in elevation occurred along the transects so it was not considered. The most significant third order interaction was aspect x slope x vegetation type indicating an imbalance among those features (Appendix Table P3-1). Phenology x aspect x slope was not significant in either a partial or marginal test of association. Phenology x aspect x vegetation type was significant in contributing information to the full model (partial association) while it did not improve the second order model (marginal association, Table P3-1). Phenology x slope x vegetation type was significant in both tests. The second order tests of partial association were not significant for any terms involving phenology, however, they were significant for the marginal tests. Overall, this indicated that third order interactions were needed to explain where vegetation was phenologically advanced, that is, phenology was more related to interactions of slope, aspect, or vegetation type, than it was to any single variable.

The importance of the imbalance among cells was manifested in the table of standardized deviates (Appendix Table P3-2). All cells that had significantly larger frequencies of early stops also had more stops with late-developing vegetation. This could be interpreted as meaning that those cells had more observations in general which was supported by an analysis of the slope, aspect, and vegetation type alone. The cells with significantly more stops than would be expected by chance included closed-open forest and woodland forest-scrub on 0 - 30° north-facing slopes. These last two categories account for the other two cells with significantly more stops with late-developing vegetation. Unless there was a difference in sign or a large difference in absolute value between the standardized deviates, the results were not considered indicative of early greenup locations because the methodology was not really suited to this type analysis. This problem arose because all variables were treated equally rather than treating the phenological advancement as a dependent variable. This problem is considered further in the discussion section.

5.2.1.4 Watana Slide

Layers of wind-deposited silt were noticed on leaves and branches at the top of the east-facing transects during all sample periods. A long, deep fracture line was apparent along these transects, and probably indicated an impending mud slide. The east-facing transects were located to avoid the worst of the earth-movement problems. Feltleaf willow was heavily browsed at the bottom of these transects.

Watana Slide was rather late developing with only 28% of its sites classified as advanced during period 5. Aspects with more early greenup stops on the Watana Slide transects included east, south, and northwest (Table 28). Southeast-facing slopes were noticeably later with only 5% of the 191 stops qualifying as early (Table 28). Vegetation above elevation bands 570 m and 690 m were earlier developing although lower-elevations vegetation tended to be more advanced phenologically (Table 29). Slope had no effect (Table 30) while low shrub types tended to develop earlier (Table 31).

The first log-linear model for Watana Slide included slope, elevation (above, below Watana impoundment), and aspect (SE, S-SW, W, NW-E). Fourth order interactions were significant as were most third order interactions (Appendix Table P4-1). Again, the aspect x elevation x slope interaction was highly significant because of the imbalance. Aspect and its interactions seemed to explain much of the frequency distributions. Elevation and slope did not contribute individually to interactions with phenology. However, their third order interaction was significant in the partial association test, but not in the marginal association test.

Cells which were more phenologically advanced included 0 - 10° south to southwesterly slopes below the potential impoundment level, 3 - 10° south-southwest slopes below the impoundment, northerly 3 - 10° slopes below, and 10 - 30° south-southwest slopes above the impoundment (Appendix Table P4-2). Neighboring aspect categories frequently showed the opposite response. South-southwesterly 10 - 30° slopes above the impoundment were more advanced while southeasterly aspects were less advanced. Hence it was the interaction terms that were very important.

A second log-linear model was considered using phenological advancement, aspect, elevation, and vegetation type. Vegetation type alone as a main treatment explained less variability than did slope alone. However, its interaction with phenology was significant. This model was also more interpretable than the one using slope. Stops that were more phenologically advanced included woodland forest-scrub and low shrub types on the south-southwest slopes below the impoundment and possibly low shrub types on northerly-facing slopes above the impoundment (Appendix Table P4-4).

An analysis of vegetation type, aspect, elevation, and slope indicated the four parameters were not independent. The only interaction that might not be considered significant was elevation x slope (partial $p = 0.07$, marginal $p = 0.10$), but vegetation and slope were dependent.

5.2.1.5 Watana Creek

Bears had been digging on the beach trying to unearth sweet-vetch roots as a source of early spring food during period 2. This coincided with similar observations along Fish Creek and Devil Creek. Two bear dens were located near the Watana Creek transects on the north side of the river. one of these bear dens was recently vacated while the other appeared to be quite old. During the last week of study, utilization of iris, a monocotyledon, was observed along the Susitna River. The transect areas were used by wildlife during spring, but the measurements did not appear at any stop.

Watana Creek was late developing and only contained 9% "early" stops. Aspect and slope had no significant relationship to phenology (Tables 28, 30) while elevation had a small effect ($p = 0.07$, Table 29) and vegetation type was significant. Scrub, closed forest, and herbaceous types were most advanced phenologically although only scrub types had enough stops to make it ecologically meaningful (Table 31). The effect of slope was not significant, but there was a tendency for 0 - 3° slopes to be more advanced (Table 30). Lower elevations were generally later developing (Table 29).

Watana Creek had an unbalanced design in terms of aspect, vegetation, and slope for the log-linear model. The only interaction that was not significant in both the partial and marginal tests was phenology x vegetation x slope (Appendix Table P5-1). Slope seemed to contribute least to the two-way interactions. Vegetation type had the most significant two-way interaction. Cells which had a higher frequency of occurrence for advanced phenology sites were dwarf tree scrub on 3 - 10° northeast slopes and 0 - 3° southerly and north slopes (Appendix Table P5-2).

5.2.1.6 Fish Creek

Sweet-vetch roots were utilized at the bottom of this transect as evidence by digging and bear tracks in the area. This also occurred at Watana and Devil Creeks.

Fish Creek was a rather late developing area with only 20% of the recorded stops in period 5 being early or middle phenological advancement (Table 28). Aspects were predominantly south and southwest versus north and northeast. East- and southwest-facing slopes had fewer early stops than would be expected by chance alone. The southwest-facing slopes appeared warmer.

Elevation bands 540 - 570 m had more early stops than would be expected, while bands 510 and 660 m contained fewer early stops (Table 29). The warmest slopes were in the 3 - 10° range with steeper slopes having fewer early stops than would be expected (Table 30). Early stops occurred more often in low shrub vegetation types than in other types (Table 31).

The elevation and aspect were collapsed according to above or below the potential Watana impoundment zone and the three aspects: E-S, SW, and W-NE. The three vegetation types used were open forest, woodland forest - scrub, and low shrub. The north and northeast slopes seemed to green up earlier while southwest-facing slopes were noticeably slower. Elevations below the impoundment seemed to develop slightly earlier, but the percentages were not very different. The 3 - 10° slopes had more phenologically-advanced stops than the others.

The full log-linear model indicated the phenology was significantly affected by aspect, slope, and elevation, but the elevation term was somewhat questionable (Appendix Table P6-1). Cells with significantly more early stops than would be expected included west to northeast-facing 3 - 10° slopes above the impoundment, east to south-facing slopes on 10 - 30° slopes below the impoundment, and west to northeast 0 - 3° slopes below the impoundment (Appendix Table P6-2).

The model using vegetation type rather than slopes seemed to explain more of the variation. Low shrub types above the impoundment on west- to northeast-facing slopes, open forest types below the impoundment on east- to south-facing sites, and woodland forest-scrub types below the impoundments on southwest-facing slopes contained significantly more early stops than did other cells (Appendix Table P6-4). Some of the vegetation type effect was confounded with aspect and elevation, since low shrub types were most common on west to northeast slopes above the impoundment. Vegetation type was not independent of aspect, elevation, and slope.

5.2.1.7 Kosina Creek

Approximately 20 moose were present in the general vicinity of this transect's starting point on the north side of the river during the first week of this study. Mountain cranberry had been browsed near the bottom of the south-facing transects, and willow bark had been stripped. Stripping of willow bark by moose is a common source of food at this time of year in Denali National Park (V. Van Ballenberghe, personal communication, also personal observation by author). Nutrient levels in the cambium are probably high. Iris was also utilized near the river. The south-facing slope appeared to be used by wildlife at this time of year.

Kosina Creek was one of the earlier-developing stops with 35% of the observations being "early" in period 5 (Table 28). Aspects were predominantly south versus north with the southerly aspects having more early stops and the northerly aspects having fewer early stops than would be expected by chance (Table 28). Higher elevations, especially band 750 m, had more early stops while the lower elevations, particularly those by the river, had fewer early stops (Table 29). The late development by the river might have resulted from an earlier ice jam which deposited ice up to the bottom of the alder and covered much of the shore-line vegetation, including the bottom of the transect.

Slope did not affect the phenological development as much as the aspect and elevation did, but its effect was significant with the 3 - 10° slopes having the earliest development (Table 30). Low shrub and closed forest vegetation types had the most-advanced vegetation, although the number of observations (n = 21) in the closed forest type was too small to place much confidence in the conclusion (Table 31). Woodland forest types generally developed later.

The first full log-linear mode run for Kosina Creek included phenology, aspect, elevation, and slope. Interactions of aspect and slope with phenology were the only significant third order interactions in both partial and marginal tests (Appendix Table P7-1). All second order interactions including phenological advancement were also significant. Aspect and aspect x slope appeared to have the strongest effect on phenological advancement according to the first log-linear model (Table P7-1). Aspect x elevation x phenology was not significant. The significant cells included southerly slopes less than 30° above the impoundment and 3 - 10° and greater than 30° below the impoundment.

The model with slope replaced by vegetation type indicated that low shrub types on south slopes above the impoundment were more advanced phenologically than would be expected (Appendix Table P7-4). This was one of the few models with a relatively clear interpretation. Vegetation type and elevation were significantly related because almost all the vegetation above the impoundment was low shrub. The low shrub vegetation types seldom occurred below the impoundment. The first model appeared better, but an untested model that might also be considered would be phenology, aspect, slope, and vegetation type. After aspect, it was not clear which other variables accounted for the most variation with respect to phenology.

The contrast between the standardized deviates for early and late stops below the impoundment for the same categories indicated that this should also be considered significant and was supported by the observed frequency table. The low standardized deviates occurred because there were few south-facing low shrub sites below the impoundment.

5.2.1.8 Clarence Creek

A number of moose had been sighted in the Clarence Creek area on a 1982 fall reconnaissance. The bottom of these transects were covered by ice from an ice jam, but undamaged graminoids were observed through the spaces between the ice blocks. The area had predominantly northerly slopes and was undeveloped phenologically during period 5 with only 14% of the stops being reported as early developing. Northeast-facing slopes had a smaller frequency of early stops than would be expected (Table 28). Although the 600-m elevation band appeared to be the only band with a significant number of early stops, the small number and distribution of early stops made that questionable (Table 29). Although slope and phenology were independent by the chi-square test, gentler slopes generally were early developing phenologically (Table 30). Woodland forest types had more early stops in terms of numbers and percentage of stops (Table 31) while low shrub and open forest types were late developing.

Third order interactions involving phenology were generally significant in the partial association test, but only the elevation x slope term was important in the marginal test (Appendix Table P8-1). Vegetation type appeared to affect phenology more than slope or aspect. Indeed, the stops which developed earliest were in woodland forest-dwarf tree scrub types below the impoundment on 0 - 10° slopes (Appendix Table P8-2).

5.2.1.9 Switchbacks

The switchback area near the big bend of the Susitna River was a medium-developing area with southerly aspects containing the earliest-developing stops (Table 28). Elevation band 660 m had the greatest number of early-developing stops while elevation 690 m had the largest percentage of early-developing stops and was the only band with significantly more early stops than would be expected (Table 29). More early developing stops occurred in the 10 - 30° slopes than on gentler slopes (Table 30). Low shrub vegetation types contained more early greenup stops (n = 66) than other types because of its large areal extent (302 stops) (Table 31). However, a larger percentage of dwarf tree scrub type stops developed early in the season (44%).

The transects by the switchbacks tended to follow drainages so that the general aspect of a transect might be northeast although the aspect at the stop might be east. This resulted in the uneven distribution without clear cut north- and south-facing transects. It also prevented comparisons among time periods. The following aspect groupings were used for the log-linear model: E, SE, S, SW, NW-NE. Vegetation types used included open forest, woodland forest, dwarf tree scrub, tall shrub, and low shrub.

The full log-linear model had significant third order interactions but aspect x elevation x slope was not significant, indicating a balance of observations among these cells (Appendix Table P9-1). Third order interactions involving phenology x aspect x elevation or slope were the most significant. Cells with the earliest developing vegetation were south to southwest aspects below the impoundment regardless of slope. These same aspects above the impoundment on 10 - 30° slopes also developed early.

When slope was replaced by vegetation type, aspect x vegetation was not significant among the second order terms, nor was the third order interaction with phenology significant. Phenology x vegetation type was not significant indicating these two variables were independent. This was validated by the observation that cells with higher frequencies of earlier-developing sites included south to southwest slopes above the impoundment regardless of vegetation type (Appendix Table P9-4). Low shrub types on these same slopes below the impoundment also developed earlier.

5.2.2 Snow Cover - Period 2-6 May-12 May, 1983

Snow depth was analyzed only for the second sample period since insufficient snow remained after that to analyze any patterns. After period two, many areas were starting to green up so that analysis of snow depth past that time period was not cost beneficial. During the first sample period, large amounts of snow remained in many places and few areas appeared ready for spring forage. This was noted in the transect descriptions rather than spending time and money on computer analyses. The analysis using topographical features was done with presence or absence of snow since there was insufficient snow in the deeper categories.

5.2.2.1 Devil Creek

Approximately 78% of the stops along Devil Creek transects were snow free during period 2 with less than 3% of the stops having more than 50 cm snow cover. Aspect had a significant effect with southwest-facing slopes being more snow free than expected and northwest slopes having more snow than expected (Table 32). The lowest elevation (band 360 m) was almost completely snow free while elevation 570 and 600 m had more snow than the others (Table 33). Slope had a statistically significant effect ($P = 0.08$), but no category had less snow than would be expected (Table 34). The low shrub vegetation type had less snow while woodland forest and dwarf tree scrub had more snow than would be expected (Table 35).

The full log-linear model contained several important interaction terms and demonstrated why it was necessary to consider interactions of parameters rather than considering parameters separately. The model using snow, aspect, elevation, and slope had significant fourth order interaction while most lower order terms were significant except for aspect x elevation. Cells with significantly less snow included: 0 - 3° northerly and 3 - 10° southerly aspects below the Devil Canyon impoundment and 10 - 30° north-northeast-facing slopes above the impoundment (Appendix Table S1-1).

The model with vegetation type rather than slope was "easier" to interpret since higher order interactions were not as important. Cells with less snow included southerly aspects in open forest types regardless of elevation, low shrub types below the impoundment regardless of aspect, and low shrub types on north-northeast-facing slopes above the impoundment (Appendix Table S1-2). This included low shrub types on north-northeast aspects without regard to elevation.

5.2.2.2 Tsusena Creek

Tsusena Creek had insufficient snow to analyze statistically or generally. Little snow was present during the first sample period.

5.2.2.3 Fog Creek

Fog Creek transects had 86% of their stops free of snow during the second period. Aspect was significantly related to snow-free stops, but no one aspect was significant. However, southerly aspects tended to have more snow-free stops than would be expected by chance (Table 32). North aspects, however, did have more stops in the 1 - 10 cm and 10 - 30 cm snow-depth categories. Elevation had no effect, probably because of the small variation, although there was a tendency for higher elevations to have less snow (Table 33). Slope also had no effect (Table 34). Although vegetation type was significant, no types were particularly snow free (Table 35).

However, forest vegetation types tended to have more snow. The log-linear model indicated that snow-free stops occurred more often on 0 - 3° southerly slopes in low shrub types and 3 - 10° northwest slopes in open to woodland forest types (Appendix Table S3-10).

5.2.2.4 Watana Slide

Watana Slide had approximately 87% of the sites snow-free in period 2. Although aspect was significantly related to snow cover, no one aspect had less snow than might be expected by chance (Table 32). However, northwest-facing slopes generally had less snow cover. Elevation and vegetation type were also significantly related to snow, but no one category had more snow-free stops than would be expected by chance (Tables 33, 35). Slope and snow cover were independent (Table 34).

The full log-linear model analysis was able to isolate characteristics of snow-free stops than the 2-way tables because levels of parameters were collapsed to reduce the number of 0 cells. Significant third order interactions included snow x aspect x slope and elevation x aspect x slope. Significant second order terms involving snow included aspect and elevation. Cells with significantly less snow included 0 - 3° east facing slopes above the Watana impoundment, 3 - 10° west to northeast slopes below the impoundment, and 0 - 30° south to southwest slopes above the impoundment (Appendix Table S4-1).

When slope was replaced by vegetation type in the log-linear model, a strong dependence between aspect and vegetation type was indicated. The third order interaction of aspect x vegetation with snow was also highly significant. Many different cells had less snow than expected with no apparent pattern supporting the 1982 conclusion that factors other than slope, aspect, and elevation needed to be considered when identifying early snow-free or greenup areas.

5.2.2.5 Watana Creek

Watana Creek had only 77% snow-free stops during the second sample period with the west, southwest, and south exposures having less snow than expected (Table 32). Northwest-facing slopes had more snow than would be expected. Elevation band 450 m by the river was 99% snow free at the time and was the only elevation to have more stops free of snow than would be expected (Table 33). Higher elevations had more snow than would be expected. Only 2% of the stops had more than 30 cm of snow. Slope had a significant effect; however, no slope category had significantly more snow-free stops than any other category. Flatter slopes tended to be more snow free (Table 34). Low shrub types had more snow-free stops, and woodland forest had more snow than would be expected by chance (Table 35).

The full log-linear model had significant third order interactions for snow and vegetation type crossed with aspect x slope for partial tests. All second order terms were significant with the marginal association tests as were all second order terms. Aspect appeared to affect snow depth more than did elevation and slope. Cells with significantly more snow-free stops included northeast-south-southwest slopes in low shrub types on 0 - 3° slopes and the same aspect in open forests regardless of slope (Appendix Table S5-1).

5.2.2.6 Fish Creek

Fish Creek had 89% of its stops free of snow with less than 1% having more than 50 cm of snow. Aspect affected the snow distribution (Table 32). Although no aspect had more snow-free stops, north-facing aspects had more snow (Table 32). Similarly, elevation affected snow distribution, and more snow-free stops were located at the lower elevations (Table 33). Higher elevations contained more snow. Lower elevations contained birch-spruce forests on moderate slopes while mid-slope elevations contained spruce on gentler slopes. Slope and vegetation type were significant, but gentler slopes tended to have fewer snow-free stops and closed forest stops were completely snow free (Table 34, 35). Closed forests stops were generally birch-spruce or birch-aspen vegetation. These vegetation types were generally associated with "recent" disturbance and well-drained slopes.

Most second order interactions in the full log-linear model were significant in both partial and marginal tests of association. However, the only significant third order term which included snow was snow x elevation x slope. Cells containing more snow-free stops than would be expected were 0 - 3° southerly slopes below the impoundment, 3 - 10° souther slopes above the impoundment, and 10 - 30° northerly slopes below the impoundment (Appendix Table S6-1).

When slope was replaced by vegetation type, the snow x elevation x vegetation type was significant in the partial tests while snow x aspect x vegetation was significant in the marginal tests of association. Elevation and vegetation type were more related than elevation and slope. Hence, the model with slope was more meaningful than the model with vegetation types since the variables were less dependent on each other. Significant cells in the vegetation model included northerly aspects in closed to open forests below the impoundment and southerly aspects in woodland forests above the impoundment (Appendix Table S6-2). If the greater crown cover of closed to open forests corresponded to 10 - 30° slopes and the woodland type corresponded to 3 - 10° slopes, the two models would correspond. Indeed, the period 5 analysis using vegetation, slope, aspect, and elevation indicated a strong dependence among vegetation and slope.

5.2.2.7 Kosina Creek

Approximately 86% of the stops along the Kosina Creek transects were free of snow during period 2 with less than 2% of the stops having more than 30 cm of snow. Southern aspects had more snow-free stops than would be expected (Table 32). Elevation and snow distribution were significantly related, but no bands appeared to have significantly more snow-free stops than would be expected (Table 33). However, lower elevations tended to have less snow, and higher elevation bands had more snow. Slope also had a significant effect (Table 34). Although no category had more snow-free stops than expected, 10 - 30° slopes generally had more snow. Open forest types had more snow-free stops than expected while woodland forest and tall shrub types had more snow (Table 35).

The full log-linear model for snow on Kosina Creek transects was easier to interpret than some of the other models. Third order terms involving snow were not significant, but all second order terms were, especially the interaction of snow with aspect. Cells containing significantly more snow-free stops included south aspects below the impoundment on 0 - 10° slopes and above the impoundment on 10 - 30° slopes (Appendix Table S7-1). The model which replaced slope by vegetation type was more complicated and not interpretable because vegetation was dependent on aspect and elevation, leading to a large imbalance and many 0 cells.

5.2.2.8 Clarence Creek

Clarence Creek had more snow cover than the other transects at this time. Although less than 2% of the stops had snow greater than 30 cm, only 64% of the stops were snow free and 19% and 16% had 1 - 10 cm and 10 - 30 cm, respectively. Aspect had no effect since most areas were north-facing (Table 32). Elevation had a significant effect with the 600-m band by the river having more snow-free stops (Table 33) at this time. Earlier, this band had been covered by large blocks of ice from an ice jam. Elevation bands 810 m-840 m at the top and band 690 m had more snow. Effect of slope was significant, and 10 - 30° slopes tended to have more snow (Table 34). Vegetation type was significant with dwarf-tree scrub tending to have less snow and open-woodland forests having more snow (Table 35). Cells with less snow than expected were 3 - 30° slopes below the impoundment in dwarf tree scrub-low shrub vegetation types as indicated by the log-linear model.

5.2.2.9 Switchbacks

The switchbacks were relatively free of snow during period two with 98% of the stops being snow free. Aspect was significant, and northerly aspects tended to have more snow than southerly aspects (Table 32). Elevation was significant although the 690 m band seemed to have more snow (Table 33). Slope was also significant with 0 - 3° category tending to have more snow (Table 34). Vegetation type was significant, and woodland forest had more snow than would be expected (Table 35). No vegetation type had more snow-free stops than expected. There was insufficient snow to warrant analyzing the log-linear model so no effects of interactions could be determined.

5.2.2.10 Synopsis - Spatial Variation for Phenology and Snow

Differences occurred among the different transect groups, aspect, elevation, slope, and vegetation type for phenological advancement during period 5 (27 May - 2 June) and snow cover during period 2 (6 May - 12 May). Although any aspect might have a significant number of stops that were phenologically advanced, southern aspects prevailed in this respect (Table 28). Elevations that were significantly more advanced also varied among transect groups with approximately half being above and half below the potential impoundments. Slope frequently did not have a significant effect on phenological advancement, although flat slopes (0 - 3°) were usually late developing (Table 30). When slope did have an effect, the steeper slopes were the earlier sites. Hence, vegetation on steeper south-facing slopes might develop faster than other areas, but there were many exceptions. The 1982 study indicated that fire history played a role.

Similarly, vegetation type effects varied among transects (Table 31). Closed forests and herbaceous vegetation types were always significantly advanced where they occurred, but the number of stops in these types was often small and the conclusion might be misleading (Table 31). Closed forests were associated with mixed broadleaf-evergreen or broadleaf forest. These vegetation types were usually seral and associated with warm, well-drained slopes. Stops in low shrub areas contained earlier developing vegetation than would be expected on a third of the transects. The successional nature of the vegetation supports the 1982 conclusion concerning fire.

Transects also varied greatly in their relative phenological development. The percentage of stops classified as phenologically advanced varied from 7 to 53% during period 5 (Table 44). The percentage of snow-free stops varied from 64 to 99% during period 2. One would expect transects with relatively little snow during period 2 to be phenologically advanced by period 5. However, the relative rankings of the transects differed slightly between periods 2 and 5.

Tsusena Creek was the most advanced area both times probably because of the well-drained, southern exposure. Over half the stops were considered advanced during period 5 and almost all sites were free of snow in the second period. The birch-spruce forest covering much of its slopes was a seral vegetation type. Seral vegetation seemed to be associated with early plant development in many areas.

Devil Creek had almost as large a percentage of advanced stops in period 5 but had a lot of snow in period 2. It either had deeper winter snow than other areas or had slower melting snow. Kosina Creek was farther behind with only 35% advanced stops. It was tied for fifth with snow-free areas but was only 3% behind the third ranked transect at that time. Hence, it's rank did not really change between periods 2 and 5.

Watana Slide was a medium area in both time periods with a rank of 4. Switchbacks ended up in fifth position phenologically although they were almost completely (98%) snow free in the second period. Either this site may have had less snow than others or the vegetation types or plant species may have been slow developing. Fish Creek was ranked sixth during period 5 but third in period 2, and was only 3% ahead of sixth place. Hence, it remained about the same. Clarence Creek was slow during both periods, but this was largely because of north-facing aspects and a large ice jam that covered almost the entire portion of the transect parallel to the Susitna River. Watana Creek was also relatively slow during the entire study. Fog Creek was the least developed transect group during the last sample period, but had been tied for fifth, only 3% behind the third ranked transects in period 2.

Overall most transects retained their same relative positions although some differences occurred. Fog Creek and the Switchbacks were slower developing after snow melted while Devil Creek advanced rapidly. Rates of development could differ greatly among transects as seen by comparing Devil and Watana Creeks. Both had the same percentage of snow-free areas during period two, but Devil Creek had 53% advanced sites and Watana had only 9% in period 5.

5.2.2.11 Discussion - 1983 Study

Determining what factors affect forage availability in the spring was a complex problem. As with the 1982 phenological study, no generalizations about aspect, elevation, slope, or vegetation type could be made with confidence. It was true that, in some cases, southern aspects were more advanced phenologically than northern ones or that higher (above the impoundment zones) were more advanced. However, there were many cases where northern aspects or lower elevations were more advanced. The same was true about vegetation type and slope. More or different environmental parameters affect growth initiation than what were measured in either 1982 or 1983.

The objective of these studies has been to identify why moose were using the slopes of the impoundment zone prior to parturition. This question was raised based on several years of ADF&G data (Ballard et al 1982, Ballard et al 1983). However, in 1983 the moose had moved out of the impoundment zone prior to parturition, although numerous moose were sighted near the south-facing Kosina Creek transects just before sampling was initiated and occasional moose were spotted during the study period. They could have been using the areas in the evenings or early mornings and been undetected. Fewer moose signs were observed in 1983 relative to 1982. However, this was partly attributable to different methods of descent. Animal trails were followed in 1982, but compass courses were followed in 1983. The presumed moose-vegetation relationship may be very variable among years.

Many problems with the field and statistical techniques were encountered. The usual errors involved in field measurement problems were present, even though only codes were being recorded. Tapping an altimeter could result in a 30-m change, which was the width of the elevation bands. Bands were made this narrow so that possible differences in the reservoir height could be assessed; however, they were not used this way in the analysis.

Analysis among time periods was hampered by not having precisely located points. Relocation between time periods resulted in considerable error. In some cases the recorded aspects were sufficiently different that there was no way development through time with respect to aspect could be studied. Part of this was relocation error and part was sampling error with respect to aspect. This problem existed for all the other variables also. Relocatable sample locations are strongly recommended for studies over a period of time.

This was the big difference why plant development could be followed in 1982, but not in 1983.

Observation of snow depth and species phenology was extremely dependent on exact placement of the observers foot. No matter how hard one tried not to bias steps, if one were wearing snowshoes on one tended to walk on snow, and if one did not have snowshoes on one tended to walk on snow-free areas. Since snow depth was based on the snow at the tip of the boot or snowshoe, considerable bias was introduced. Depth could vary within a few centimeters of the boot which meant that unless exactly the same location was hit next time, changes in depth could result from different location as well as a different snow depth. This might have accounted for the apparent rapid snow disappearance after the first period. Our recollections indicated there was still considerable snow at that time, which were not substantiated by the data.

The phenological development by species would not be as affected as the snow depth by the "snowshoe" bias because the species were selected within a 0.5-m radius. But this meant plants could be fully leafed out at the same location where 30-50 cm of snow was recorded. This was not unusual because plants absorb and create heat as a byproduct which, in turn, melts snow around the plants. Hence, snow depth was extremely difficult to relate to phenological stage of individual species. Development of individual species could not be traced statistically across time because of insufficient reliable data. However, the data listings were scanned for general trends. A species that was recorded during period one was generally a low shrub (approximately 50 - 100 cm tall). As snow melted and dwarf shrubs (< 20 cm tall) became visible, the low shrubs might not be the closest shrub to the boot anymore.

Qualitative data were less expensive to obtain in the field than quantitative data for a given observation, however, many more observations of qualitative data were needed for a meaningful analysis. Statistical techniques for qualitative data are fewer, less well understood, and much more expensive than quantitative techniques. Our overall experience (field and computer time) on this indicates that quantitative data may be less expensive.

The most appropriate statistical techniques available were contingency tables, their full log-linear model equivalent, and logistic regression. The full log-linear model produced a table of significance similar to an analysis of variance, but used qualitative data. Since it was an iterative procedure whose running time depended on the number of cells (which depended on number of treatments and levels), it was expensive as more variables and levels were added. This analysis treated all variables as independent variables, as in contingency tables. Logistic regression was a special case where one variable was considered to be the dependent and the others as independent variables like a regression analysis using qualitative data. By considering interactions only with the dependent variable, a log-linear model could be interpreted as a logistic regression. The log-linear model was used since it was understood better.

The log-linear model was limited by computer core space and data (no 0 cells). Since each cell needed space, the amount of computer space that was needed grew astronomically if more than a few categories were used for each (elevation, aspect, slope, vegetation type). All recorded levels of variables (treatments) could be used if only 2-way analyses were performed. Since most phenological development was assumed to be a response to interactions of terms, several variables had to be analyzed simultaneously. If many levels (coded values for treatments, or variables) were used, costs were exorbitant or the amount of computer memory needed exceeded that available to the program. Hence, many treatment levels had to be collapsed together. Levels also had to be combined to eliminate most 0 cells which would invalidate the results. This sometimes meant either eliminating levels that were unimportant or too rare to have an effect, or combining levels that did not have a uniform response. The latter was a violation of assumptions.

Effect of vegetation type was difficult to interpret because of the combination of levels of vegetation types. These categories were grouped by canopy cover since this seemed to be the most relevant factor during the field work. During some of the interpretation, it seemed like a moisture gradient might have been useful although slope accounted for part of this. Usually slope and vegetation were not considered in the same run. Data were inadequate to fill additional cells created by a moisture variable unless it replaced some other variable.

One item that was not considered in this analysis was the use of two different elevations: absolute elevation and elevation relative to the river. The river elevation near the Switchbacks was slightly lower than the highest elevation by Devil Creek. The microenvironment associated with the river may have an effect on phenological advancement and could be as biologically important as the actual elevation. Theoretically the elevation x slope interaction may take some of this into account. However, one of the main objectives of this study was to assess the effect of the impoundments.

Hence, only absolute elevations were considered because of the objectives and time limitations.

Another characteristic of vegetation that could be relevant for snow accumulation might be whether the vegetation at a stop was the same as the surrounding vegetation. Some low shrub stops, for example were in a large expanse of low shrub type with a lot of exposure for sun and wind while others were in an inclusion sheltered by surrounding trees. This could account for why low shrub types had a lot of snow in some areas and other places they were relatively snow free.

These results were reported as if no sampling error were involved. A slightly different foot placement could give a different results as has been discussed. We have found evidence of this by the lack of matchup for aspects, slope, elevation and vegetation type among sample periods.

5.2.3 Berry Availability - Period 5; 27 May-2 June, 1983

Berry availability was analyzed on a presence or absence basis since there were insufficient stops with high abundance of berries for a meaningful analysis. Availability of overwintered berries was directly related to snow melt since no time was needed for development of berries after the snow melted. The fifth period was selected for analysis since the most berries would be available then for a spatial analysis of berry occurrence. Timeliness of availability could generally be considered to start during period 2 and by period 3 most berries would be available.

5.2.3.1 Devil Creek

Berries occurred at only 7% of the stops along the Devil Creek transects, with northeast-facing aspects being the most likely aspect based on two-way models (Table 36). Berries occurred more frequently at higher elevations (630-660 m) (Table 37) and on steeper slopes than in other slope categories, (Table 38). Low shrub types had more frequent occurrences of berries than would be expected (Table 39).

Aspect and elevation were the two individual factors that affected berry distribution according to the full log-linear model containing berry presence, aspect, elevation and vegetation type. Vegetation type was strongly dependent on aspect. Berries were found predominantly on the northerly slopes in low shrub types above the Devil Canyon impoundment (Appendix Table B1-1). Hence, the Devil Canyon dam would not be expected to impact berry availability here.

5.2.3.2 Tsusena Creek

Berries were found at only three stops (Table 36). This was insufficient to draw conclusions.

5.2.3.3 Fog Creek

Berries were relatively rare on these transects with less than 3% of the stops having berries. The analysis was questionable because of the small sample size but some trends might be indicated. North aspects tended to have more frequent berry occurrences than south aspects (Table 36) while the steeper slopes had larger berry frequencies than the gentler slopes (Table 38). Berry frequency was independent of vegetation type (Table 39).

5.2.3.4 Watana Slide

Approximately 7% of the stops along the Watana Slide transects had overwintered berries with the northwest, north, and northeast aspects being the predominant aspects on which to find berries (Table 36). Higher elevations, especially band 690 m, were also favored with smaller frequencies at lower elevations (Table 37). Slope and vegetation type had no effect on berry frequency although low shrub types seemed to contain berries more frequently (Tables 38, 39).

The full log-linear model was analyzed with berries, aspect, elevation, and vegetation type. Berries interacted significantly with aspect and elevation alone, but did not have significant interaction with vegetation. However, the berry x aspect x elevation term was not significant. In reality, there was one major area of berry abundance on the northerly aspects in the low shrub types above the Watana impoundment zone (Appendix Table B4-1). The other pair of transects also had frequent berry occurrences near the top. Hence, the project should have no effect on berry availability in this area.

5.2.3.5 Watana Creek

Watana Creek transects had an average frequency for berries of almost 8%. Aspects with the most frequent occurrences of berries were northeast and east (Table 36) while elevations where berries occurred most frequently were 510 m, 540 m, and 660 m (Table 37). Slopes from 10 - 30° had larger frequencies for berries (Table 38) while vegetation type was not significantly related to berry frequency (Table 29).

The full log-linear model for berry distribution was affected primarily by aspect and vegetation x slope. The only features to have a significantly larger frequency of berries were northeast aspects on 3 - 10° slopes in open to woodland forest and 10 - 30° slopes in dwarf tree scrub (Appendix Table B5-1). All of these areas were below the impoundment zone since no portion of the transects were above the potential water level.

5.2.3.6 Fish Creek

Overwintered berries were more frequent on south- and east-facing slopes with north- and northeast-facing aspects having less frequent berries (Table 36). Approximately 13 to 17% of the south- and east-facing stops contained berries. Berries were more common in elevation bands 660 m and 720 m (above impoundment) while bands 510 and 570 m (below impoundment) contained fewer berries than would be expected (Table 37). Berries had less tendency to occur on 0 - 3° slopes (Table 38). Frequencies were relatively large in woodland forest stops and small in low shrub stops (Table 39). Almost 12% of the woodland forest stops contained berries.

The full log-linear model for berries indicated that berries were affected more by single factors than by an interaction of factors. The interaction of aspect, elevation, and vegetation type contributed greatly to the model which indicated the dependency of these variables. All cells which had more stops with berries than would be expected also had more stops with berries (i.e. had more stops) (Appendix Table B6-1). This again pointing out the problems with the unbalanced design inherent when treatments (aspect, elevation, vegetation) are dependent.

5.2.3.7 Kosina Creek

Berries were found on about 6% of the stops along the Kosina Creek transects. Aspect and vegetation types were not related to berry frequency (Tables 36, 39) while elevations with frequent berry occurrence included 600 m and 720 m (Table 37). Slope and berries were not independent with 10 - 30° slopes tending to have larger frequencies and 0 - 3° slopes having significantly lower frequencies than would be expected by chance (Table 38).

The full log-linear model for berries was significant; however, virtually none of the terms involving berries were included. Hence, the model did not explain berry distribution and was dominated by dependencies among vegetation type and elevation. Higher elevations were dominated by low shrub types and forested types occurred predominantly below the impoundment zone. These low shrub types had a more frequent berry distribution than would be expected by chance (Appendix Table B7-1). Hence, the impoundment would not have a major effect on berries in this area.

5.2.3.8 Clarence Creek

Clarence Creek had a larger frequency of berries (12%) than most other transects. Aspect and vegetation types were not related to berry frequencies (Tables 36, 39). Elevation 630 m had a significantly larger frequency of berries than would be expected by chance (Table 37), although fluctuations among adjacent elevations appeared random. Slope had a significant relationship, but no slope category had a larger frequency than would be expected by chance (Table 38).

The only significant interaction with berries in the full log-linear model was with slope. The only cell that appeared to have more frequent occurrences of berries was low shrub types above the impoundment on slopes greater than 30° (Appendix Table B8-1). Again, the impoundment would probably have negligible effect.

5.2.3.9 Switchbacks

Berries were rather scarce in the switchback area with only 2% of the stops containing berries (Table 36). South-facing slopes contained more berries than did other aspects (Table 36). Differences among elevation bands were not significant, but all stops with berries occurred above the impoundment zone (Table 37). Slope did not significantly affect berry frequency, although slopes greater than 3° tended to have more berries than those less than 3° (Table 38). Berries occurred most frequently in the low shrub vegetation types with woodland forest being the only other type where berries were recorded (Table 29). Frequency of berry occurrence on the Switchback transects was insufficient to warrant a full log-linear analysis.

5.2.3.10 Synopsis - Spatial Variation for Berries

Berry availability also varied considerably among transects. Clarence Creek had the largest frequency of berries in period 5 while Tsusena Creek, Switchbacks, and Fog Creek had the lowest frequency (Table 44). There appeared to be a weak inverse relationship between frequency of berries in period 5 and of snow-free transects in period 2. Significant aspects tended to be more northerly ones (7 significant cells vs 3 significant cells for southerly aspects, Table 36).; This could also relate to later snowmelt. Elevation patterns differed with transects, but higher elevations tended to have larger frequencies of berries than did lower elevations (Table 37).

5.2.3.7 Kosina Creek

Berries were found on about 6% of the stops along the Kosina Creek transects. Aspect and vegetation types were not related to berry frequency (Tables 36, 39) while elevations with frequent berry occurrence included 600 m and 720 m (Table 37). Slope and berries were not independent with 10 - 30° slopes tending to have larger frequencies and 0 - 3° slopes having significantly lower frequencies than would be expected by chance (Table 38).

The full log-linear model for berries was significant; however, virtually none of the terms involving berries were included. Hence, the model did not explain berry distribution and was dominated by dependencies among vegetation type and elevation. Higher elevations were dominated by low shrub types and forested types occurred predominantly below the impoundment zone. These low shrub types had a more frequent berry distribution than would be expected by chance (Appendix Table B7-1). Hence, the impoundment would not have a major effect on berries in this area.

5.2.3.8 Clarence Creek

Clarence Creek had a larger frequency of berries (12%) than most other transects. Aspect and vegetation types were not related to berry frequencies (Tables 36, 39). Elevation 630 m had a significantly larger frequency of berries than would be expected by chance (Table 37), although fluctuations among adjacent elevations appeared random. Slope had a significant relationship, but no slope category had a larger frequency than would be expected by chance (Table 38).

The only significant interaction with berries in the full log-linear model was with slope. The only cell that appeared to have more frequent occurrences of berries was low shrub types above the impoundment on slopes greater than 30° (Appendix Table B8-1). Again, the impoundment would probably have negligible effect.

5.2.3.9 Switchbacks

Berries were rather scarce in the switchback area with only 2% of the stops containing berries (Table 36). South-facing slopes contained more berries than did other aspects (Table 36). Differences among elevation bands were not significant, but all stops with berries occurred above the impoundment zone (Table 37). Slope did not significantly affect berry frequency, although slopes greater than 3° tended to have more berries than those less than 3° (Table 38). Berries occurred most frequently in the low shrub vegetation types with woodland forest being the only other type where berries were recorded (Table 29). Frequency of berry occurrence on the Switchback transects was insufficient to warrant a full log-linear analysis.

5.2.3.10 Synopsis - Spatial Variation for Berries

Berry availability also varied considerably among transects. Clarence Creek had the largest frequency of berries in period 5 while Tsusena Creek, Switchbacks, and Fog Creek had the lowest frequency (Table 44). There appeared to be a weak inverse relationship between frequency of berries in period 5 and of snow-free transects in period 2. Significant aspects tended to be more northerly ones (7 significant cells vs 3 significant cells for southerly aspects, Table 36).; This could also relate to later snowmelt. Elevation patterns differed with transects, but higher elevations tended to have larger frequencies of berries than did lower elevations (Table 37).

Slope generally was not significantly related to berries, but on transects where it was significant, the 10 - 30° category had larger berry frequencies (Table 38). Similarly vegetation type was not usually related to berry frequency, but low shrub types tended to have larger frequencies of berries where vegetation type was significant. Hence, the many areas with a high berry frequency would remain above the impoundment.

5.2.4 Horsetail Abundance - Period 5 - 27 May-2 June, 1983

Analysis of horsetail abundance had the same major problem as berries: there were too few values in the various categories to analyze anything except presence or absence, and distribution was very localized. Horsetail, on the other hand, required time to green up before it was available. All species were recorded with no differentiation, and the bear diet work (Miller and McAllister 1982, Miller 1983) did not indicate which species of horsetail was eaten. Some species occur primarily in riparian areas while others occur on wooded hillsides. Hence, the different species would be impacted differently by the proposed hydroelectric project. Two moose calves, apparently killed by a bear, were found on a north-facing slope near Tsusena Creek in spring 1982. Relatively fresh (within past day) bear feces were found and appeared to contain pieces of an upland horsetail species. An upland horsetail species had been grazed along the 1982 Jay Creek transect, but it is unknown whether bear or moose grazed it. No utilization of riparian horsetail (such as Equisetum variegatum) has been observed. The evidence is not strong but it seems to indicate that the upland species may be used by bears, but they dig sweet-vetch roots along the river, which would account for their presence along the river.

5.2.4.1 Devil Creek

Aspect (Table 40) and slope (Table 42) did not explain horsetail frequency, but it was most frequent at elevation band 480 m (Table 41) as indicated by 2-way contingency analyses. The 450-m band also had significantly more horsetail occurrences than would be expected, but had a smaller percentage of occurrences than the 480-m band (Table 41). Horsetail was more abundant in open and woodland forest vegetation types than would be expected by chance (Table 43).

Horsetail was probably too scarce along these transects to justify a full log-linear analysis, however, the vegetation type interaction appeared to affect the horsetail distribution the most. Open forest-dwarf tree scrub forest on northwest to northeast aspects below the impoundment and east to southeast aspects above the impoundment had more horsetail than would be expected (Appendix Table H1-1). Most other cells had none.

5.2.4.2 Tsusena Creek

Horsetail was found predominantly at lower elevations with larger frequencies than would be expected at elevation 480 m (Table 41). The 3 - 10° slopes and open forests had larger frequencies of horsetail than would be expected (Table 42, 43).

The full log-linear model for horsetail had some of the same problems that the phenological model did: namely, a strong dependence among elevation and slope which resulted in many empty cells. Vegetation type and slope had significant interactions with horsetail frequency. In reality, horsetail occurred most frequently in open forests on 3 - 10° slopes regardless of elevation (Appendix Table H2-1). It occurred least frequently in open forests on 10 - 30° slopes above the impoundment and 0 - 3° slopes below the impoundment.

5.2.4.3 Fog Creek

Horsetail was much more frequent on western aspects (Table 40) and lower elevations (660 m) (Table 41). It was most abundant on 0 -3° slopes and open forests (Tables 42, 43). One location accounted for most of the stops with horsetail.

The full log-linear model for horsetail along Fog Creek had the problem with imbalance among cells. Aspect x slope x vegetation type was the most significant third order interaction so these variables were dependent. Slope x vegetation type x horsetail frequency was the only third order term involving horsetail that was significant in both partial and marginal tests of association. North-facing 0 - 3° slopes in closed to open forest types were the only stops that appeared to have a significantly higher frequency for horsetail occurrence (Appendix Table H3-1). One other cell did, but it was equally significant for absence of horsetail, an artifact of the methodology.

5.2.4.4 Watana Slide

Approximately 27% of the stops along the Watana Slide transects contained horsetail. Southerly aspects had higher frequencies and the northerly aspects had lower frequencies of horsetail than would be expected by chance (Table 40). Elevation bands 540 and 570 m contained the largest number of stops with horsetail as well as the largest percentage and these effects were significant (Table 40). Horsetail frequency and elevation were generally inversely related along these transects: horsetail occurred more often at higher than lower elevations. Slope and horsetail frequency were dependent with 0 - 3° slopes having the most in number and percentage of horsetail occurrences (Table 42). Horsetail occurred more frequently in herbaceous and low shrub types than in other vegetation types (Table 43). Much of this distribution resulted from a stand of willow and horsetail on the west side of Watana Creek at the bottom of the transects. This stand would be inundated.

The full log-linear model and the observed frequency table verified some of the above discussion. Low shrub types below the impoundment level, regardless of aspect, contained the most significant frequencies of horsetail (Appendix Table H4-1). All the third order and lower interaction terms were significant except for the partial test for horsetail x aspect x elevation.

5.2.4.5 Watana Creek

Horsetail was recorded at 14% of the stops along Watana Creek with southwestern aspects having horsetail at 42% of these stops (Table 40). Elevation 480 m contained horsetail at 37% of its stops, which was significant (Table 41). Horsetail was more frequent on 0 - 3° slopes than would be expected with 20% of the stops containing horsetail (Table 42). Approximately 36% of the open forest stops contained horsetail (Table 43). In reality, most of the horsetail along these transects occurred on gentle southwest aspects in open balsam poplar - spruce forest near the bottom of the transects on the north side of the river. This location would be inundated with Watana Dam in place.

The only interactions not significant in the full log-linear model were horsetail x vegetation x slope. Vegetation and slope appeared to be strongly dependent. The most significant location for horsetail was 0 - 3° southerly slopes in open-woodland forests as reported previously (Appendix Table H5-1). Secondary locations were the same aspect and vegetation on 10 - 30° slopes and 0 - 3° slopes in low shrub types.

5.2.4.6 Fish Creek

Horsetail was most frequent on northeast-facing slopes as indicated by the number of stops containing it, the percentage of stops on this aspect containing it, and the significance of the standardized deviates (Table 40). All three of these measures indicate something different: whether it occurred in many places, whether most transect contained it, and whether it was significant. It was most frequent on elevation band 510 m with 25% of the stops in this elevation band containing horsetail (Table 41). Bands 660 m and 720 m contained fewer horsetail than would be expected. Horsetail tended to be more abundant on 0 - 3° slopes and less abundant on 10 - 30° slopes although this was significant only at the P = 0.07 level (Table 42). Low shrub types contained the largest percentage of stops with horsetail, while open forest types had the largest number of stops with horsetail (Table 43). In other words, low shrub types had a higher frequency of horsetail than did open forest types, but the latter contained horsetail at more stops. Significantly more horsetail was present in low shrub types and less in woodland forest types than would be expected by chance.

Horsetail frequency had interactions with elevation, vegetation type, and aspect in the full log-linear model. The three environmental variables were dependent since 10 - 30° slopes were vegetated predominantly with open forests. Low shrub types below the impoundment on west- to northeast-facing slopes contained more horsetail while the same locations above the impoundment contained lower frequencies of horsetail (Appendix Table H6-1).

5.2.4.7 Kosina Creek

Horsetail was most abundant on south- and southeast-facing slopes both in number of stops, percentage of stops with horsetail, and significance (Table 40). Elevation bands 540, 570, and 660 m (boundary), which were all below the potential impoundment zone, and flat slopes (0 - 3°) contained the most stops with horsetail (Tables 41, 42). Horsetail was most common in open forest stops with 19% of those stops containing horsetail (Table 43).

The full log-linear model indicated that second order interactions explained most of the horsetail abundance. Vegetation and elevation were strongly dependent which accounted for a lot of the variation. Most vegetation above the impoundment was low shrub, while forest types occurred primarily below the impoundment. Almost all the horsetail occurred below the impoundment on south aspects. Low shrub and closed to open forest were the most important vegetation types there (Appendix Table H7-1)

5.2.4.8 Clarence Creek

Horsetail was found at only 9% of the stops along the Clarence Creek transects. Aspect had no effect, but the transects were located only on the south side of the river (Table 40). Elevation band 780 m and to some extent 750 m contained higher frequencies of horsetail than would be expected (Table 41). Slope had no effect (Table 42), but all shrub sites contained more stops with horsetail (Table 43). The only cells with a significant frequency of horsetail in the full log-linear model were woodland forest - dwarf tree scrub and low shrub types on 10 - 30° slopes above the impoundment (Appendix Table H8-1).

5.2.4.9 Switchbacks

Almost 17% of the switchback stops contained horsetail during period 5 with northeast-facing slopes having a higher frequency of horsetail than would be expected (Table 40). Horsetail occurred at more stops on east- and southeast-facing slopes, but there was more area there. Elevation bands 690 and 750 m contained horsetail at more stops than would be expected and a larger percentage of contained horsetail than other elevations (Table 41). Slopes in the 3 - 10° range had a higher frequency of horsetail than would be expected (Table 42). The 10 - 30° slopes had a slightly lower percentage of stops with horsetail, but the result was not significant. Tall shrub and woodland and open forest types generally contained larger frequencies than other types (Table 43).

The full log-linear model indicated the most important interactions with horsetail were aspect, vegetation type, and elevation x vegetation type. The only cell that definitely had a larger frequency than would be expected was low shrub type above the impoundment on northerly slopes (Appendix Table H9-1).

5.2.4.10 Synopsis - Spatial Variation for Horsetail

Horsetail frequencies ranged from 4 to 27% with Devil Creek having the lowest percentages and Watana Slide having the highest (Table 44). The effect of aspect was variable, but the more southerly aspects tended to have larger frequencies of horsetail (Table 40). Horsetail tended to be more frequent at lower elevations below the potential impoundment level (Table 41). The 0 - 3° slope category had significantly higher frequencies of horsetail on almost half of the transects (Table 42). Open forest vegetation type was significant on two-thirds of the transects (Table 43). Tall shrub may also be an important vegetation type for horsetail, but the number of stops in this vegetation was rather small. Horsetail was more likely to be frequent on 0 - 3° slopes below the impoundment in open forest types. Many of these areas would apparently be lost by inundation in the impoundments.

5.2.5 Phenological Development over time by Transect Group

Phenological development over time was evaluated in a very general sense by scanning the listings of raw data to look for trends or which species were initiating growth first. This was performed only on a transect group basis since reports for vegetation type, aspect, and slope were not very consistent over time. Scanning the printouts also pointed out possible biases among observers or sampling errors that may have occurred.

5.2.5.1 Devil Creek

Most shrubs were dormant along most of the Devil Creek transects during sample period 1 on May 3, 1983. However, mountain cranberry had broken some buds at a few stops. Dwarf birch and alder were visible, but were dormant. An unknown grass was just emerging from the ground at one stop. More species were visible at the lower elevations, but they were still dormant. Paper birch had burst some buds and bluejoint, bluegrass, and fireweed were just emerging near some stops, but were not the recorded individuals. Utilization was reported on alder, willow, and rose in the area, but not on any stops.

Many of the dwarf shrubs were visible above the snow during period 2 (11 May), whereas during period 1 only low and tall shrubs were visible. Mountain cranberry and Labrador tea had broken bud, especially at the higher elevations around 660 m, which was above the potential Devil Canyon impoundment zone. Currant leaves were partly expanded at some stops on the south-facing aspects. Twinflower (Linnaea borealis) and wintergreen (Pyrola spp.) had burst buds at some stops.

Leaves of dwarf birch and spiraea were partly expanded on the north-facing slopes during sample period 3, May 18, 1983. Twinflower leaves were partly expanded at some stops on north-facing aspect. Most shrubs had half-expanded leaves on the south-facing slopes below elevation band 570 m. Much forage was available especially below elevation 570 m. Since the upper level of the impoundment would be near 450-m band, some of this forage would be lost to the impoundment, but a lot would still be available in the spring.

5.2.5.2 Tsusena Creek

Tsusena Creek was among the areas with the earliest available forage. It was virtually snow-free during the first sample period. Mountain cranberry had broken some buds, and an unknown grass species was just emerging from the ground at this time. By the second sample period, 12 May, mountain cranberry and twinflower had burst buds in many places, and bluejoint was emerging from the ground.

Most mountain cranberry had burst their buds by period 3, 19 May, while some willows had produced catkins. About half of the unknown grass observations were dormant while the other half ranged from just emerging to fully grown. All three life forms in an open white spruce type at elevation 480 m, just above the impoundment, were either just opening buds or emerging from the ground or had half-expanded leaves or half-grown stems. Most shrubs and forbs were still dormant in an open black spruce area while bluejoint and an unknown grass were just emerging or half grown. By the fourth period, abundant forage was available.

5.2.5.3 Fog Creek

Most plants were dormant during the first sample period, 29 April, along the Fog Creek transects, but an unknown sedge was just emerging on one stop. This was generally true during the second period also except that sedges at many stops in woodland white spruce were emerging and cottongrass was half grown in a sedge tundra vegetation type. An unknown grass was also emerging. By the third period, (18 May) sedges were approximately half-grown along half of one transect while diamondleaf willow had leaves about half-expanded. Crowberry was just starting leaf expansion. Most grasses were either just emerging or half grown during period 4 (25 May), but sedges were half to full grown. Shrubs mostly had leaves half expanded, but some had fully expanded leaves or catkins.

5.2.5.4 Watana Slide

Most plants were dormant along the Watana Slide transects during period 1 (2 May) except for an occasional mountain cranberry just breaking bud.

Bluejoint and sedges were emerging during period 2 (9 May), but bluejoint was half-grown in some closed alder stands. Mountain cranberry was just breaking bud. During period 3 (16 May) bluejoint was half grown in some woodland white spruce vegetation types and open alder stands. Sedge was half grown in some birch shrub stops. Dwarf scouring rush was half grown on some stops. Grass in a low willow shrub stand at the bottom of the transects was still dormant at this time, but shrubs and forbs were just initiating growth (phenological state=2).

By period 4 (23 May), most shrubs had half-expanded leaves, forbs, bluejoint and sedges were just emerging or half grown. Variegated scouring rush was mostly half grown. Most species were half developed (phenological state=3) during period 5 (30 May). This was a relatively slow developing transect, but there was considerable unused forage during period 3.

5.2.5.5 Watana Creek

Vegetation along the Watana Creek transects was mostly dormant during the first sample period (28 April) although some individuals of mountain cranberry had burst buds and some bluejoint and sedges were just emerging. By the second period (6 May), most plants were still dormant, but sedges were half grown on a few stops. The same was true during period 3 except that some grasses had started to emerge and mountain cranberry had started to break bud. Plants finally started developing during period 4 (20 May) when grasses were just emerging or half grown, and twinflower and horsetail were half grown in some stops. Mountain cranberry had also broken bud by this time. Great growth had occurred by period 5 (27 May) when shrubs had leaves half expanded at the higher elevations. Although sedges were generally just emerging or half grown, some stops had individuals fully grown, in the boot stage, or in anthesis.

5.2.5.6 Fish Creek

Vegetation along Fish Creek was somewhat earlier developing than that at mouth of Watana Creek. During period 1 (28 April), sedge was just emerging and mountain cranberry was breaking bud at the higher elevations above the impoundment. A wintergreen was also initiating growth when few forbs were visible. Open black spruce stops in the 540-m elevation band below the impoundment also seemed to develop earlier with many individuals of mountain cranberry breaking bud and some having leaves half expanded.

Sedges were either just emerging or half grown on many stops during period 2 (10 May). Bluejoint and other grasses were just emerging. By period 3, most shrubs had broken bud and graminoids were just emerging. Forbs were still generally dormant. Leaves were occasionally half expanded for resin birch, grayleaf willow, rose, and alder. Leaves on diamondleaf willow were half expanded more often.

During period 4 (24 May), shrubs at higher elevations were generally still breaking bud while those at lower elevations had half-expanded leaves. Sedges and grasses were generally half grown, but sedges sometimes were full grown or in boot stage already. By the last sample period (31 May) everything was either half grown or had leaves half expanded.

5.2.5.7 Kosina Creek

Vegetation along the Kosina Creek transects was generally dormant during the first sample period (26 April) except for bluejoint and mountain cranberry and sedges. Some sedges were as far advanced as having leaves half expanded. The same was true for period 2 (10 May) except that more sedge individuals were half grown, especially in open alder and woodland black spruce. Twinflower and horsetail were also just emerging.

Shrubs and sedges were initiating growth or half developed in period 3 (17 May) while twinflower, astragalus, artemisia, and an unknown forb were half developed. Tall bluebell was half grown at lower elevations while diamondleaf and grayleaf willows and rose had leaves half expanded.

Mountain cranberry had floral buds in some places along these transects during period 4 (24 May) although most individuals had half-expanded leaves. Shrubs generally were initiating growth but some had half-expanded leaves. Most forbs and graminoids at the bottom of the transects were half grown. Resin birch, diamondleaf and grayleaf willows had half-expanded leaves at lower elevations, but the willows occasionally had catkins.

5.2.5.8 Clarence Creek

Clarence Creek was one of the slower developing transect areas where everything was dormant during the first sample period (4 May). By period 2 (12 May) occasional sedge individuals and mountain cranberry and alder were initiating growth. The most important vegetation type for the sedges for greenup was in the woodland and open black spruce scrub near the bottom of the transects.

Most shrubs had at least initiated growth by period 3 (19 May) and resin birch and rose occasionally had half-expanded leaves. Sedges and grasses were generally just emerging, but sedges were occasionally half grown. Grasses and shrubs were initiating growth or were half developed by period 4 (26 May). Sedges were generally half developed with occasional individuals being in the boot stage, especially in the open black spruce forest and scrub types. Good growth was present by the last sample period.

5.2.5.9 Switchbacks

Cottongrass and sedges were half grown at some stops during the first sample period (5 May) along the Switchback transects, and these stops were above the impoundment zone. Additional species which had initiated growth by this time were unknown grasses, bluegrass (Poa spp.) and wheatgrass (Agropyron spp.), bluejoint, and highbush cranberry (Viburnum edule).

By period 2 (12 May), most grasses had initiated growth or were half grown. Cottongrass had developed seedheads at stops above the impoundment level. Shrubs were still generally dormant except for mountain cranberry.

Shrubs and grasses were generally half developed in open ericaceous shrub tundra and woodland white spruce forests above the impoundment and open low willow below the impoundment by period 3 (11 May). Some shrubs in the latter case had catkins already developed.

By period 4 (26 May), most shrubs had half-expanded leaves, dwarf scouring rush was fully grown, field horsetail had strobili, coltsfoot (Petasites frigida) and cottongrass were in flower.

5.2.6 Berry Availability Over Time

Berry availability over time was analyzed by scanning the printouts of raw data in the same manner that phenological development over time was analyzed. All of the same limitations apply.

5.2.6.1 Devil Creek

Berries were available during period 1 at elevation band 420 m in open and woodland black spruce and birch shrub vegetation types. This would be below the potential Devil Canyon impoundment. During the second sample period, however, as snow melted and dwarf shrubs became visible, berries were frequent in birch shrub vegetation at the higher elevations. More berries became available by period 3. At least one of these groups of stops was below the impoundment, but most were above. More berries were available from 540- to 570-m band by period 5. Berries along these transects became relatively abundant by the second period, and these were generally located above the impoundment.

5.2.6.2 Tsusena Creek

Berries were never abundant along the Tsusena Creek transects partly because the most important species were not berry producers.

5.2.6.3 Fog Creek

Scattered berries were available during period 1 in woodland white spruce forest and open ericaceous shrub tundra stops along the Fog Creek transects. They were also available in woodland white spruce scrub and open white spruce forest during the second period. Some of the difference in vegetation was very likely the results of different observers. Berries, however, never seemed to be very important in this area.

5.2.6.4 Watana Slide

Watana slide was an important berry area at the higher elevations in shrub birch and woodland and open white spruce sites during period 1. These areas had a heavy cover by berry-producing species and little or no snow cover at this time. Berry abundance did not increase noticeably with time since everything was available during the first period.

5.2.6.5 Watana Creek

Scattered berries occurred during period 1 in woodland white spruce forest and shrub vegetation types. Open spruce - cottonwood vegetation types were important for berries at lower elevations, which would be below the impoundment. Berries became more available during periods 2 and 3, mostly at the higher elevations along the transects. All elevations were below the impoundment zone, so some loss of berries would occur with the project. However, these transects are not nearly as important as the Watana slide transects as far as supplying berries is concerned.

5.2.6.6 Fish Creek

Scattered berries were available during period 1 at elevations above the impoundment in open white spruce forest and open ericaceous shrub tundra vegetation types. Berries appeared to be slightly more abundant during period 2, but again, this was not an important berry area.

5.2.6.7 Kosina Creek

Scattered berries were found during period 1 along the Kosina Creek transects, but more stops with berries were found during the second and third sample periods. The more important areas seemed to be below the impoundment zone in woodland and open white spruce forest sites and open mixed white spruce - aspen sites. Reports of berries were rare during period 4 except in the spruce - aspen sites. This resulted either from berries falling off, bears eating them, or sampling error with the latter being the most likely explanation.

5.2.6.8 Clarence Creek

Only scattered berries were available during period 1 along the Clarence Creek transects, but abundant berries were available during period 2 in woodland black spruce scrub near the top, which would be above the Watana impoundment. Berries were not abundant again until period 5. This lends some support to the previous statement that some of the variability resulted from sampling error.

5.2.6.9 Switchback

Berries were abundant during the first sample period at higher elevations in woodland white spruce forest and open dwarf birch - willow along the switchback transects. They remained important throughout the study, and probably represent one of the richer sources of berries.

5.2.7 Horsetail Availability Over Time

Horsetail availability over time was evaluated by scanning the printouts of raw data as was done for berries and phenological development. The same limitations apply. Additionally, horsetail abundance was recorded whether the plants had greened up or not. Unless horsetail was also the closest forb so that its phenological state was recorded, there was no way of telling from the data if new growth of horsetail was available. The abundance was recorded even if horsetail were not growing, so information would be available on location of potential horsetail sites.

5.2.7.1 Devil Creek

Horsetail was negligible along the Devil Creek transects.

5.2.7.2 Tsusena Creek

Horsetail was of minor importance along the Tsusena Creek transects. None was recorded during period 1, and only at one stop during period 2. Horsetail was reported in more places during period 3.

5.2.7.3 Fog Creek

Horsetail was not available on the Fog Creek transects until period 2 when it was recorded in an open low willow tundra area. These transects were generally not important for horsetail.

5.2.7.4 Watana Slide

Some horsetail was present in open and woodland white spruce forests and open low willow shrub during period 1. There was a concentration of horsetail near the bottom and all recordings were probably below the impoundment level or very close.

5.2.7.5 Watana Creek

Horsetail was abundant along this set of transects even during the first sample period. All stops were below the impoundment. The most important horsetail areas occurred in open white and black spruce forests at 600-m band and open white spruce and open mixed white spruce - cottonwood vegetation types in the 480-m elevation band. Individuals in these horsetail sites began emerging from the ground during period 3. Inundation of these sites would represent loss of important horsetail sites.

5.2.7.6 Fish Creek

Horsetail along the Fish Creek transects was first recorded during the second period at elevations generally below the impoundment (600 to 660-m elevation bands) in open white and black spruce forest sites. No major changes were reported over time.

5.2.7.7 Kosina Creek

Horsetail was reported along the Kosina Creek transects for the first time during period 2 in an open white spruce site very close to the impoundment level. Horsetail had begun to emerge from the ground by period 3 and was identified as field horsetail. Horsetail was reported at several other stops during period 4 and all were below the impoundment. Most horsetail along these slopes would be lost to inundation.

5.2.7.8 Clarence Creek

Horsetail was not recorded on the Clarence Creek transects until the third period. It was found primarily at higher elevations and would not be affected by the impoundment.

5.2.7.9 Switchbacks

Horsetail was not recorded until the second sample period on the switchback transects. It was found at higher elevations in closed alder and open low willow stands. Field horsetail was emerging at that time. Horsetail was relatively important along these transects, but it was almost always above the impoundment so would not be impacted directly.

6 GENERAL SUMMARY

Generalized south and north-facing slopes are illustrated in Figure 5. They do not illustrate all conditions that exist, but give a general idea of typical situations. The highest elevations sampled on both aspects contained low shrub vegetation, such as resin birch with some diamondleaf willow in cases. These sites were frequently good for overwintered berries. Occasionally the transects started in an alpine mat-and-cushion vegetation type in dry, windy areas. Proceeding downhill on a well-drained south-facing slope, one would find white spruce or paper birch-white spruce stands. Birch-spruce stands were found generally in the warmer or more recently disturbed areas. Pure aspen stands also occurred in one disturbed location. Black spruce forests or scrub were found in poorly-drained locations. Riparian vegetation along the shorelines consisted of shrubs and herbaceous species. Some areas were dominated by shrubs, others by forbs, and some by graminoids. Reasons for the differences were unknown.

North-facing slopes generally had white spruce on well-drained sites, but black spruce occurred on some adequately-drained sites, whereas on south-facing slopes it only occurred in poorly drained sites. Black spruce also occurred on poorly-drained north-facing slopes. Some slopes had dips, then a knoll with a south-facing slope, the opposite direction of the overall slope. This enabled vegetation typical of a warmer, drier area to grow there. A band of alder was frequently present just above the riparian vegetation.

No combination of topographical factors measured in 1982 or 1983 adequately described areas with early plant development. However, observations did not contradict our 1982 conclusion: recently disturbed areas midway up the slope contained earlier-developing plants than other areas. Fire has removed the insulating layer of moss so soils may warm up more rapidly. Tree canopies are more open, and deciduous trees, such as birch and aspen, are leafless at this time of year. This allows more solar radiation to reach the understory and soil than in a more closed vegetation.

Locations at the top of the slopes were generally cooler because of the elevation. Elevations near the river, in many cases, were either covered by ice from ice jams or were relatively shaded by the sides of the steep valley. Sometimes south-facing aspects were shaded by surrounding mountains, but locations on the north-facing transects might get more solar radiation. Sometimes flat areas were well-drained while sloping areas were poorly drained.

Moose fecal samples (pellets) collected during this study contained the following major forage components, in order of percentage of diet: willows, mosses, and resin birch and mountain cranberry (similar percentage). Other species were minor. No forbs or graminoids were identified although some were included in unknown categories. Willows were, by far, the most important component. This could be related to the observation of willows having been stripped by moose, or it could be a result of normal browsing.

Overwintered berries were generally available by the second period of the 1983 study, the second week of May, and were most abundant in some low shrub vegetation and some white spruce forests predominantly above the impoundment zones. Horsetail was seldom more than half-grown during the study, but was most often found in forests below the impoundment zone.

Based on the current estimates of impoundment levels, a substantial number of areas with early phenological development and areas with a high frequency of overwintered berries would probably not be impacted by the impoundment. Several areas with high horsetail frequencies would be inundated.

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TABLES

TABLE 1. Coded values for variables measured at 10-m intervals along phenology transects.

Code	Elevation midpoint (m)	Slope (degrees)	Aspect	Snow Depth (cm)	Berry Abundance (berries)	Horsetail Abundance (stems)
1	300	0-1	E	0-1	None	None
2	330	1-3	SE	1-10	1-10	1-5
3	360	3-7	S	10-30	11-25	6-10
4	390	7-10	SW	30-50	> 25	> 10
5	420	10-15	W	50-100		
6	450	15-30	NW	> 100		
7	480	> 30	N			
8	510		NE			
9	540					
10	570					
11	600					
12	630					
13	660					
14	690					
15	720					
16	750					
17	780					
18	810					

TABLE 2. Codes for phenological states for the shrub, forb, and graminoid life forms.

Code	Shrub	Forb	Graminoid
1	dormant	dormant	dormant
2	leaf buds burst	emerging from ground	emerging from ground
3	leaves partly expanded	about 50% maximum height or 15 cm tall, whichever is less	about 50% maximum height or 15 cm tall, whichever is less
4	leaves fully expanded	maximum height or 30 cm tall, whichever is less	maximum height or 30 cm tall, whichever is less
5	catkins present	floral bud	boot stage
6		anthesis	anthesis
7		fruit	fruit

TABLE 3. Codes for species observed during 1983 phenology study.

Code	Scientific Name	Common Name
1	Vaccinium vitis-idaea	Mountain cranberry
2	Vaccinium uliginosum	Bog blueberry
3	Ledum groenlandicum	Northern Labrador tea
4	Empetrum nigrum	Crowberry
5	Arctostaphylos alpina	Alpine bearberry
6	Arctostaphylos rubra	Bearberry
7	Arctostaphylos uva-ursi	Kinnikinnick
8	Andromeda polifolia	Bog rosemary
9	Ribes spp.	Currant
10	Populus balsamifera	Balsam poplar
11	Betula glandulosa	Resin birch
12	Betula papyrifera	Paper birch
13	Salix pulchra	Diamondleaf willow
14	Salix glauca	Grayleaf willow
15	Salix lanata	Richardson willow
16	Rosa acicularis	Prickly rose
17	Salix spp.	Willow
18	Potentilla fruticosa	Shrubby cinquefoil
19	Spiraea beauverdiana	Beauverd spiraea
20		Unknown with red bud
21	Shepherdia canadensis	Soapberry
22	Salix alaxensis	Feltleaf willow
23	Viburnum edule	Highbush cranberry
24	Myrica gale	Sweet gale
25	Cassiope tetragona	Four-angle mountain-heather
26	Salix novae-angliae	Tall blueberry willow
27	Rubus idaeus	Raspberry
28	Salix reticulata	Netleaf willow
29	Salix fusescens	Bog willow
31	Alnus sinuata	Sitka alder
32	Potentilla spp.	Cinquefoil
FORBS		
38	Equisetum sp.	Hollow horsetail
39	Valeriana capitata	Capitate valerian
41	Cornus canadensis	Bunchberry
42	Petasites frigidus	Arctic sweet coltsfoot
43	Epilobium angustifolium	Fireweed
44	Mertensia paniculata	Tall bluebell
45	Equisetum arvense	Meadow horsetail
46	Equisetum silvaticum	Field horsetail
47	Lycopodium complanatum	Ground cedar
48	Linnaea borealis	Twinflower
49	Pyrola spp.	Wintergreen
50	Rubus chamaemorus	Cloudberry
51	Artemisia tilesii	
52	Astragalus spp.	Milk-vetch
53		Unknown forb

54	Epilobium latifolium	Dwarf fireweed
55	Tofieldia spp.	Asphodel
56	Equisetum pratense	Meadow horsetail
57	Rubus articus	Nagoon berry
58	Boykinia richardsonii	Richardson boykinia
59	Aster spp.	Aster
60	Aconitum delphinifolium	Monks hood
61	Compositae	Unknown composite
62	Rumex spp.	Sorrel
63	Pyrola secunda	One-sided wintergreen
64	Equisetum scirpoides	Dwarf scouring rush
65	Equisetum variegatum	Variegated scouring rush
66	Anemone sp.	Anemone
67	Iris sp.	Iris
68	Pteropsida	Fern
69	Hedysarum sp.	Sweet-vetch (probably sp. alpinum)
70	Pedicularis sp.	Lousewort
71	Sedum rosea	Roseroot
72	Geranium sp.	Geranium
73	Gentianaceae	Gentian
74	Lupinus sp.	Lupine
75	Geocaulon lividum	Geocaulon
76	Cruciferae	Purple mustard
77		Forb, Devil Creek
78	Anemone sp.	Anemone
79	Dryas spp.	Dryas
80	Sanguisorba sp.	Burnet

GRAMINOIDS

81	Calamagrostis canadensis	Bluejoint
82	Carex spp.	Sedge
83	Eriophorum spp.	Cottongrass
84	Gramineae	Unknown grass
85	Juncus spp.	Rush
86	Poa spp.	Bluegrass
87	Agropyron	Wheatgrass
88	Agrostis scabra	Ticklegrass
89	Festuca altaica	Fescue
90	Trisetum spicatum	Downy oatgrass
91	Trichophorum caespitosum	Tufted clubrush
92	Deschampsia sp.	Hairgrass
93	Hierochloe sp.	Holygrass

Table 4. Codes for vegetation types recorded during phenology study 1983. Nomenclature according to Viereck et al. (1982).

Forest types	
1113	Closed white spruce forest
1123	Open white spruce forest
1124	Open black spruce forest
1133	Woodland white spruce forest
1134	Woodland black spruce forest
1211	Closed paper birch forest
1213	Closed aspen forest
1214	Open aspen-paper birch forest
1221	Open paper birch forest
1311	Closed mixed paper birch-spruce forest
1321	Open mixed paper birch-white spruce forest
1323	Open mixed paper birch-black spruce forest
1324	Open mixed white spruce-cottonwood forest
1325	Open mixed white spruce-aspen forest
1331	Woodland mixed paper birch-white spruce forest
Scrub types	
2113	Woodland white spruce scrub
2123	Open white spruce scrub
2114	Woodland black spruce scrub
2124	Open black spruce scrub
2212	Closed alder tall shrub
2222	Open alder tall shrub
2321	Open dwarf birch shrub
2322	Open low willow shrub
2323	Open dwarf birch willow shrub
2324	Open ericaceous shrub tundra
2325	Open ericaceous shrub-sphagnum
2326	Open low alder shrub
2327	Open low paper birch shrub
2328	Open soapberry-cinquefoil shrub
2424	Sedge shrub tundra
2425	Open low willow tundra
Herbaceous types	
3122	Bluejoint-forb meadow
3211	Sedge tundra

TABLE 5

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

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

TABLE 6

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

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

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

TABLE 7

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

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

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

TABLE 8

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

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

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

TABLE 9

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

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

TABLE 10

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

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

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

TABLE 11

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

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

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

TABLE 12

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

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

TABLE 13

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

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

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

TABLE 14

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

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

TABLE 15

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

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

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

TABLE 16

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

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

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

TABLE 17

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

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

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

TABLE 18

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

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

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

TABLE 19

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

TABLE 20

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

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	6	3.3	233	32.1	5	3
Low Shrub						
Betula glandulosa	17	3.4	60	4.4	20	3
Salix pulchra	2	1.0	50	0.0	1	5
Salix glauca	1	0.5	46	0.0	1	3
Rosa acicularis	1	0.3	26	4.3	4	3
Ribes triste	3	1.3	32	6.0	5	4
Dwarf Shrub						
Vaccinium vitis-idaea	4	1.1	9	1.1	19	6
Vaccinium uliginosum	19	3.6	24	1.5	20	4
Ledum groenlandicum	2	1.0	29	3.2	7	4
Ledum decumbens	7	2.9	20	2.3	10	4
Empetrum nigrum	1	0.4	8	1.2	4	3
Arctostaphylos uva-ursi	1	0.5				
Forb						
Equisetum silvaticum	<1	0.2	13	2.4	7	3
Graminoid						
Grass spp.	2	0.7	19	2.1	14	3
Other						
Total moss	21	4.5				
Total lichen	11	2.9				
Litter	5	2.2				

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

TABLE 21

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

TABLE 22

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

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

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

TABLE 23

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

TABLE 24

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^2 quadrats).

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

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

TABLE 25

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

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

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

TABLE 26

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

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

TABLE 27

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

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

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

TABLE 28. Number and percentage (in parentheses) of stops by aspect with early phenological advancement during period 5, 1983, Plant Phenology Study. [a]

Transect	Aspect							
	E	SE	S	SW	W	NW	N	NE
Devil Creek***	6(100)*	55(78.6)***	49(59.8)	85(85.0)***	36(55.4)	-	37(38.9)	93(35.6)
Tsusena Creek	-	-	162(57.7)	-	-	-	7(38.9)	-
Fog Creek**	-	2(3.8)	4(2.5)	-	8(11.1)	3(5.4)	24(11.2)**	-
Watana Slide***	18(45.0)**	10(5.2)	73(38.2)***	13(38.2)	28(27.2)	29(46.8)***	12(46.2)	1(16.7)
Watana Creek	3(9.7)	-	5(9.8)	9(8.4)	4(9.1)	3(4.3)	30(11.2)	10(7.2)
Fish Creek***	-	11(24.4)	46(23.2)	20(8.5)	1(50.0)	2(40.0)	38(23.8)	43(24.6)*
Kosina Creek***	2(66.7)	18(58.1)**	153(55.6)***	25(73.5)***	8(66.7)*	-	31(9.9)	-
Clarence Creek***	-	1(25.0)	-	-	1(16.7)	12(19.4)	23(19.0)*	3(3.1)
Switchbacks***	6(2.8)	56(29.5)**	63(48.8)***	20(26.7)	-	-	-	-

[a] Asterisks immediately following transect names indicate the significance of a chi-square test. Asterisks printed after each cell indicate significance of the standardized residuals. *** $p \leq .01$, ** $p \leq .05$, * $p \leq .10$.

TABLE 29. Number and percentage (in parentheses) of stops by elevation with early phenological advancement during period 5, 1983, Plant Phenology Study. [a]

Transect	Elevation (m) 360	390	420	450	480	510	540	570
Devil Creek***	40(100)***	67(64.4)*	20(62.5)	33(38.4)	14(28.6)	22(51.2)	37(57.8)	26(37.1)
Tsusena Creek***	-	-	-	66(41.8)	31(100)***	22(100)***	15(100)**	17(100)**
Fog Creek***	-	-	-	-	-	-	-	-
Watana Slide***	-	-	-	-	-	-	30(33.7)	35(50.7)***
Watana Creek*	-	-	-	-	9(4.3)	9(12.0)	5(8.9)	5(6.0)
Fish Creek***	-	-	-	-	-	8(7.8)	25(37.9)***	40(36.0)***
Kosina Creek***	-	-	-	-	-	2(7.4)	19(20.0)	65(36.1)
Clarence Creek**	-	-	-	-	-	-	-	4(6.8)
Switchbacks***	-	-	-	-	-	-	-	-

[a] Asterisks immediately following transect names indicate the significance of a chi-square test. Asterisks printed after each cell indicate the significance of the standardized residuals. *** $p \leq .01$, ** $p \leq .05$, * $p \leq .10$.

TABLE 29. Number and percentage (in parentheses) of stops by elevation with early phenological advancement during period 5, 1983, Plant Phenology Study.[a]

Transect	Elevation (m) 600	630	660	690	720	750	780	810	840
Devil Creek***	25(29.1)	39(58.2)	38(84.4)***	-	-	-	-	-	-
Tsusena Creek***	14(51.9)	4(13.8)	-	-	-	-	-	-	-
Fog Creek***	-	-	28(13.4)***	3(1.3)	10(7.2)	-	-	-	-
Watana Slide***	24(40.7)*	23(20.5)	8(7.7)	60(45.5)***	4(6.3)	-	-	-	-
Watana Creek*	29(12.0)*	5(14.7)	2(12.5)	-	-	-	-	-	-
Fish Creek***	17(21.5)	15(17.0)	5(6.1)	18(12.7)	33(19.1)	-	-	-	-
Kosina Creek***	18(25.7)	14(29.2)	23(24.5)	33(54.1)***	19(41.3)	44(81.5)***	-	-	-
Clarence Creek**	7(28.0)**	4(18.2)	5(23.8)	1(5.3)	5(22.7)	2(10.5)	8(22.9)	4(5.3)	-
Switchbacks***	-	4(15.4)	43(23.0)	28(42.4)***	15(6.9)	9(13.6)	32(27.4)	14(11.6)	-

[a] Asterisks immediately following transect names indicate the significance of a chi-square test. Asterisks printed after each cell indicate the significance of the standardized residuals. *** $p \leq .01$, ** $p \leq .05$, *$p \leq .10$.

TABLE 30. Number and pecentage (in parentheses) of stops by slope class with early phenological advancement during period 5, 1983, Plant Phenology Study. [a]

Transect	Slope(°) 0-3	3-10	10-30
Devil Creek**	86(60.1)	150(53.8)	125(47.3)
Tsusena Creek***	59(35.8)	39(72.2)	71(88.8)***
Fog Creek***	34(11.4)***	7(2.9)	-
Watana Slide	84(31.2)	59(24.5)	41(28.7)
Watana Creek	36(11.4)	17(7.1)	11(6.9)
Fish Creek**	23(17.2)	103(22.6)*	35(13.8)
Kosina Creek***	69(31.4)	110(42.6)**	58(29.4)
Clarence Creek	7(19.4)	18(14.6)	15(10.9)
Switchbacks***	31(14.4)	44(17.0)	70(35.5)***

[a] Asterisks immediately following transect names indicate the significance of a chi-square test. Asterisks printed after each cell indicate significance of the standardized residuals. ***$p \leq .01$, **$p \leq .05$, *$p \leq .10$.

TABLE 31. Number and percentage (in parentheses) of stops by vegetation class with early phenological advancement during period 5, 1983, Plant Phenology Study. [a]

Transect	Vegetation Type [b]						
	CF	OF	WF	SB	TS	LS	HB
Devil Creek***	40(95.2)***	95(43.2)	39(41.1)	6(24.0)	29(72.5)*	152(57.6)	-
Tsusena Creek***	-	138(65.7)**	4(12.1)	-	-	27(52.9)	-
Fog Creek***	-	14(10.8)*	19(10.3)*	3(9.4)	-	5(2.4)	-
Watana Slide***	-	30(15.0)	62(30.5)	-	-	89(36.6)***	3(75.0)*
Watana Creek***	6(33.3)***	7(3.4)	16(6.1)	18(20.9)***	-	14(9.9)	3(42.9)***
Fish Creek***	-	77(16.0)	30(15.2)	-	3(50.0)*	51(32.9)***	-
Kosina Creek***	16(76.2)***	75(29.8)	44(24.4)	4(25.0)	1(20.0)	97(48.3)***	-
Clarence Creek***	1(100)**	2(4.0)	25(26.9)***	8(11.6)	3(11.1)	1(2.7)	-
Switchbacks**	-	12(26.7)	35(17.9)	12(44.4)***	20(19.8)	66(21.9)	-

[a] Asterisks immediately following transect names indicate the significance of a chi-square test. Asterisks printed after each cell indicate significance of the standardized residuals. *** $p \leq .01$, ** $p \leq .05$, * $p \leq .10$.

[b] CF=closed forest, OF=open forest, WF=woodland forest, SB=scrub forest, TS=tall shrub, LS=low shrub, HB=herbaceous.

TABLE 32. Number and percentage (in parentheses) of stops by aspect without snow during period 2, 1983, Plant Phenology Study. [a]

Transect	Aspect E	SE	S	SW	W	NW	N	NE
Devil Creek***	8(80.0)	2(100)	29(96.7)	175(90.7)	59(90.8)	56(50.9)	70(70.7)	133(76.9)
Tsusena Creek	-	19(100)	229(98.3)	-	-	-	29(100)	-
Fog Creek***	10(100)	169(90.9)	33(89.2)	1(100)	-	109(85.8)	138(79.3)	17(100)
Watana Slide***	121(87.7)	161(87.0)	26(100)	37(92.5)	50(86.2)	65(74.7)	6(75.0)	39(95.1)
Watana Creek***	13(92.9)	22(95.7)	45(97.8)	112(91.8)	95(96.0)	41(47.1)	177(69.1)	33(61.1)
Fish Creek***	3(100)	39(90.7)	230(90.9)	115(89.8)	23(95.8)	78(87.6)	103(80.5)	134(90.5)
Kosina Creek***	-	-	290(99.3)	54(100)	2(100)	18(38.3)	183(74.7)	-
Clarence Creek	1(100)	4(80.0)	-	-	-	120(66.3)	62(56.4)	9(90.0)
Switchbacks***	122(100)	15(100)	111(98.2)	227(98.7)	-	-	74(90.2)	104(97.2)

[a] Asterisks immediately following transect names indicate the significance of a chi-square test. Levels of significance were based on 6 snow depths rather than presence or absence. *** $p \leq .01$, ** $p \leq .05$, * $p \leq .10$

TABLE 33. Number and percentage (in parentheses) of stops by elevation without snow during period 2, 1983, Plant Phenology Study.[a]

	Elevation (m)								
Transect	360	390	420	450	480	510	540	570	600
Devil Creek***	79(98.8)	53(88.3)	25(86.2)	61(77.2)	37(72.5)	30(75.0)	59(84.3)	42(58.3)	53(57.0)
Tsusena Creek	-	-	-	72(96.0)	104(99.0)	18(100)	14(100)	16(100)	23(100)
Fog Creek	-	-	-	-	-	-	-	-	-
Watana Slide*	-	-	-	-	-	-	90(87.4)	28(80.0)	56(84.8)
Watana Creek***	-	-	-	86(98.9)	69(81.2)	55(84.6)	74(86.0)	42(73.7)	181(73.0)
Fish Creek***	-	-	-	-	-	135(94.4)	118(99.2)	62(93.9)	68(88.3)
Kosina Creek***	-	-	-	-	-	42(85.7)	104(99.0)	114(88.4)	57(89.1)
Clarence Creek***	-	-	-	-	-	-	-	-	45(90.0)
Switchbacks*	-	-	-	-	-	-	-	-	-

[a] Asterisks immediately following transect names indicate the significance of a chi-square test. Levels of significance were based on 6 snow depths rather than presence or absence. *** $p \leq .01$, ** $p \leq .05$, * $p \leq .10$.

TABLE 33. Number and percentage (in parentheses) of stops by elevation without snow during period 2, 1983, Plant Phenology Study.[a]

	Elevation (m)							
Transect	630	660	690	720	750	780	810	840
Devil Creek***	53(81.5)	40(93.0)	-	-	-	-	-	-
Tsusena Creek	28(100)	-	-	-	-	-	-	-
Fog Creek	-	139(83.7)	211(86.1)	127(90.1)	-	-	-	-
Watana Slide*	90(90)	127(79.9)	24(92.3)	23(100)	67(94.4)	-	-	-
Watana Creek***	8(32.0)	23(47.9)	-	-	-	-	-	-
Fish Creek***	57(90.5)	101(91.0)	109(77.9)	75(77.3)	-	-	-	-
Kosina Creek***	37(82.2)	80(84.2)	39(70.9)	28(70.0)	46(79.3)	-	-	-
Clarence Creek***	20(83.3)	18(75.0)	3(23.1)	12(75.0)	25(62.5)	33(75.0)	12(30.8)	28(48.3)
Switchbacks*	99(97.1)	107(98.2)	60(92.3)	88(97.8)	73(98.6)	185(98.4)	41(100)	-

[a] Asterisks immediately following transect names indicate the significance of a chi-square test. Levels of significance were based on 6 snow depths rather than presence or absence. *** $p \leq .01$, ** $p \leq .05$, * $p \leq .10$.

TABLE 34. Number and percentage (in parentheses) of stops by slope class without snow during period 2, 1983, Plant Phenology Study. [a]

Transect	Slope(°) 0-3	3-10	10-30
Devil Creek*	89 (79.5)	247 (75.3)	196 (81.0)
Tsusena Creek	175 (98.3)	36 (97.3)	66 (100)
Fog Creek	295 (87.0)	157 (86.7)	25 (78.1)
Watana slide	159 (85.0)	220 (86.6)	126 (88.7)
Watana Creek***	268 (83.5)	141 (73.1)	129 (69.0)
Fish Creek*	138 (84.7)	406 (90.6)	181 (88.3)
Kosina Creek***	101 (92.7)	277 (90.8)	169 (74.8)
Clarence Creek**	12 (75.0)	95 (70.9)	89 (56.3)
Switchbacks*	193 (95.5)	295 (98.3)	165 (98.8)

[a] Asterisks immediately following transect names indicate the significance of a chi-square test. Levels of significance were based on 6 snow depths rather than presence or absence. ***$p \leq .01$, **$p \leq .05$, *$p \leq .10$.

TABLE 35. Number and percentage (in parentheses) of stops by vegetation class without snow during period 2, 1983, Plant Phenology Study. [a]

Transect	CF	OF	WF	SB	TS	LS	HB
			Vegetation Type [b]				
Devil Creek***	20(95.2)	238(81.0)	32(43.2)	7(24.1)	16(80.0)	219(89.8)	-
Tsusena Creek	29(100)	148(97.4)	24(100)	-	-	74(100)	-
Fog Creek***	-	149(82.3)	97(88.2)	23(67.6)	-	182(90.5)	26(100)
Watana slide*	-	115(83.9)	205(87.2)	27(100)	-	152(86.9)	6(66.7)
Watana Creek***	7(100)	229(83.3)	176(64.5)	36(67.9)	4(80.0)	86(97.7)	-
Fish Creek***	32(100)	427(89.3)	135(84.4)	-	22(95.7)	109(88.6)	-
Kosina Creek***	15(100.0)	282(96.2)	80(68.4)	1(100.0)	23(59.0)	145(83.3)	1(100)
Clarence Creek***	-	58(55.2)	32(51.6)	85(77.3)	7(63.6)	14(70.0)	-
Switchbacks***	12(92.3)	150(98.7)	49(90.7)	53(96.4)	72(98.6)	317(98.4)	-

[a] Asterisks immediately following transect names indicate the significance of a chi-square test. Levels of significance were based on 6 snow depths rather than presence or absence. *** $p \leq .01$, **$p \leq .05$, *$p \leq .10$.

[b] CF=closed forest, OF=open forest, WF=woodland forest, SB=scrub forest, TS=tall shrub, LS=low shrub, HB=herbaceous.

TABLE 36. Number and percentage (in parentheses) of stops by aspect with berries present during period 5, 1983, Plant Phenology Study. [a]

Transect	Aspect E	SE	S	SW	W	NW	N	NE
Devil Creek***	-	-	1(1.2)	2(2.0)	2(3.1)	2(28.6)**	3(3.2)	40(15.3)***
Tsusena Creek	-	-	3(1.1)	-	-	-	-	-
Fog Creek	1(6.3)	1(1.9)	1(0.6)	-	1(1.4)	2(3.6)	10(4.7)*	-
Watana Slide***	4(10.0)	6(3.1)	7(3.7)	4(11.8)	5(4.9)	9(14.5)**	9(34.6)***	3(50.0)***
Watana Creek***	5(16.1)*	-	-	5(4.7)	2(4.5)	5(7.1)	11(4.1)	27(19.6)***
Fish Creek***	4(16.7)*	1(2.2)	26(13.1)***	21(8.9)	-	-	3(1.9)	5(2.9)
Kosina Creek	-	-	18(6.5)	5(14.7)**	1(8.3)	-	17(5.4)	-
Clarence Creek	1(16.7)	-	-	-	1(16.7)	3(4.8)	18(14.9)	12(2.2)
Switchbacks**	1(0.5)	4(2.1)	8(6.2)***	1(1.3)	-	-	-	2(3.8)

[a] Asterisks immediately following transect lines indicate the significance of a chi-square test. Asterisks printed after each cell indicate significance of the standardized residuals. *** $p \leq .01$, ** $p \leq .05$, *$p \leq .10$.

TABLE 37. Number and percentage (in parentheses) of stops by elevation with berries present during period 5, 1983, Plant Phenology Study.[a] Page 1 of 2

Transcect	Elevation (m) 360	390	420	450	480	510	540	570	600
Devil Creek***	-	2(1.9)	1(3.1)	4(4.7)	1(2.0)	6(14.1)*	6(9.4)	2(2.9)	10(11.6)
Tsusena Creek	-	-	-	1(0.6)	-	-	-	1(5.9)**	1(3.7)
Fog Creek**	-	-	-	-	-	-	-	-	-
Watana Slide***	-	-	-	-	-	-	-	1(1.4)	2(3.4)
Watana Creek***	-	-	-	-	8(3.8)	10(13.3)*	9(16.1)**	7(8.3)	17(7.0)
Fish Creek***	-	-	-	-	-	-	5(7.6)	1(0.9)	2(2.5)
Kosina Creek*	-	-	-	-	-	1(3.7)	4(4.2)	12(6.7)	8(11.4)*
Clarence Creek*	-	-	-	-	-	-	-	2(3.4)	2(8.0)
Switchbacks	-	-	-	-	-	-	-	-	-

[a] Asterisks immediately following transect lines indicate the significance of a chi-square test. Asterisks printed after each cell indicate significance of the standardized residuals. *** $p \leq .01$, ** $p \leq .05$, * $p \leq .10$.

TABLE 37. Number and percentage (in parentheses) of stops by elevation, with berries present during period 5, 1983, Plant Phenology Study.[a]

	Elevation (m)							
Transect	630	660	690	720	750	780	810	840
Devil Creek***	10(14.9)**	8(17.8)***	-	-	-	-	-	-
Tsusena Creek	-	-	-	-	-	-	-	-
Fog Creek**	-	2(1.0)	12(5.1)**	2(1.4)	-	-	-	-
Watana Slide***	7(6.3)	7(6.7)	20(15.2)***	8(12.7)*	2(8.0)	-	-	-
Watana Creek***	1(2.9)	3(18.8)*	-	-	-	-	-	-
Fish Creek***	5(5.7)	11(13.4)**	12(8.5)	24(13.9)***	-	-	-	-
Kosina Creek*	-	7(7.4)	2(3.3)	6(13.0)*	1(1.9)	-	-	-
Clarence Creek*	6(27.3)**	2(9.5)	1(5.3)	4(18.2)	4(21.1)	2(5.7)	12(16.0)	-
Switchbacks	-	-	3(4.5)	4(4.5)	1(1.5)	3(2.6)	5(4.1)	-

[a] Asterisks immediately following transect lines indicate the significance of a chi-square test. Asterisks printed after each cell indicate significance of the standardized residuals. *** $p \leq .01$, ** $p \leq .05$, * $p \leq .10$.

TABLE 38. Number and percentage (in parentheses) of stops by slope class with berries present during period 5, 1983, Plant Phenology Study.[a]

	Slope(°)		
Transect	0-3	3-10	10-30
Devil Creek**	4(2.8)	20(7.2)	26(9.8)
Tsusena Creek	1(0.6)	-	2(2.5)
Fog Creek***	4(1.3)	8(3.4)	4(8.9)***
Watana Slide	21(7.8)	13(5.4)	13(9.1)
Watana Creek***	13(4.1)	19(7.9)	23(14.4)***
Fish Creek*	3(2.2)	37(8.1)	20(7.9)
Kosina Creek***	5(2.3)	18(7.0)	18(9.1)*
Clarence Creek**	6(16.7)	7(5.7)	22(15.9)
Switchbacks	2(0.9)	8(3.1)	6(3.0)

[a] Asterisks immediately following transect lines indicate the significance of a chi-square test. Asterisks printed after each cell indicate significance of the standardized residuals.

*** $p \leq .01$, ** $p \leq .05$, * $p \leq .10$.

TABLE 39. Number and percentage (in parentheses) of stops by vegetation class with berries present during period 5, 1983, Plant Phenology Study. [a]

Transect	Vegetation Type [b]						
	CF	OF	WF	SB	TS	LS	HB
Devil Creek***	-	13(5.9)	5(5.3)	1(4.0)	-	31(11.7)***	-
Tsusena Creek	-	3(1.4)	-	-	-	-	-
Fog Creek	-	2(1.5)	4(2.2)	2(6.3)	-	8(3.9)	-
Watana Slide	-	12(6.0)	12(5.9)	-	-	23(9.5)	-
Watana Creek	4(22.2)**	15(7.4)	23(8.8)	7(8.1)	-	6(4.3)	-
Fish Creek***	-	34(7.1)	23(11.6)**	-	-	3(1.9)	-
Kosina Creek	3(14.3)	14(5.6)	16(8.9)	-	-	8(4.0)	-
Clarence Creek	-	8(16.0)	10(10.8)	9(13.0)	4(14.8)	4(10.8)	-
Switchbacks*	-	-	3(1.5)	-	-	13(4.3)**	-

[a] Asterisks immediately following transect names indicate the significance of a chi-square test. Asterisks printed after each cell indicate significance of the standardized residuals. ***p $\leq$.01, **p $\leq$.05, *p $\leq$.10.

[b] CF=closed forest, OF=open forest, WF=woodland forest, SB=scrub forest, TS=tall shrub, LS=low shrub, HB=herbaceous.

TABLE 40. Number and percentage (in parentheses) of stops by aspect with equisetum present during period 5, 1983, Plant Phenology Study. [a]

Transect	Aspect							
	E	SE	S	SW	W	NW	N	NE
Devil Creek	-	4(5.7)	1(1.2)	4(4.0)	3(4.6)	-	3(3.2)	13(5.0)
Tsusena Creek	-	-	36(12.8)	-	-	-	1(5.6)	-
Fog Creek***	-	-	2(1.2)	-	26(36.1)***	-	19(8.9)	-
Watana Slide***	13(32.5)	63(33.0)	59(30.9)	14(41.2)*	23(22.3)	5(8.1)	-	1(16.7)
Watana Creek***	-	-	2(3.9)	45(42.1)***	8(18.2)	9(12.9)	36(13.4)	3(2.2)
Fish Creek**	-	1(2.2)	16(8.1)	15(6.4)	-	-	12(7.5)	26(14.9)***
Kosina Creek***	-	19(61.3)***	63(22.9)***	1(2.9)	1(8.3)	-	8(2.5)	-
Clarence Creek	2(33.3)*	-	-	-	1(16.7)	3(4.8)	9(7.4)	13(13.3)
Switchbacks***	45(21.1)*	30(15.8)	15(11.6)	3(4.0)	-	2(33.3)	-	16(30.2)**

[a] Asterisks immediately following transect lines indicate the significance of a chi-square test. Asterisks printed after each cell indicate significance of the standardized residuals. *** $p \leq .01$, ** $p \leq .05$, * $p \leq .10$.

TABLE 41. Number and percentage (in parentheses) of stops by elevation with equisetum present during period 5, 1983, Plant Phenology Study.[a]

Transect	Elevation (m) 360	390	420	450	480	510	540	570	600
Devil Creek***	1(2.5)	1(1.0)	-	7(8.1)*	7(14.3)***	1(2.3)	-	2(2.9)	6(7.0)
Tsusena Creek***	-	-	-	22(13.9)	14(45.2)***	1(4.5)	-	-	-
Fog Creek***	-	-	-	-	-	-	-	-	-
Watana Slide***	-	-	-	-	-	-	45(50.6)***	49(71.0)***	15(25.4)
Watana Creek***	-	-	-	-	78(37.1)***	10(13.3)	1(1.8)	14(16.7)	-
Fish Creek***	-	-	-	-	-	26(25.2)***	8(12.1)	12(10.8)	12(15.2)**
Kosina Creek***	-	-	-	-	-	-	21(22.1)**	38(21.1)***	2(2.9)
Clarece Creek***	-	-	-	-	-	-	-	4(6.8)	-
Switchbacks***	-	-	-	-	-	-	-	-	-

[a] Asterisks immediately following transect lines indicate the significance of a chi-square test. Asterisks printed after each cell indicate significance of the standardized residuals. *** p ≤ .01, ** p ≤ .05, * p ≤ .10.

TABLE 41. Number and percentage (in parentheses) of stops by elevation, with equisetum present during period 5, 1983, Plant Phenology Study.[a] Page 2 of 2

Transect	Elevation (m) 630	660	690	720	750	780	810	840
Devil Creek***	3(4.5)	-	-	-	-	-	-	-
Tsusena Creek***	-	-	-	-	-	-	-	-
Fog Creek***	-	44(21.1)***	1(0.4)	2(1.4)	-	-	-	-
Watana Slide***	12(10.7)	22(21.2)	27(20.5)	8(12.7)	-	-	-	-
Watana Creek***	-	-	-	-	-	-	-	-
Fish Creek***	4(4.5)	1(1.2)	7(4.9)	-	-	-	-	-
Kosina Creek***	-	21(22.3)**	5(8.2)	2(4.3)	3(5.6)	-	-	-
Clarence Creek***	-	1(4.8)	-	2(9.1)	4(21.1)*	11(31.4)***	6(8.0)	-
Switchbacks***	-	32(17.1)	22(33.3)***	16(18.0)	23(34.8)***	12(10.3)	6(5.0)	-

[a] Asterisks immediately following transect lines indicate the significance of a chi-square test. Asterisks printed after each cell indicate significance of the standardized residuals. *** $p \leq .01$, ** $p \leq .05$, * $p \leq .10$.

TABLE 42. Number and percentage (in parentheses) of stops by slope class with equisetum present during period 5, 1983, Plant Phenology Study. [a]

Transect	Slope(°) 0-3	3-10	10-30
Devil Creek	7(4.9)	13(4.7)	8(3.0)
Tsusena Creek***	14(8.5)	19(35.2)***	4(5.0)
Fog Creek***	44(14.8)***	3(1.3)	-
Watana Slide***	95(35.3)***	47(19.5)	36(25.2)
Watana Creek***	62(19.6)***	21(8.7)	20(12.5)
Fish Creek*	15(11.2)	42(9.2)	13(5.1)
Kosina Creek***	48(21.8)***	30(11.6)	14(7.1)
Clarence Creek	5(13.9)	8(6.5)	15(10.9)
Switchbacks***	15(6.9)	56(21.6)**	40(20.3)

[a] Asterisks immediately following transect names indcate the significance of a chi-square test. Asterisks printed after each cell indicate significance of the standardized residuals. *** $p \leq .01$, ** $p \leq .05$, * $p \leq .10$.

TABLE 43. Number and percentage (in parentheses) of stops by vegetation class with equisetum present during period 5, 1983, Plant Phenology Study. [a]

Transect	Vegetation Type [b]						
	CF	OF	WF	SF	TS	LS	HB
Devil Creek***	2(4.8)	14(6.4)*	8(8.4)**	-	4(10.0)*	-	-
Tsusena Creek***	-	35(16.7)*	2(6.1)	-	-	-	-
Fog Creek***	-	32(24.6)***	13(7.0)	-	-	2(1.0)	-
Watana Slide***	-	46(23.0)	46(22.7)	-	-	82(33.7)*	4(100)***
Watana Creek***	-	74(36.3)***	9(3.4)	1(1.2)	-	19(13.5)	-
Fish Creek***	-	45(9.4)	3(1.5)	-	-	22(14.2)***	-
Kosina Creek***	4(19.0)	47(18.7)**	12(6.7)	1(6.3)	1(20.0)	27(13.4)	-
Clarence Creek***	-	6(12.0)	4(4.3)	8(11.6)	9(33.3)***	1(2.7)	-
Switchbacks***	1(100)**	12(26.7)*	43(21.9)*	4(14.8)	27(26.7)***	24(7.9)	-

[a] Asterisks immediately following transect names indicate the significance of a chi-square test. Asterisks printed after each cell indicate significance of the standardized residuals.

*** $p \leq .01$, ** $p \leq .05$, * $p \leq .10$.

[b] CF=closed forest, OF=open forest, WF=woodland forest, SB=scrub forest, TS=tall shrub, LS=low shrub, HB=herbaceous.

TABLE 44. Summary of numbers and percentage (parentheses) of stops that were phenologically advanced, snow-free, or had berries or horsetail by transect. The third number represents relative rank.

Transect	Phenology	Snow-Free	Berries	Horsetail
Devil Creek	361(53) 2	532(78) 7	50(7) 4	28(4) 9
Tsusena Creek	169(57) 1	277(99) 1	3(1) 9	37(12) 5
Fog Creek	41(7) 9	477(86) 5.5	16(3) 7	47(8) 8
Watana Slide	184(28) 4	(87) 4	47(7) 4	178(27) 1
Watana Creek	64(9) 8	538(77) 8	55(8) 2	103(14) 3.5
Fish Creek	161(19) 6	725(89) 3	60(7) 4	70(8) 7
Kosina Creek	237(35) 3	547(86) 5.5	41(6) 6	92(14) 3.5
Clarence Creek	40(14) 7	196(64) 9	35(12) 1	28(9) 6
Switchbacks	145(22) 5	653(98) 2	16(2) 8	111(17) 2

FIGURES

FIGURE 1

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

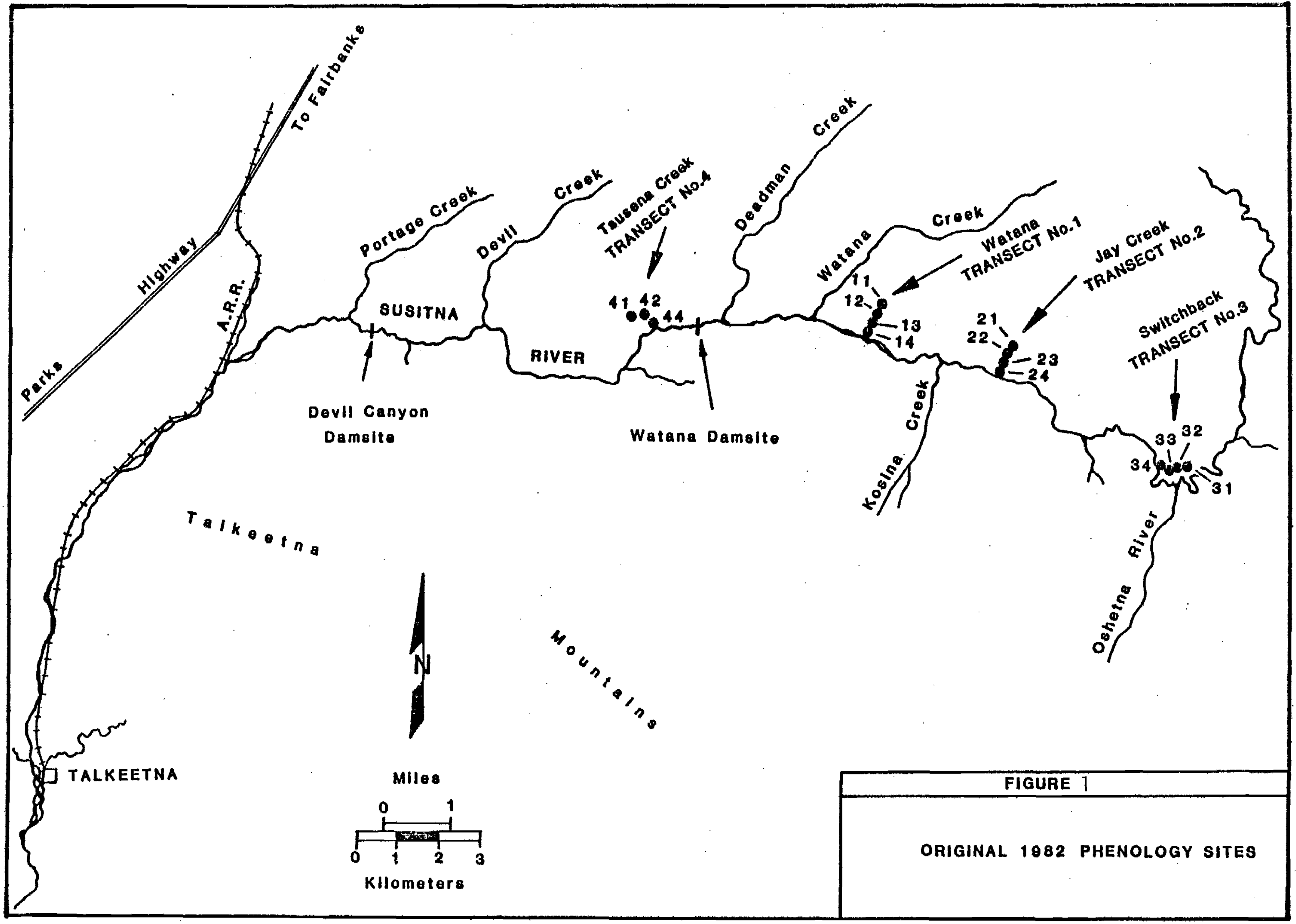


FIGURE 1

ORIGINAL 1982 PHENOLOGY SITES

FIGURE 2

Locations of plant phenology transects, 1983, and areas of moose concentrations.

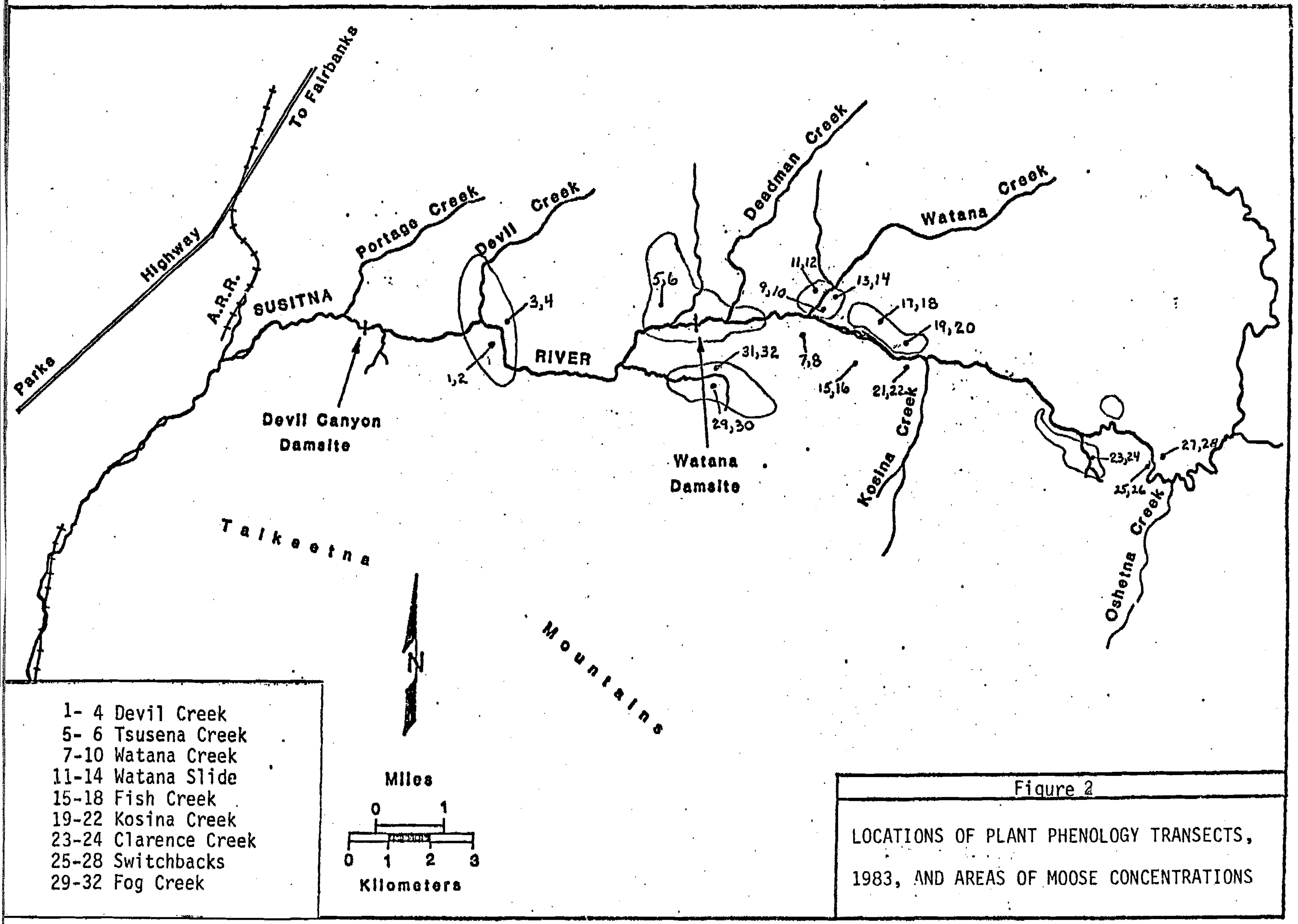


Figure 2

LOCATIONS OF PLANT PHENOLOGY TRANSECTS, 1983, AND AREAS OF MOOSE CONCENTRATIONS

FIGURE 3

Effect of transect location on phenological development of 4 shrub species over weeks with elevation held relatively constant, 1982.

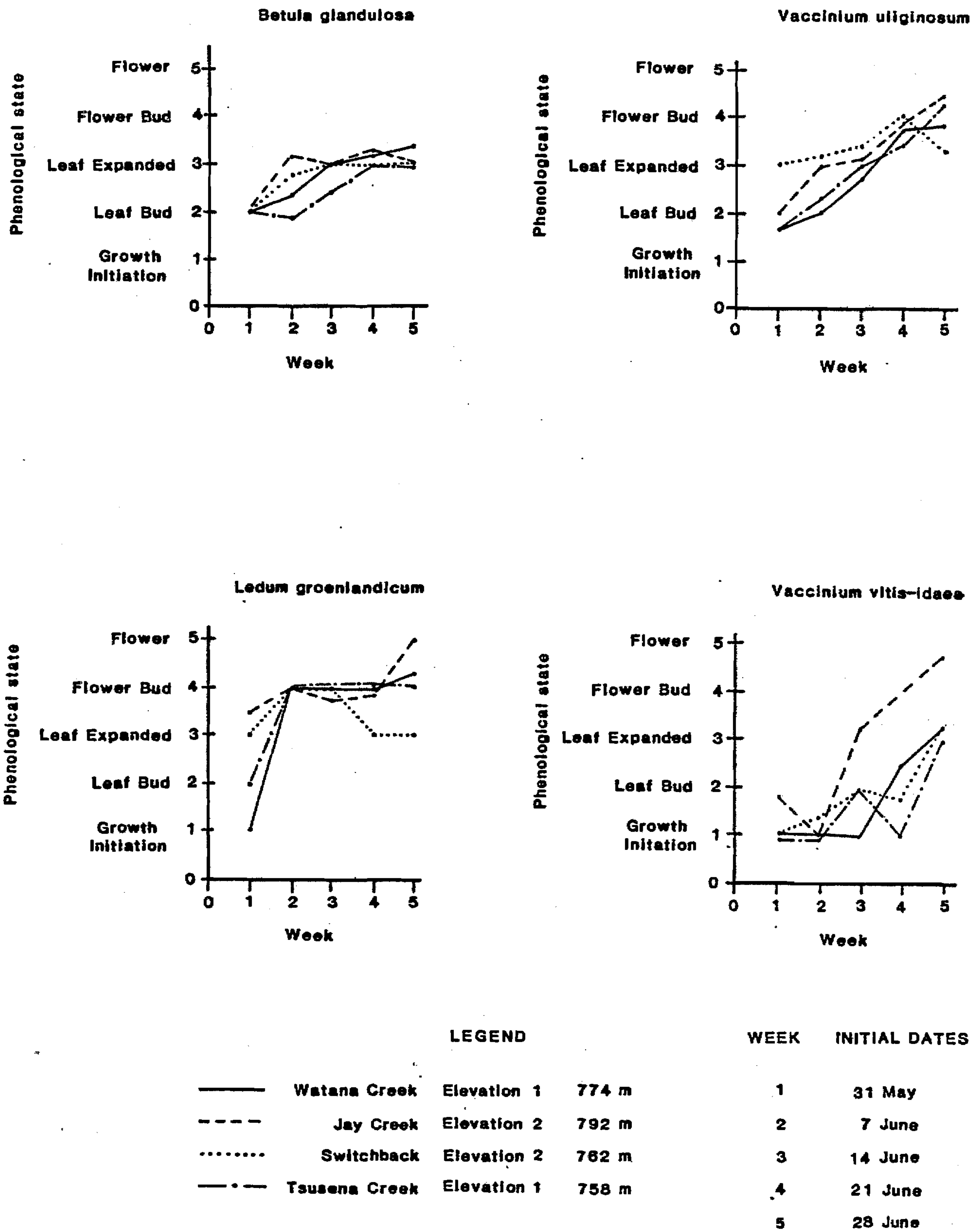
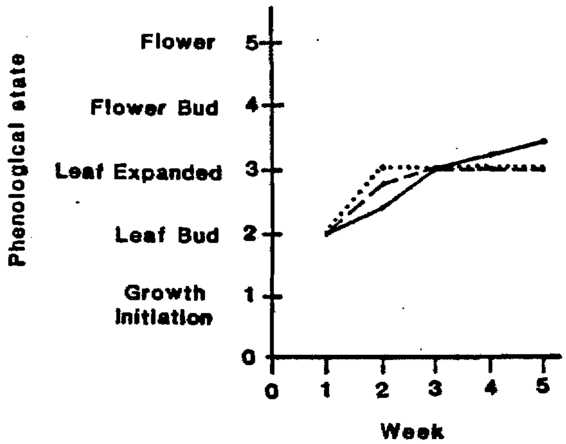

Betula glandulosa
Vaccinium uliginosum
Ledum groenlandicum
Vaccinium vitis-idaea
Phenological state
Flower
Flower Bud
Leaf Expanded
Leaf Bud
Growth Initiation
Week
LEGEND
Watana Creek Elevation 1 774 m
Jay Creek Elevation 2 792 m
Switchback Elevation 2 762 m
Tsusena Creek Elevation 1 758 m
WEEK INITIAL DATES
1 31 May
2 7 June
3 14 June
4 21 June
5 28 June

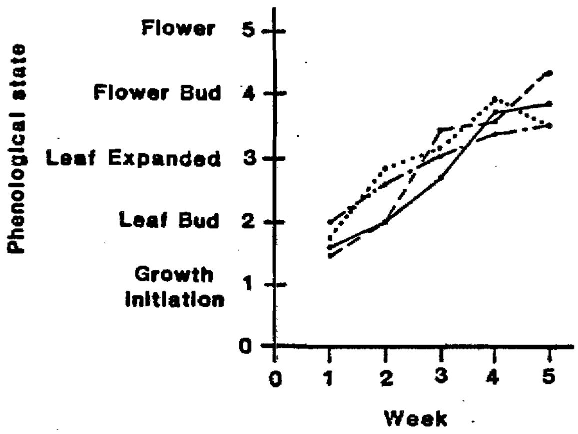
FIGURE 4

Effect of elevation on phenological development of 4 shrub species over weeks on 1 transect, 1982.

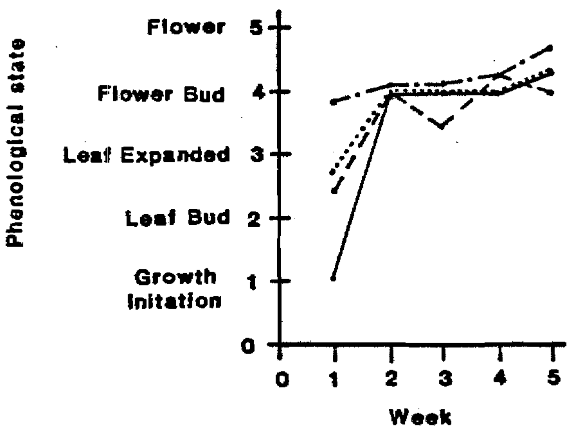
Betula glandulosa



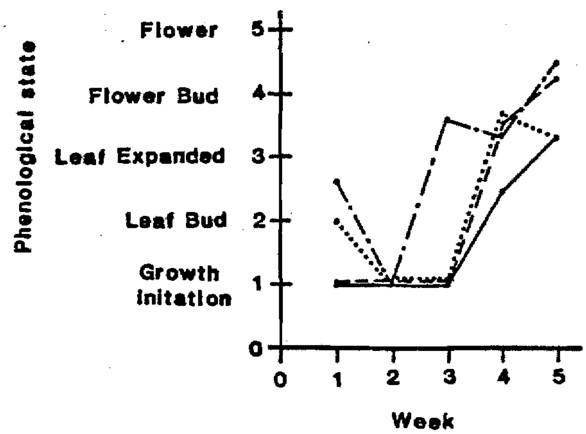
Vaccinium uliginosum



Ledum groenlandicum



Vaccinium vitis-idaea



LEGEND

Watana Creek Transect

———	Elevation 1	774 m
– – – –	Elevation 2	683 m
········	Elevation 3	610 m
—·—	Elevation 4	549 m

WEEK	INITIAL DATES
1	31 May
2	7 June
3	14 June
4	21 June
5	28 June

FIGURE 5

Generalized South- and North-facing slopes, middle Susitna River Basin.

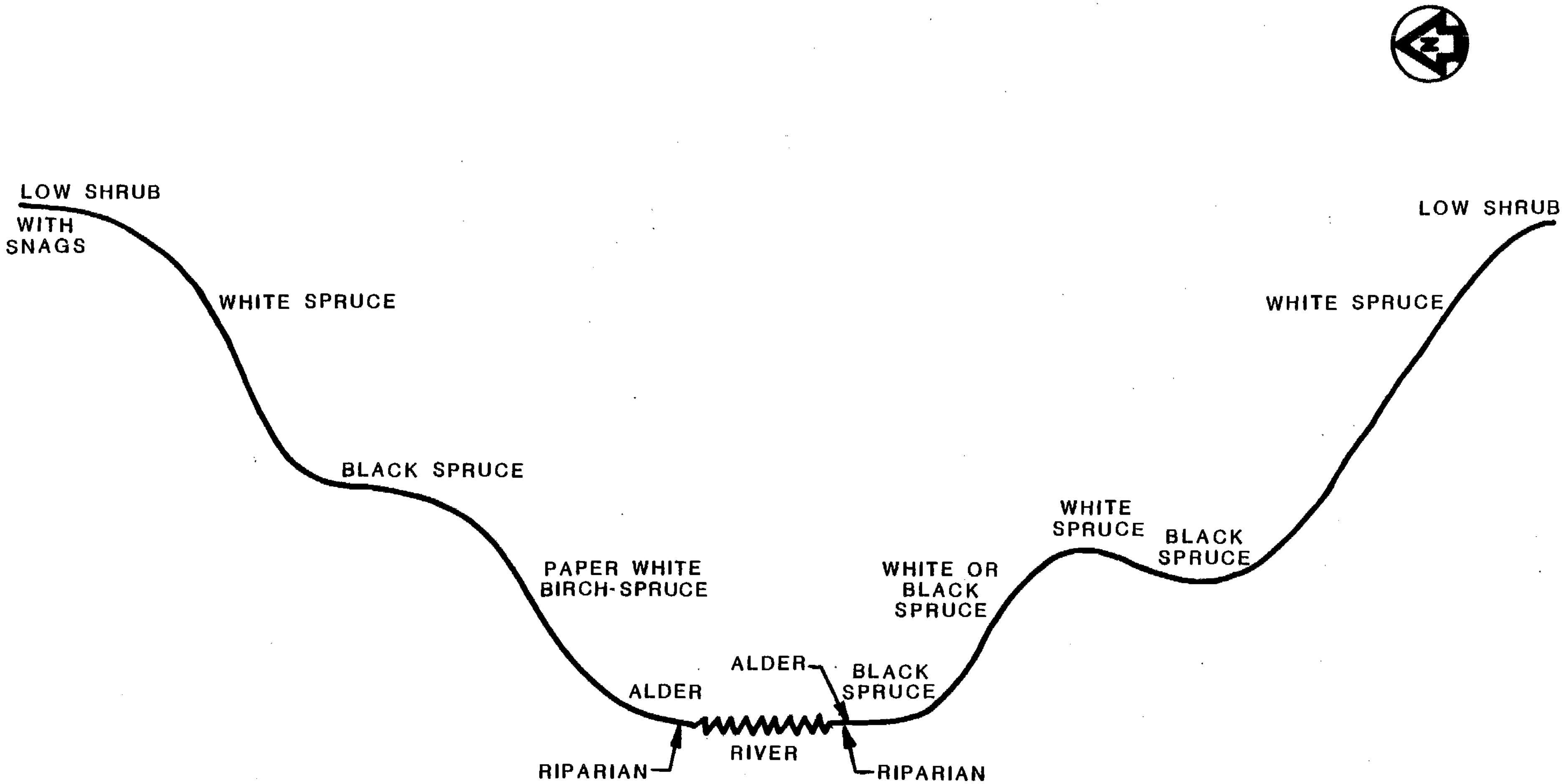


FIGURE 5

GENERALIZED SOUTH- AND NORTH-FACING SLOPES, MIDDLE SUSITNA RIVER BASIN

APPENDICES

APPENDIX A

METHODS AND RESULTS - 1982 BIOMASS STUDY

Appendix A

Methods-Biomass Estimations 1982

Standing crop biomass (current annual growth) of forbs and graminoids, and current annual growth biomass of four individual twigs with associated leaves of birch, willow and alder 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 four representative twigs. This permitted an analysis of total mass per four twigs, but not mass/unit area. During the first five weeks (31 May through 2 July) only plots located outside the exclosures were clipped. During week 6 (31 August through 3 September) plots inside and outside the exclosures were clipped. This information makes up the phenology current annual growth data set.

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

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

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

Current Annual Growth - Twig Diameter - Length Relationships

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

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

RESULTS

Biomass Estimations

Forbs and graminoids were the most abundant plants measured in terms of current annual growth biomass (Table G1). Forbs averaged 29 kg/ha over all sites and graminoids averaged 33 kg/ha. Biomass of forbs ($P < 0.05$) and graminoids ($P < 0.05$) increased over the growing season. Betula glandulosa had the greatest current growth of twigs and leaves for all sites. Weights of paired leaves and twigs were closely correlated ($P < 0.01$) for all species measured. Shrub biomass remained relatively constant over the period of study, except for B. glandulosa leaves which increased slightly ($P > 0.05$) in biomass over time.

Graminoid biomass was greatest ($P < 0.05$) at Jay Creek and Switchback, bottom elevation when compared to all other locations (Table G1). Forb biomass was greatest ($P < 0.05$) at Jay Creek, mid-slope and Switchback, bottom elevation. Few significant trends in differences among transects and elevations were observed for any shrub species. However, B. glandulosa biomass of 100 twigs was different ($P < 0.05$) among all sites, depending on week and elevation. Alnus sinuata was most abundant ($P < 0.05$) at Switchback, bottom elevation averaging 24 g current growth of leaves and stems per 100 twigs. Betula papyrifera biomass was greatest ($P < 0.05$) at Jay Creek, mid-slope averaging 8 g current annual growth of leaves and twigs per 100 twigs (Table 91).

During week 1 (31 May - 3 June), *B. glandulosa* current twig biomass (per 100 twigs) was significantly greater ($P < 0.05$) at Watana Creek, bench location than any other location (Table 91). Current twig biomass per 100 twigs of *A. sinuata* was greatest ($P < 0.05$) at Switchback, bottom elevation. Jay Creek, mid-slope had the greatest ($P < 0.05$) biomass of *B. papyrifera* during week 1.

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

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

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

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

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

Comparisons inside and outside the exclosures during week 6 indicate that forb biomass was significantly greater ($P < 0.05$) inside the exclosures at Watana Creek, top- and mid-slope, and Switchback, bottom elevation (Table G1). Current growth biomass per 100 twigs of _A. sinuata_ was greatest ($P < 0.05$) inside the exclosures at Switchback, bottom elevation. No other significant differences occurred between inside and outside the exclosures for the other plants measured.

General trends indicated that forb biomass was greater inside the exclosures, and grass biomass outside the exclosures (Table G1). _Betula glandulosa_ leaf and twig biomass per 100 twigs was highly variable when comparisons between inside and outside the exclosures were made (Table 89).

Total current annual growth biomass of shrubs was similar ($P > 0.05$) inside and outside of the exclosures (Table G2). However, twig and leaf biomass of _B. papyrifera_ was greater ($P < 0.05$) outside the exclosures at the Switchback bottom elevation.

Transect and elevation differences in total current annual growth biomass were similar to those in current annual growth data for all plants measured (Tables G1 and G2).

6.2.9.1 - Discussion of Biomass Estimations

Results of the phenology study addressing current annual growth biomass indicate that differences among sites and elevations in plant biomass exist, but few significant trends were apparent for any species. Generally, graminoid and forb biomass was greatest at mid-slope and bottom elevations at all transects (Table G1). Shrub current growth biomass per 100 twigs was greatest at bench and top-slope exclosures (Table G1). These results would be expected as the plant communities change with elevation going from low shrub scrub woodland and open spruce forest types on the bench above the river slopes, into a mixed deciduous-coniferous forest on the slope of the river channel, to various plant communities at the bottom of the slope, reflecting successional stage and environmental characteristics of the site. Generally, these bottom-slope sites were the oldest sites sampled. Moisture regimes and soil communities also played a part in these elevational trends. However, site fire history also provided an important modifying influence, overcoming the effects of elevation at some sites.

Over the period of this study, forb and graminoid biomass steadily increased at all sites (Fig. G1). 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 G1).

Comparisons of plant current growth biomass inside and outside the exclosures (week 6, both data sets) reveal few significant differences (Tables G1 and G2). 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 at many of the sites sampled in the middle basin. Biomass of A. sinuata per 100 twigs was greater inside the exclosures than outside (Tables G1 and G2). This may also reflect utilization by large herbivores.

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

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

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

6.2.10 - Current Annual Growth Diameter - Length Relationships

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

Mean basal diameters ranged from 1.8 to 2.9 mm (Table G3). 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 G3).

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 G3).

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

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

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

Photographic Study

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

Larger Exclosures

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

APPENDIX G

TABLES - 1982 BIOMASS STUDY

TABLE G1

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
1	1	1	(out				11.25±1.46								
		2	only				8.42±1.93								
		3	weeks		1±1		8.42±1.46								
		4	1-5)		5±1						1.25±1.25				
	2	1					6.40±1.00								
		2			1±1		6.87±1.04								
		3		15±12	28±22			3.93±1.76	14.55±1.92						
		4			29±16		6.38±1.29								
	3	1					4.88±0.73								
		2			3±2		4.30±0.76								
		3			1±1		4.43±1.64								
		4		5±5	18±7										35.25±7.25
	4	1					4.63±0.63								
		2					3.13±0.35								
		4					2.88±1.69								
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	8.88±0.89	9.38±1.23								
		4			78±23	3.25±1.91	2.30±1.38								
	3	1				2.63±0.68	3.88±0.89								
		2				2.63±0.55	3.63±0.38								
		3			4±4	3.93±1.51	5.18±1.77			1.75±1.75	1.18±1.13				
		4		5±5	41±10									10.50±2.43	14.38±4.30
	4	1					6.80±0.79								
		2					3.80±1.20								
		4					3.38±1.18								

TABLE G1 (continued 2)

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

TABLE G1 (continued 3)

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

TABLE G1 (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	6.38±2.01								
			out	30±8	6±4	4.68±1.89	4.63±1.72								
		3	In	1176±345	579±310										
			out	316±85	281±209										
		4	In	94±31	76±30	2.13±2.13	2.55±2.55								
			out	19±19	116±46	1.56±0.94	2.13±1.88								
	3	1	In	1±1	3±2	5.80±1.41	7.05±1.81								
			out	5±5	1±1	7.30±3.48	9.00±4.86			0.63±0.63	1.88±1.88				
		2	In	<1	3±1	3.55±1.44	4.13±1.44			3.75±3.75	1.25±1.25				
			out	19±12	32±15	2.43±1.48	3.00±2.24								
		3	In	78±47	30±10	5.30±0.35	6.05±0.33								6.88±6.88
			out	42±22	4±3									6.87±6.87	
		4	In	121±49	238±82									30.67±4.88	23.37±5.74
			out	16±2	411±278			3.75±3.75	3.30±3.30					18.75±8.43	16.63±16.12
	4	1	In	26±23		5.38±1.35	5.88±2.26								
			out	47±22		2.25±0.83	5.63±1.38								
		2	In	54±23	2±1	5.25±1.71	3.68±0.33								
			out	22±9	13±8	3.00±0.84	5.30±1.49								
		4	In	60±13		4.43±1.56	4.68±2.19								
			out	35±16	1±1	3.38±2.73	3.88±2.96								

[a] Elevation 3 not established at transect 4.

TABLE G2

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

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

TABLE G2 (continued 2)

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

[a] Elevation 3 not established at transect 4.

TABLE G3

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

FIGURE G1

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

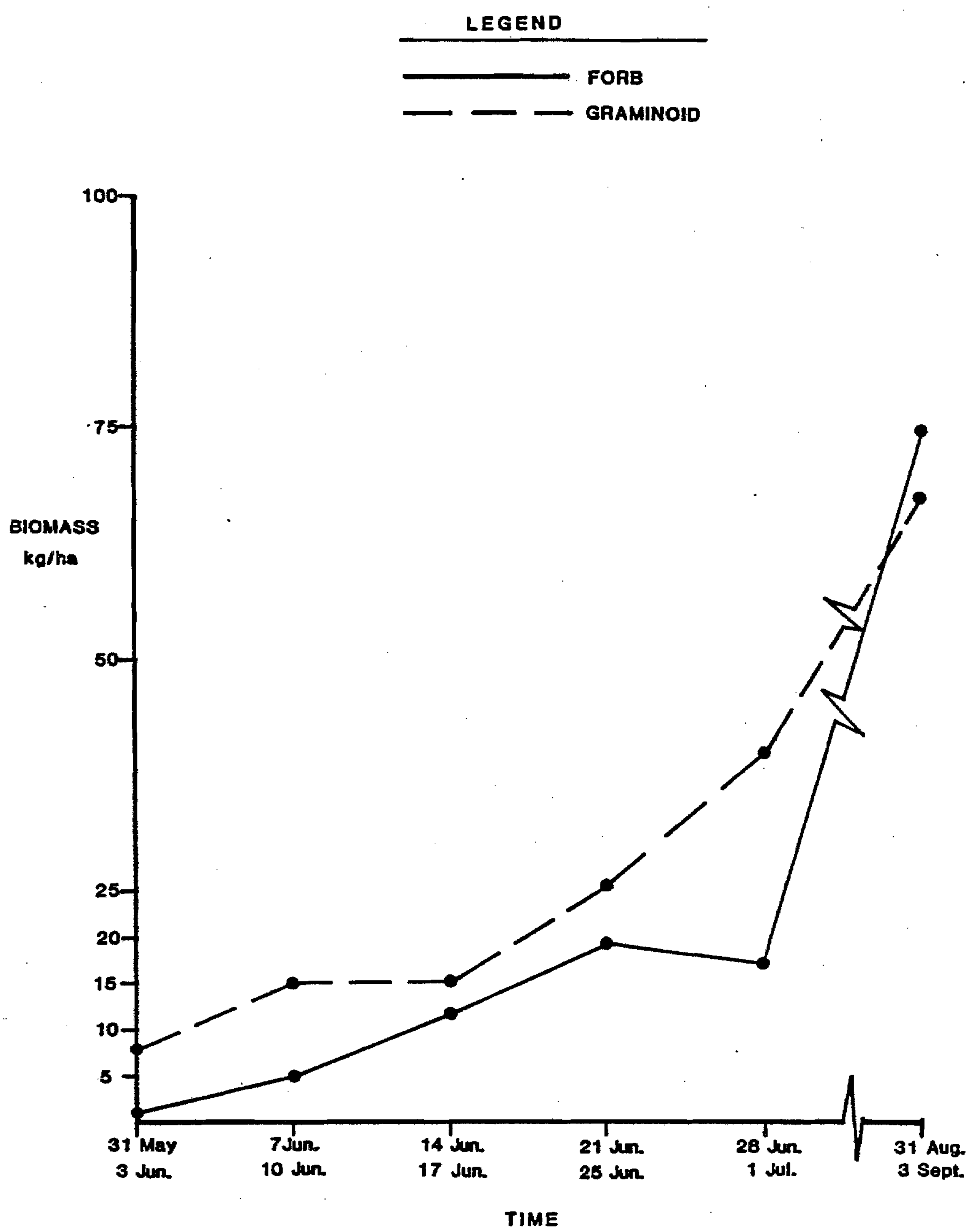
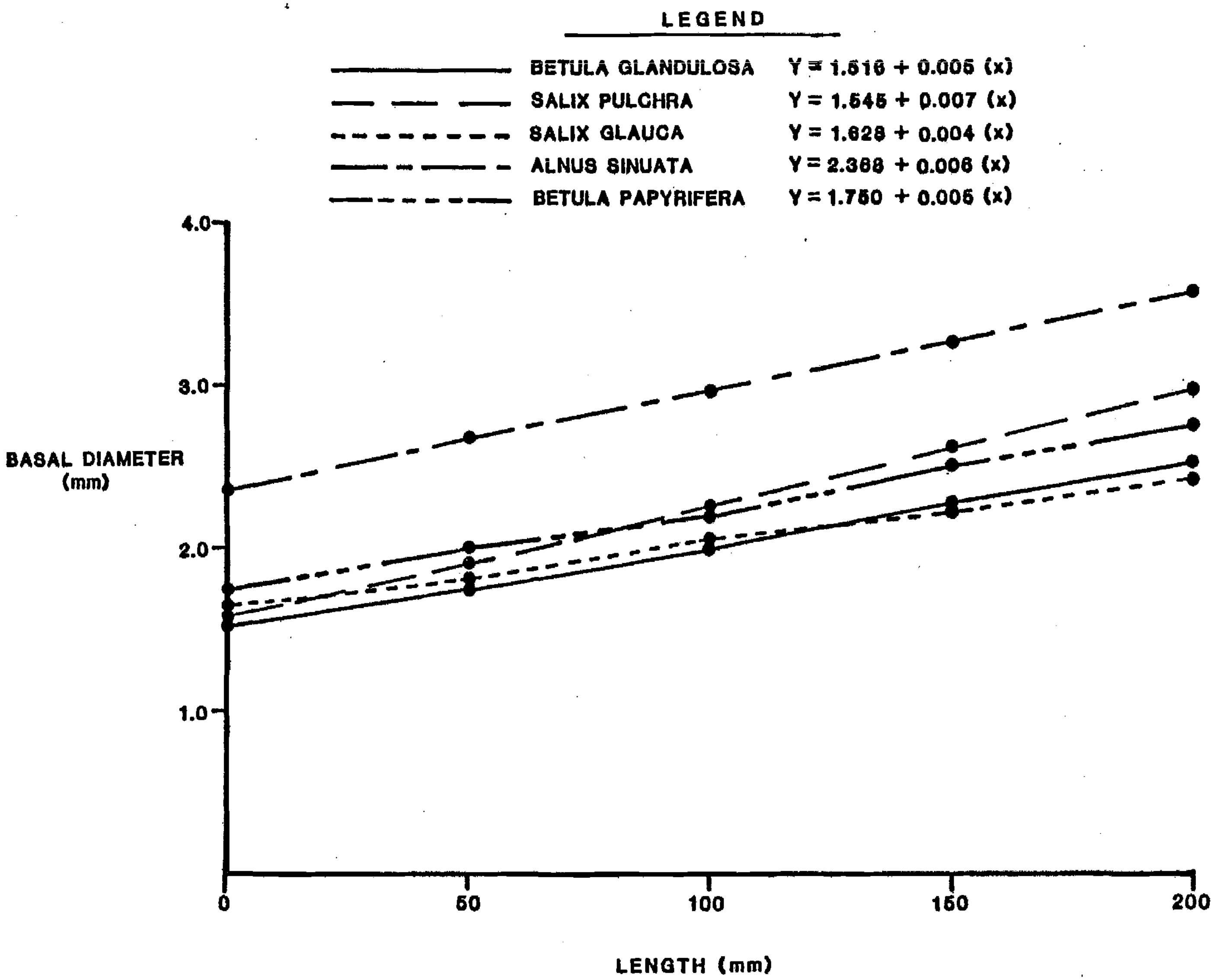

LEGEND
FORB
GRAMINOID
BIOMASS
kg/ha
100
75
50
25
20
15
10
5
31 May
3 Jun.
7 Jun.
10 Jun.
14 Jun.
17 Jun.
21 Jun.
25 Jun.
28 Jun.
1 Jul.
31 Aug.
3 Sept.
TIME

FIGURE G2

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


LEGEND
BETULA GLANDULOSA Y = 1.516 + 0.005 (x)
SALIX PULCHRA Y = 1.545 + 0.007 (x)
SALIX GLAUCA Y = 1.628 + 0.004 (x)
ALNUS SINUATA Y = 2.368 + 0.006 (x)
BETULA PAPYRIFERA Y = 1.750 + 0.005 (x)
BASAL DIAMETER (mm)
4.0
3.0
2.0
1.0
0
50
100
150
200
LENGTH (mm)

APPENDIX P

1983 PHENOLOGICAL STATE TABLES

Table P1-1. Tests of partial and marginal association for phenological advancement,aspect,elevation, and slope,Devil Creek, period 5, 1983.

***** ASSOCIATION OPTION SELECTED FOR ALL TERMS OF ORDER LESS THAN OR EQUAL TO 4

EFFECT	D.F.	PARTIAL ASSOCIATION CHISQUARE	PROB	ITER	MARGINAL ASSOCIATION CHISQUARE	PROB	ITER
P.	1	1.89	0.1692				
A.	4	371.80	0.				
E.	1	38.62	0.				
S.	3	114.08	0.				
PA.	4	99.32	0.	6	115.58	0.	2
PE.	1	4.13	0.0422	6	12.20	0.0005	2
PS.	3	6.58	0.0864	6	22.67	0.0000	2
AE.	4	23.55	0.0001	6	32.08	0.0000	2
AS.	15	132.05	0.	5	148.59	0.	2
ES.	3	51.34	0.	6	59.70	0.	2
PAE.	4	26.96	0.0000	20	21.48	0.0003	6
PAS.	11	5.54	0.9023	17	18.36	0.1052	6
PES.	3	15.26	0.0016	7	24.30	0.0000	4
AES.	12	135.72	0.	8	149.27	0.	6
PAES.	9	11.07	0.2708				

Table F1-2. Standardized deviates for phenological advancement, aspect, elevation, and slope, Devil Creek, period 5, 1983.

SLOPE	ELEV	ASP	PADV LATE-MID	PADV EARLY
0-3	BLW 465M	E-SE	-0.5	7.2
		S	-1.2	4.6
		SW	-1.9	0.4
		W	-1.6	-1.7
		NW-NE	3.6	2.5
	ABV 465M	E-SE	1.1	4.3
		S	2.2	0.6
		SW	-1.7	-1.5
		W	-2.0	-2.1
		NW-NE	-3.0	-4.4
3-10	BLW 465M	E-SE	-2.4	1.1
		S	0.4	-1.4
		SW	-2.0	8.3
		W	-1.3	-0.6
		NW-NE	-1.3	-4.7
	ABV 465M	E-SE	-1.0	-0.6
		S	-1.5	-1.2
		SW	-2.0	-1.4
		W	2.6	3.5
		NW-NE	3.6	1.2
10-30	BLW 465M	E-SE	-1.9	3.5
		S	-2.0	-1.6
		SW	-2.2	-0.1
		W	-1.7	0.3
		NW-NE	0.2	-2.7
	ABV 465M	E-SE	-2.4	-2.1
		S	-0.9	-1.5
		SW	-0.9	-0.5
		W	2.7	-0.2
		NW-NE	8.3	-1.0
GR 30	BLW 465M	E-SE	-1.3	-0.7
		S	-0.6	-0.0
		SW	-1.5	4.1
		W	-1.2	-1.3
		NW-NE	4.8	0.3
	ABV 465M	E-SE	-1.7	-1.8
		S	1.1	5.8
		SW	-1.4	5.9
		W	-0.9	0.8

Table F1-3. Observed frequencies for phenological advancement, aspect, elevation, and slope, Devil Creek, period 5, 1983.

SLOPE	ELEV	ASP	PADV LATE-MID	EARLY	TOTAL
0-3	BLW 465M	E-SE	2	16	18
		S	1	12	13
		SW	0	5	5
		W	0	0	0
		NW-NE	27	25	52
		TOTAL	30	58	88
	ABV 465M	E-SE	7	15	22
		S	10	7	17
		SW	2	3	5
		W	0	0	0
		NW-NE	8	3	11
		TOTAL	27	28	55
3-10	BLW 465M	E-SE	0	9	9
		S	7	3	10
		SW	2	32	34
		W	2	4	6
		NW-NE	20	4	24
		TOTAL	31	52	83
	ABV 465M	E-SE	6	8	14
		S	5	7	12
		SW	5	8	13
		W	15	19	34
		NW-NE	67	56	123
		TOTAL	98	98	196
10-30	BLW 465M	E-SE	0	11	11
		S	0	1	1
		SW	0	5	5
		W	0	4	4
		NW-NE	18	7	25
		TOTAL	18	28	46
	ABV 465M	E-SE	0	1	1
		S	4	3	7
		SW	5	7	12
		W	11	5	16
		NW-NE	71	25	96
		TOTAL	91	41	132
GR 30	BLW 465M	E-SE	0	1	1
		S	1	2	3
		SW	0	9	9
		W	0	0	0
		NW-NE	22	10	32
		TOTAL	23	22	45
	ABV 465M	E-SE	0	0	0
		S	5	14	19
		SW	1	16	17
		W	1	4	5
		NW-NE	0	0	0
		TOTAL	7	34	41

Table P1-4. Standardized deviates for phenological advancement, aspect, elevation, and vegetation type, Devil Creek, period 5, 1983.

VC	ELEV	ASP	PADV LATE-MID	PADV EARLY
CF	BLW 465M	E-SE	-0.9	-1.0
		S	-1.0	-1.0
		SW	-1.1	16.9
		W	1.5	8.1
		NW-NE	-2.0	-2.1
	ABV 465M	E-SE	-1.2	-1.2
		S	-1.2	-1.3
		SW	-1.3	7.1
		W	-1.1	-1.1
		NW-NE	-2.6	-2.7
OF-SCRUB	BLW 465M	E-SE	-1.8	1.6
		S	0.2	3.4
		SW	-2.3	-0.3
		W	-2.4	-2.5
		NW-NE	2.9	-4.7
	ABV 465M	E-SE	-0.0	2.5
		S	2.9	4.6
		SW	-1.4	0.5
		W	3.8	2.6
		NW-NE	3.2	-7.0
TS-LS	BLW 465M	E-SE	-2.5	7.0
		S	-2.2	-2.7
		SW	-2.8	4.4
		W	-2.3	-2.4
		NW-NE	1.6	1.0
	ABV 465M	E-SE	-2.5	-2.4
		S	-2.6	-3.1
		SW	-2.5	-2.7
		W	-0.8	-0.1
		NW-NE	3.3	3.7

Table P2-1. Tests of partial and marginal association for phenological advancement, vegetation type, slope, and elevation, Tsusena Creek , period 5, 1983.

***** ASSOCIATION OPTION SELECTED FOR ALL TERMS OF ORDER LESS THAN OR EQUAL TO 4

		PARTIAL ASSOCIATION			MARGINAL ASSOCIATION		
EFFECT	D.F.	CHISQUARE	PROB	ITER	CHISQUARE	PROB	ITER
P.	1	3.94	0.0471				
E.	1	1.65	0.1993				
S.	2	67.43	0.				
V.	2	163.98	0.				
PE.	1	3.42	0.0643	20	27.76	0.	2
PS.	2	31.92	0.0000	20	69.62	0.	2
PV.	2	21.83	0.0000	20	41.77	0.	2
ES.	3	228.47	0.	6	201.78	0.	2
EV.	2	56.43	0.	6	11.94	0.0026	2
SV.	6	112.18	0.	10	81.11	0.	2
PES.	0	0.58	1.0000	20	4.02	1.0000	15
PEV.	2	0.06	0.9681	20	82.20	0.	5
PSV.	0	4.94	1.0000	20	30.99	0.	4
ESV.	1	1.91	0.1665	20	1.89	0.3888	20
PESV.	5	0.28	0.9979				

****

Table P2-2. Standardized deviates for phenological advancement, slope, vegetation type, and elevation, Tsusena, period 5, 1983.

VC	SLOPE	ELEV	PADV LATE-MID	PADV EARLY
DF	0-3	BLW 465M	5.7	-0.9
		ABV 465M	-4.9	-5.4
	3-10	BLW 465M	-1.0	-0.1
		ABV 465M	-2.8	-5.5
	10-30	BLW 465M	-3.5	-4.0
		ABV 465M	-0.5	14.3
WP-SCRB	0-3	BLW 465M	9.7	-1.3
		ABV 465M	0.3	-2.3
	3-10	BLW 465M	-1.3	-1.4
		ABV 465M	0.5	-0.6
	10-30	BLW 465M	-1.5	-1.7
		ABV 465M	-1.4	-1.6
LOWSHRB	0-3	BLW 465M	-1.8	4.9
		ABV 465M	3.8	-1.2
	3-10	BLW 465M	-1.5	-1.7
		ABV 465M	3.7	-1.6
	10-30	BLW 465M	-1.8	-2.0
		ABV 465M	-1.6	-1.8

Table P2-3. Observed frequencies for phenological advancement, vegetation type, elevation, and slope, Tsusena Creek, period 5, 1983.

***** OBSERVED FREQUENCY TABLE 1

VC	SLOPE	ELEV	PADV LATE-MID	EARLY	TOTAL
OF	0-3	BLW 465M	57	29	86
		ABV 465M	0	0	0
		TOTAL	57	29	86
	3-10	BLW 465M	6	11	17
		ABV 465M	0	27	27
		TOTAL	6	38	44
	10-30	BLW 465M	0	0	0
		ABV 465M	9	66	75
		TOTAL	9	66	75
WF-SCRB	0-3	BLW 465M	27	3	30
		ABV 465M	5	0	5
		TOTAL	32	3	35
	3-10	BLW 465M	0	0	0
		ABV 465M	2	1	3
		TOTAL	2	1	3
	10-30	BLW 465M	0	0	0
		ABV 465M	0	0	0
		TOTAL	0	0	0
LOWSHRB	0-3	BLW 465M	2	23	25
		ABV 465M	15	4	19
		TOTAL	17	27	44
	3-10	BLW 465M	0	0	0
		ABV 465M	7	0	7
		TOTAL	7	0	7
	10-30	BLW 465M	0	0	0
		ABV 465M	0	0	0
		TOTAL	0	0	0

Table P3-1. Tests of partial and marginal association for phenological advancement, aspect, slope, and vegetation type, Fog Creek, period 5, 1983.

***** ASSOCIATION OPTION SELECTED FOR ALL TERMS OF ORDER LESS THAN OR EQUAL TO 4

		PARTIAL ASSOCIATION			MARGINAL ASSOCIATION		
EFFECT	D.F.	CHISQUARE	PROB	ITER	CHISQUARE	PROB	ITER
P.	1	405.18	0.				
A.	1	14.57	0.0001				
S.	2	173.00	0.				
V.	2	86.08	0.				
PA.	1	2.36	0.1249	5	8.55	0.0035	2
PS.	7	11.86	0.1054	5	18.29	0.0107	2
PV.	2	3.65	0.1616	5	12.26	0.0022	2
AS.	2	61.14	0.	5	67.91	0.	2
AV.	2	66.16	0.	4	75.12	0.	2
SV.	4	36.21	0.0000	5	45.40	0.	2
PAS.	0	2.47	1.0000	8	2.41	1.0000	3
PAV.	2	12.46	0.0020	4	3.57	0.4675	4
PSV.	1	8.03	0.0046	6	6.07	0.0481	3
ASV.	4	50.36	0.	20	53.03	0.	6
PASV.	3	0.15	0.9848				

ːable P3-2. Standardized deviates for phenological advancement, aspect, slope, and vegetation type, Fog Creek, period 5, 1983.

VC	SLOPE	ASP	PADV	
			LATE-MID	EARLY
CF-OF	0-3	SOUTH	-1.4	-0.9
		NORTH	3.7	4.2
	3-10	SOUTH	-2.0	-1.0
		NORTH	-1.4	-1.1
	10-30	SOUTH	-1.4	-0.4
		NORTH	1.9	-0.5
WF-SCRB	0-3	SOUTH	-5.1	-0.4
		NORTH	4.9	6.7
	3-10	SOUTH	1.1	0.2
		NORTH	-1.5	-2.0
	10-30	SOUTH	-1.6	-0.7
		NORTH	-1.2	-0.8
LOWSHRB	0-3	SOUTH	2.1	-1.6
		NORTH	-5.4	-1.4
	3-10	SOUTH	7.2	-1.0
		NORTH	-2.4	-0.4
	10-30	SOUTH	-2.4	-0.7
		NORTH	5.1	-0.8

able F3-3. Observed frequencies for phenological advancement, aspect, egetation type, and slope, Fog Creek, period 5, 1983.

			LATE-MID	EARLY	TOTAL
CF-DF	0-3	SOUTH	7	0	7
		NORTH	32	6	38
		TOTAL	39	6	45
	3-10	SOUTH	5	0	5
		NORTH	11	0	11
		TOTAL	16	0	16
	10-30	SOUTH	0	0	0
		NORTH	6	0	6
		TOTAL	6	0	6
WF-SCRB	0-3	SOUTH	5	2	7
		NORTH	85	17	102
		TOTAL	90	19	109
	3-10	SOUTH	42	3	45
		NORTH	40	0	40
		TOTAL	82	3	85
	10-30	SOUTH	2	0	2
		NORTH	5	0	5
		TOTAL	7	0	7
LOWSHRB	0-3	SOUTH	47	0	47
		NORTH	11	1	12
		TOTAL	58	1	59
	3-10	SOUTH	77	1	78
		NORTH	33	3	36
		TOTAL	110	4	114
	10-30	SOUTH	0	0	0
		NORTH	23	0	23
		TOTAL	23	0	23

Table P4-1. Tests of partial and marginal association for phenological advancement,elevation,slope, and aspect,Watana Slide , period 5, 1983.

***** ASSOCIATION OPTION SELECTED FOR ALL TERMS OF ORDER LESS THAN OR EQUAL TO 4

		PARTIAL ASSOCIATION			MARGINAL ASSOCIATION		
EFFECT	D.F.	CHISQUARE	PROB	ITER	CHISQUARE	PROB	ITER
P.	1	134.83	0.				
A.	3	66.26	0.				
E.	1	62.47	0.				
S.	2	50.98	0.				
PA.	3	91.89	0.	5	91.83	0.	2
PE.	1	1.17	0.2796	5	0.46	0.4962	2
PS.	2	1.81	0.4044	5	2.41	0.2991	2
AE.	3	55.13	0.	4	56.46	0.	2
AS.	6	68.88	0.	4	71.52	0.	2
ES.	2	2.67	0.2629	6	4.66	0.0971	2
PAE.	3	10.87	0.0124	20	6.38	0.0946	5
PAS.	8	39.51	0.0000	11	26.44	0.0009	6
PES.	2	8.43	0.0148	8	2.65	0.2655	3
AES.	8	151.20	0.	6	136.41	0.	5
PAES.	2	11.07	0.0040				

Table P4-2. Standardized deviates for phenological advancement, aspect, elevation, and slope, Watana Slide, period 5, 1983.

SLOPE	ELEV	ASP	PADV LATE-MID	PADV EARLY
0-3	BLOW 765	SE	1.8	-3.8
		S-SW	0.8	6.2
		W	-0.3	-0.8
		NW-E	-4.2	-3.1
	ABV 765M	SE	-4.2	-2.7
		S-SW	-0.7	-1.6
		W	3.4	1.6
		NW-E	2.2	8.2
3-10	BLOW 765	SE	3.5	-3.6
		S-SW	0.9	2.7
		W	1.3	-0.6
		NW-E	-3.5	0.2
	ABV 765M	SE	0.9	-2.6
		S-SW	-1.8	-1.4
		W	-1.7	1.4
		NW-E	0.3	2.1
10-30	BLOW 765	SE	3.5	0.7
		S-SW	-4.7	-2.9
		W	-0.8	-1.4
		NW-E	0.8	4.3
	ABV 765M	SE	3.2	-1.4
		S-SW	-0.5	2.7
		W	-2.2	-1.4
		NW-E	1.8	-1.6

Table P4-3. Observed frequencies for phenological advancement, elevation, aspect, and slope, Watana Slide, period 5, 1983.

			LATE-MID	EARLY	TOTAL
0-3	BLOW 765	SE	49	0	49
		S-SW	50	42	92
		W	18	5	23
		NW-E	4	0	4
		TOTAL	121	47	168
	ABV 765M	SE	1	0	1
		S-SW	20	4	24
		W	21	7	28
		NW-E	21	23	44
		TOTAL	63	34	97
3-10	BLOW 765	SE	55	0	55
		S-SW	46	26	72
		W	23	5	28
		NW-E	6	9	15
		TOTAL	130	40	170
	ABV 765M	SE	22	0	22
		S-SW	13	4	17
		W	4	6	10
		NW-E	13	9	22
		TOTAL	52	19	71
10-30	BLOW 765	SE	34	9	43
		S-SW	0	0	0
		W	7	1	8
		NW-E	15	14	29
		TOTAL	56	24	80
	ABV 765M	SE	20	1	21
		S-SW	10	10	20
		W	0	0	0
		NW-E	11	0	11
		TOTAL	41	11	52

Table P4-4. Standardized deviates for phenological advancement,elevation vegetation type, and aspect,Watana Slide, period 5, 1983.

VC	ELEV	ASP	PADV LATE-MID	PADV EARLY
OF	BLOW 765	SE	1.2	-2.3
		S-SW	3.7	-0.7
		W	1.3	-1.0
		NW-E	-0.5	-0.7
	ABV 765M	SE	2.2	-1.9
		S-SW	-1.0	0.2
		W	-2.7	-1.7
		NW-E	-0.8	-1.9
WF-SCRB	BLOW 765	SE	4.2	-1.5
		S-SW	-1.5	2.3
		W	0.7	-1.1
		NW-E	-2.9	0.7
	ABV 765M	SE	-2.6	-2.4
		S-SW	-0.6	1.7
		W	2.3	1.3
		NW-E	0.1	-0.9
LOWSHRB	BLOW 765	SE	3.1	-3.6
		S-SW	-3.7	5.5
		W	-1.3	-0.6
		NW-E	-4.1	0.2
	ABV 765M	SE	-0.8	-2.6
		S-SW	-1.4	-2.8
		W	0.6	2.4
		NW-E	4.7	12.0

Table P5-1. Tests of partial and marginal association for phenological advancement, vegetation type, slope, and aspect, Watana Creek, period 5, 1983.

***** ASSOCIATION OPTION SELECTED FOR ALL TERMS OF ORDER LESS THAN OR EQUAL TO 4

EFFECT	D.F.	PARTIAL ASSOCIATION CHISQUARE	PROB	ITER	MARGINAL ASSOCIATION CHISQUARE	PROB	ITER
P.	1	564.28	0.				
A.	3	135.95	0.				
V.	2	330.92	0.				
S.	2	73.22	0.				
PA.	3	6.35	0.0958	8	7.57	0.0558	2
PV.	2	18.50	0.0001	8	20.86	0.0000	2
PS.	2	1.97	0.3738	8	7.04	0.0296	2
AV.	11	78.38	0.	4	65.39	0.	2
AS.	6	90.36	0.	4	80.07	0.	2
VS.	4	94.95	0.	4	85.81	0.	2
PAV.	4	15.94	0.0031	5	13.09	0.0417	6
PAS.	6	20.54	0.0022	6	21.64	0.0864	4
PVS.	4	4.88	0.3003	8	8.42	0.5883	5
AVS.	10	77.53	0.	20	76.18	0.	8
PAVS.	3	1.23	0.7451				

Table P5-2. Standardized deviates for phenological advancement, slope, vegetation type, and aspect, Watana Creek, period 5, 1983.

SLOPE	VC	ASP	PADV LATE-MID	PADV EARLY
0-3	OF-WF	E-W	-0.7	-1.0
		NW	-3.7	-1.3
		N	-0.1	0.7
		NE	-3.7	-1.8
	SCRB	E-W	-0.4	3.0
		NW	-1.9	-0.6
		N	-0.4	4.4
		NE	3.0	-0.8
	LS	E-W	3.8	-0.5
		NW	2.9	3.4
		N	4.2	4.3
		NE	-2.0	-1.0
3-10	OF-WF	E-W	-2.5	-1.5
		NW	5.1	-1.2
		N	1.3	0.0
		NE	4.0	-1.0
	SCRB	E-W	-3.0	-0.9
		NW	-1.7	-0.5
		N	-0.2	-1.0
		NE	0.6	10.8
	LS	E-W	0.1	-1.1
		NW	-2.2	-0.6
		N	-3.7	-0.4
		NE	-0.4	0.2
10-30	OF-WF	E-W	6.5	0.5
		NW	1.3	-0.9
		N	-0.9	-0.4
		NE	-1.6	-1.2
	SCRB	E-W	-2.2	-0.7
		NW	-1.3	-0.4
		N	-2.0	-0.7
		NE	5.7	-0.5
	LS	E-W	-2.5	-0.8
		NW	0.9	-0.5
		N	-3.1	-0.9
		NE	-1.4	-0.7

Table P5-3. Observed frequencies for phenological advancement, vegetation type, aspect, and slope, Watana Creek, period 5, 1983.

SLOPE	VC	ASP	PADV LATE-MID	EARLY	TOTAL
0-3	OF-WF	E-W	55	3	58
		NW	3	0	3
		N	71	8	79
		NE	15	0	15
		TOTAL	144	11	155
	SCRB	E-W	10	4	14
		NW	0	0	0
		N	12	6	18
		NE	15	0	15
		TOTAL	37	10	47
	LS	E-W	35	1	36
		NW	13	3	16
		N	42	8	50
		NE	5	0	5
		TOTAL	95	12	107
3-10	OF-WF	E-W	30	1	31
		NW	35	0	35
		N	66	5	71
		NE	51	1	52
		TOTAL	182	7	189
	SCRB	E-W	0	0	0
		NW	0	0	0
		N	10	0	10
		NE	7	8	15
		TOTAL	17	8	25
	LS	E-W	15	0	15
		NW	0	0	0
		N	2	1	3
		NE	8	1	9
		TOTAL	25	2	27
10-30	OF-WF	E-W	59	3	62
		NW	12	0	12
		N	26	2	28
		NE	10	0	10
		TOTAL	107	5	112
	SCRB	E-W	0	0	0
		NW	0	0	0
		N	1	0	1
		NE	13	0	13
		TOTAL	14	0	14
	LS	E-W	1	0	1
		NW	4	0	4
		N	0	0	0
		NE	2	0	2
		TOTAL	7	0	7

Table P6-1. Tests of partial and marginal association for phenological advancement, elevation, slope, and aspect, Fish Creek, period 5, 1983.

***** ASSOCIATION OPTION SELECTED FOR ALL TERMS OF ORDER LESS THAN OR EQUAL TO 4

		PARTIAL ASSOCIATION			MARGINAL ASSOCIATION		
EFFECT	D.F.	CHISQUARE	PROB	ITER	CHISQUARE	PROB	ITER
P.	1	336.85	0.				
A.	2	12.13	0.0023				
E.	1	46.45	0.				
S.	2	192.92	0.				
PA.	2	34.41	0.0000	7	28.04	0.0000	2
PE.	1	5.84	0.0157	7	2.47	0.1164	2
PS.	2	15.35	0.0005	7	7.67	0.0217	2
AE.	2	59.95	0.	5	41.61	0.	2
AS.	4	145.72	0.	4	123.07	0.	2
ES.	2	40.32	0.	5	20.67	0.0000	2
PAE.	2	43.09	0.	6	72.47	0.	4
PAS.	4	11.49	0.0216	6	7.25	0.1234	5
PES.	3	17.11	0.0007	5	21.27	0.0003	4
AES.	4	74.03	0.	8	80.20	0.	7
PAES.	2	3.57	0.1678				

Table P6-2. Standardized deviates for phenological advancement, elevation, slope, and aspect, Fish Creek, period 5, 1983.

SLOPE	ELEV	ASP	PADV LATE-MID	PADV EARLY
0-3	BLW 765M	E-S	-3.6	-1.4
		SW	-3.9	-1.7
		W-NE	8.5	3.6
	ABV 765M	E-S	2.0	-1.8
		SW	-0.8	-1.7
		W-NE	-2.7	0.6
3-10	BLW 765M	E-S	-4.2	0.6
		SW	1.3	0.2
		W-NE	-0.8	-0.4
	ABV 765M	E-S	0.3	-0.2
		SW	4.7	-2.8
		W-NE	-1.9	6.2
10-30	BLW 765M	E-S	-0.6	5.4
		SW	4.3	-2.1
		W-NE	-0.8	-1.7
	ABV 765M	E-S	8.4	-2.3
		SW	-4.5	-2.2
		W-NE	-4.5	-2.5

Table P6-3. Observed frequencies for phenological advancement, elevation, aspect, and slope, Fish Creek, period 5, 1983.

SLOPE	ELEV	ASP	PADV LATE-MID	EARLY	TOTAL
0-3	BLW 765M	E-S	5	2 I	7
		SW	2	1 I	3
		W-NE	69	15 I	84
		TOTAL	76	18 I	94
	ABV 765M	E-S	21	0 I	21
		SW	9	0 I	9
		W-NE	5	5 I	10
		TOTAL	35	5 I	40
3-10	BLW 765M	E-S	38	20 I	58
		SW	76	16 I	92
		W-NE	80	19 I	99
		TOTAL	194	55 I	249
	ABV 765M	E-S	48	10 I	58
		SW	70	1 I	71
		W-NE	40	35 I	75
		TOTAL	158	46 I	204
10-30	BLW 765M	E-S	34	25 I	59
		SW	58	2 I	60
		W-NE	39	5 I	44
		TOTAL	131	32 I	163
	ABV 765M	E-S	64	0 I	64
		SW	0	0 I	0
		W-NE	4	0 I	4
		TOTAL	68	0 I	68

Table P6-4. Standardized deviates for phenological advancement, aspect, elevation, and vegetation type, Fish Creek, period 5, 1983.

VC	ELEV	ASP	PADV LATE-MID	PADV EARLY
OF	BLW 765M	E-S	-2.8	6.3
		SW	3.1	-3.3
		W-NE	3.0	1.2
	ABV 765M	E-S	5.4	-3.1
		SW	-3.2	-3.1
		W-NE	-4.4	-3.4
WF-SCRB	BLW 765M	E-S	-4.9	-2.7
		SW	-1.0	3.8
		W-NE	-0.6	-1.6
	ABV 765M	E-S	5.2	1.2
		SW	10.0	-1.5
		W-NE	-4.1	-2.3
LOWSHRB	BLW 765M	E-S	-1.1	-1.6
		SW	-0.5	-2.3
		W-NE	0.9	0.4
	ABV 765M	E-S	-2.4	-0.9
		SW	-3.7	-1.8
		W-NE	1.1	16.6

Table P7-1. Tests of partial and marginal association for phenological advancement, elevation, slope, and aspect, Kosina Creek, period 5, 1983.

***** ASSOCIATION OPTION SELECTED FOR ALL TERMS OF ORDER LESS THAN OR EQUAL TO 4

		PARTIAL ASSOCIATION			MARGINAL ASSOCIATION		
EFFECT	D.F.	CHISQUARE	PROB	ITER	CHISQUARE	PROB	ITER
------	----	---------	----	----	---------	----	----
P.	1	59.40	0.				
A.	1	2.39	0.1222				
E.	1	194.55	0.				
S.	3	165.16	0.				
PA.	1	180.39	0.	8	188.35	0.	2
PE.	1	51.72	0.	8	53.06	0.	2
PS.	3	19.53	0.0002	7	18.21	0.0004	2
AE.	1	0.55	0.4584	9	3.17	0.0752	2
AS.	3	52.98	0.	10	52.95	0.	2
ES.	3	49.64	0.	9	42.98	0.	2
PAE.	1	1.75	0.1854	20	1.06	0.3030	11
PAS.	5	49.74	0.	8	49.39	0.	8
PES.	3	1.16	0.7625	10	19.97	0.0002	8
AES.	3	7.06	0.0701	[illegible]	14.32	0.0025	7
PAES.	1	1.83	0.1766				

able P7-2. Standardized deviates for phenological advancement, elevation, slope, and aspect, Kosina Creek, period 5, 1983.

SLOPE	ELEV	ASP	PADV	
			LATE-MID	EARLY
0-3	BLW 675M	E-SW	3.2	1.7
		W-N	1.8	-4.1
	ABV 675M	E-SW	-3.1	3.3
		W-N	-4.0	-2.3
3-10	BLW 675M	E-SW	-2.7	2.2
		W-N	3.3	-3.9
	ABV 675M	E-SW	-3.2	8.0
		W-N	-1.9	0.7
10-30	BLW 675M	E-SW	-5.3	-1.7
		W-N	5.9	-4.3
	ABV 675M	E-SW	-2.9	6.1
		W-N	7.6	-2.4
GR 30	BLW 675M	E-SW	-2.3	5.4
		W-N	1.7	-2.6
	ABV 675M	E-SW	-2.1	-0.9
		W-N	1.2	-1.4

Table P7-3. Observed frequencies for phenological advancement, elevation, aspect, and slope, Kosina Creek, period 5, 1983.

SLOPE	ELEV	ASP	PADV LATE-MID	EARLY	TOTAL
0-3	BLW 675M	E-SW	82	41	123
		W-N	64	6	70
		TOTAL	146	47	193
	ABV 675M	E-SW	5	20	25
		W-N	0	2	2
		TOTAL	5	22	27
3-10	BLW 675M	E-SW	44	49	93
		W-N	84	10	94
		TOTAL	128	59	187
	ABV 675M	E-SW	6	38	44
		W-N	10	12	22
		TOTAL	16	50	66
10-30	BLW 675M	E-SW	5	13	18
		W-N	68	0	68
		TOTAL	73	13	86
	ABV 675M	E-SW	2	22	24
		W-N	35	0	35
		TOTAL	37	22	59
GR 30	BLW 675M	E-SW	5	22	27
		W-N	18	0	18
		TOTAL	23	22	45
	ABV 675M	E-SW	0	1	1
		W-N	6	0	6
		TOTAL	6	1	7

Table P7-4. Standardized deviates for phenological advancement, aspect, elevation, and vegetation type, Kosina Creek, period 5, 1983.

ELEV	ASP	VC	PADV LATE-MID	PADV EARLY
BLW 675M	E-SW	CF-OF	2.1	5.8
		WF-SCRB	-0.7	0.4
		LOWSHRB	-7.1	-1.6
	W-N	CF-OF	3.3	-5.5
		WF-SCRB	7.0	-2.6
		LOWSHRB	0.6	-4.6
ABV 675M	E-SW	CF-OF	-4.1	0.5
		WF-SCRB	-3.5	-0.9
		LOWSHRB	-2.1	17.5
	W-N	CF-OF	-4.4	-3.3
		WF-SCRB	-1.9	-2.8
		LOWSHRB	7.7	2.2

Table P8-1. Tests of partial and marginal association for phenological advancement, elevation, slope, and vegetation type, Clarence Creek, period 5, 1983.

***** ASSOCIATION OPTION SELECTED FOR ALL TERMS OF ORDER LESS THAN OR EQUAL TO 4

		PARTIAL ASSOCIATION			MARGINAL ASSOCIATION		
EFFECT	D.F.	CHISQUARE	PROB	ITER	CHISQUARE	PROB	ITER
P.	1	166.88	0.				
E.	1	4.37	0.0366				
V.	2	51.59	0.				
S.	3	65.59	0.				
PE.	1	0.02	0.8920	7	1.39	0.2384	2
PV.	2	20.77	0.0000	6	15.97	0.0003	2
PS.	3	7.83	0.0497	6	2.35	0.5029	2
EV.	2	31.19	0.0000	5	29.46	0.0000	2
ES.	3	14.53	0.0023	6	12.12	0.0070	2
VS.	6	69.16	0.	3	60.58	0.	2
PEV.	2	14.00	0.0009	20	2.63	0.2688	3
PES.	5	25.93	0.0001	6	20.69	0.0043	3
PVS.	6	15.20	0.0188	10	4.93	0.8956	5
EVS.	6	63.36	0.	20	52.88	0.0000	6
PEVS.	0	0.21	1.0000				

Table P8-2. Standardized deviates for phenological advancement, elevation, slope, and vegetation type, Clarence Creek, period 5, 1983.

SLOPE	VC	ELEV	PADV LATE-MID	PADV EARLY
0-3	OF	BLOW 765	-0.1	1.1
		ABV 765M	7.2	-0.7
	WF-SCRB	BLOW 765	-1.7	3.0
		ABV 765M	-0.8	-1.1
	LOWSHRB	BLOW 765	-1.9	0.6
		ABV 765M	-1.7	-0.8
3-10	OF	BLOW 765	-1.8	-1.1
		ABV 765M	2.1	0.3
	WF-SCRB	BLOW 765	-2.7	2.3
		ABV 765M	-1.8	0.2
	LOWSHRB	BLOW 765	7.9	-1.4
		ABV 765M	-2.3	0.3
10-30	OF	BLOW 765	-2.5	-1.0
		ABV 765M	-0.3	-1.1
	WF-SCRB	BLOW 765	3.7	2.0
		ABV 765M	-0.1	0.3
	LOWSHRB	BLOW 765	-3.1	-1.2
		ABV 765M	1.0	-1.4
GR30	OF	BLOW 765	-1.8	-0.7
		ABV 765M	0.0	-0.8
	WF-SCRB	BLOW 765	1.0	-1.2
		ABV 765M	0.1	1.6
	LOWSHRB	BLOW 765	-2.2	-0.9
		ABV 765M	2.6	-1.0

Table P8-3. Observed frequencies for phenological advancement, elevation, vegetation type, and slope, Clarence Creek, period 5, 1983.

SLOPE	VC	ELEV	PADV LATE-MID	EARLY	TOTAL
0-3	OF	BLOW 765	2	1	3
		ABV 765M	15	0	15
		TOTAL	17	1	18
	WF-SCRB	BLOW 765	2	4	6
		ABV 765M	6	0	6
		TOTAL	8	4	12
	LOWSHRB	BLOW 765	0	1	1
		ABV 765M	1	0	1
		TOTAL	1	1	2
3-10	OF	BLOW 765	3	0	3
		ABV 765M	17	2	19
		TOTAL	20	2	22
	WF-SCRB	BLOW 765	10	8	18
		ABV 765M	20	5	25
		TOTAL	30	13	43
	LOWSHRB	BLOW 765	41	0	41
		ABV 765M	7	3	10
		TOTAL	48	3	51
10-30	OF	BLOW 765	0	0	0
		ABV 765M	7	0	7
		TOTAL	7	0	7
	WF-SCRB	BLOW 765	33	6	39
		ABV 765M	22	4	26
		TOTAL	55	10	65
	LOWSHRB	BLOW 765	0	0	0
		ABV 765M	16	0	16
		TOTAL	16	0	16
GR30	OF	BLOW 765	0	0	0
		ABV 765M	4	0	4
		TOTAL	4	0	4
	WF-SCRB	BLOW 765	12	0	12
		ABV 765M	12	4	16
		TOTAL	24	4	28
	LOWSHRB	BLOW 765	0	0	0
		ABV 765M	13	0	13
		TOTAL	13	0	13

TOTAL OF THE OBSERVED FREQUENCY TABLE IS 281

Table P9-1. Tests of partial and marginal association for phenological advancement,aspect,slope, and elevation;Switchbacks, period 5, 1983.

***** ASSOCIATION OPTION SELECTED FOR ALL TERMS OF ORDER LESS THAN OR EQUAL TO 4

		PARTIAL ASSOCIATION			MARGINAL ASSOCIATION		
EFFECT	D.F.	CHISQUARE	PROB	ITER	CHISQUARE	PROB	ITER
P.	1	230.68	0.				
A.	1	20.12	0.0000				
E.	1	92.18	0.				
S.	2	8.89	0.0118				
PA.	1	167.01	0.	5	131.47	0.	2
PE.	1	16.09	0.0001	6	0.04	0.8342	2
PS.	2	55.97	0.	5	30.80	0.0000	2
AE.	1	61.78	0.	6	40.44	0.	2
AS.	2	38.30	0.0000	7	7.84	0.0199	2
ES.	2	19.75	0.0001	9	8.79	0.0124	2
PAE.	2	18.69	0.0001	14	13.34	0.0040	7
PAS.	2	18.83	0.0001	13	15.09	0.0017	9
PES.	2	3.12	0.2098	7	7.70	0.0213	4
AES.	2	0.29	0.8641	7	0.45	0.8000	5
PAES.	0	0.00	1.0000				

Table P9-2. Standardized deviates for phenological advancement, aspect, elevation, and slope, Switchbacks, period 5, 1983.

SLOPE	ELEV	ASP	PADV LATE-MID	PADV EARLY
0-3	BELOW675	S-SW	-1.2	2.5
		NW-E	4.6	-2.5
	ABOVE675	S-SW	2.6	-1.3
		NW-E	-3.0	-3.1
3-10	BELOW675	S-SW	-4.5	1.7
		NW-E	3.4	-2.7
	ABOVE675	S-SW	1.5	0.3
		NW-E	1.1	-3.0
10-30	BELOW675	S-SW	-4.4	2.5
		NW-E	3.9	-2.4
	ABOVE675	S-SW	-3.9	9.2
		NW-E	1.4	-3.5

Table P9-3. Observed frequencies for phenological advancement, aspect, elevation, and slope, Switchbacks, period 5, 1983.

SLOPE	ELEV	ASP	PADV LATE-MID	EARLY	TOTAL
0-3	BELOW675	S-SW	25	16	41
		NW-E	44	0	44
		TOTAL	69	16	85
	ABOVE675	S-SW	89	13	102
		NW-E	27	2	29
		TOTAL	116	15	131
3-10	BELOW675	S-SW	10	16	26
		NW-E	44	0	44
		TOTAL	54	16	70
	ABOVE675	S-SW	95	24	119
		NW-E	66	4	70
		TOTAL	161	28	189
10-30	BELOW675	S-SW	5	15	20
		NW-E	38	0	38
		TOTAL	43	15	58
	ABOVE675	S-SW	31	55	86
		NW-E	53	0	53
		TOTAL	84	55	139

Table F9-4. Standardized deviates for phenological advancement, aspect, vegetation type, and elevation, Switchbacks, period 5, 1983.

***** STANDARDIZED DEVIATES = (OBS - EXP)/SQRT(EXP) FOR ABOVE MODEL

VC	ELEV	ASP	PADV LATE-MID	PADV EARLY
CF-OF	BELOW675	S-SW	-0.7	-1.4
		NW-E	6.1	-1.1
	ABOVE675	S-SW	-0.9	4.0
		NW-E	-3.2	-1.7
WF-SCRB	BELOW675	S-SW	-4.8	1.7
		NW-E	7.5	-2.5
	ABOVE675	S-SW	0.1	2.7
		NW-E	-1.2	-3.1
LOWSHRB	BELOW675	S-SW	-3.7	4.2
		NW-E	1.2	-3.4
	ABOVE675	S-SW	0.6	2.4
		NW-E	1.7	-4.1

APPENDIX S

1983 SNOW DEPTH TABLES

Table S1-/. Standardized deviates for snow, aspect, elevation, and slope, Devil Creek, period 2, 1983.

SLOPE	ELEV	ASP	CSNOW ABSENT	CSNOW PRESENT
0-3	BELOW	E-S-W	-2.1	-1.0
		NW	7.5	-0.4
		N-NE	4.9	2.3
	ABOVE	E-S-W	-2.1	-2.2
		NW	-2.3	2.2
		N-NE	-1.5	-0.5
3-10	BELOW	E-S-W	6.7	-3.4
		NW	-3.4	-2.1
		N-NE	-4.0	-1.7
	ABOVE	E-S-W	1.3	-0.0
		NW	-1.6	6.8
		N-NE	-2.2	2.7
10-30	BELOW	E-S-W	-1.5	-2.9
		NW	-0.9	3.3
		N-NE	0.7	-1.0
	ABOVE	E-S-W	1.5	-2.8
		NW	-3.5	2.8
		N-NE	2.8	0.7

Table S1-1. Standardized deviates for snow,aspect,elevation, and vegetation type,Devil Creek, period 2, 1983.

VC	ELEV	ASP	CSNOW	
			ABSENT	PRESENT
OF	BELOW	E-S-W	4.4	-2.6
		NW	-3.4	-1.5
		N-NE	-1.0	1.8
	ABOVE	E-S-W	6.7	0.1
		NW	-2.5	-1.2
		N-NE	-4.9	-0.5
WF	BELOW	E-S-W	-2.3	-1.6
		NW	-1.9	-1.0
		N-NE	-1.8	-0.9
	ABOVE	E-S-W	-2.5	-1.7
		NW	0.7	20.2
		N-NE	-0.4	3.2
SCRUB	BELOW	E-S-W	-1.9	-1.0
		NW	3.1	13.7
		N-NE	-1.8	-1.0
	ABOVE	E-S-W	-2.5	-1.3
		NW	-0.9	5.1
		N-NE	-2.0	4.9
LS	BELOW	E-S-W	2.0	-2.9
		NW	3.7	-1.8
		N-NE	2.1	-2.5
	ABOVE	E-S-W	-3.6	-3.1
		NW	-3.9	0.0
		N-NE	5.7	0.2

Table S3-1. Standardized deviates for snow, aspect, slope, and vegetation type, Fos Creek, period 2, 1983.

SLOPE	VC	ASP	CSNOW ABSENT	CSNOW PRESENT
0-3	OF-WF	NE-S-SW	-6.1	-2.4
		NW	1.6	-0.2
		N	1.2	1.9
	SCRUB	NE-S-SW	-2.9	-1.1
		NW	-1.5	-0.8
		N	-2.4	4.3
	LS-HERB	NE-S-SW	14.4	2.5
		NW	-4.7	-2.1
		N	-4.7	-1.6
3-10	OF-WF	NE-S-SW	-0.9	-2.0
		NW	5.5	2.9
		N	1.6	2.9
	SCRUB	NE-S-SW	-2.1	-0.8
		NW	6.6	4.5
		N	3.4	0.8
	LS-HERB	NE-S-SW	-2.4	-1.7
		NW	-2.8	-1.5
		N	-2.9	-1.8
10-30	OF-WF	NE-S-SW	-2.6	-1.0
		NW	-1.8	-0.7
		N	5.3	5.0
	SCRUB	NE-S-SW	-0.9	-0.3
		NW	1.0	7.8
		N	-0.7	-0.3
	LS-HERB	NE-S-SW	-1.4	-0.9
		NW	-1.6	-0.6
		N	1.3	-0.8

able S4-1. Standardized deviates for snow,slope,elevation, and aspect, stana slide, period 2, 1983.

SLOPE	ELEV	ASP	CSNOW	
			ABSENT	PRESENT
0-3	BELOW	E	1.2	1.5
		SE	-0.6	1.9
		S-SW	1.2	-0.8
		W-NE	-2.1	-0.6
	ABOVE	E	6.1	0.7
		SE	-2.3	-1.3
		S-SW	-1.4	-0.8
		W-NE	-0.9	-0.5
3-10	BELOW	E	-4.4	-0.2
		SE	1.0	0.8
		S-SW	0.3	-0.6
		W-NE	2.6	1.0
	ABOVE	E	1.6	-0.5
		SE	1.2	-0.1
		S-SW	-0.5	-0.9
		W-NE	-2.3	-1.5
10-30	BELOW	E	-0.4	-1.9
		SE	-0.2	-2.2
		S-SW	-0.9	-1.3
		W-NE	0.4	4.9
	ABOVE	E	1.2	-1.0
		SE	0.3	-1.1
		S-SW	4.2	-0.7
		W-NE	-1.5	-1.1

Table S4-2. Standardized deviates for snow,vegetation type,elevation and aspect,Watana Slide, period 2, 1983.

VC	ELEV	ASP	CSNOW ABSENT	CSNOW PRESENT
OF	BELOW	E	2.5	-1.3
		SE	0.8	1.6
		S-SW	0.4	-1.2
		W-NE	-2.3	3.3
	ABOVE	E	3.4	-0.9
		SE	-2.5	-1.1
		S-SW	-1.6	-0.6
		W-NE	-2.6	-0.2
WF	BELOW	E	-5.8	-1.6
		SE	2.5	1.5
		S-SW	-2.6	-0.3
		W-NE	2.1	1.0
	ABOVE	E	1.9	-0.4
		SE	0.6	-0.0
		S-SW	2.6	-0.8
		W-NE	0.1	-1.5
SCRUB	BELOW	E	-2.1	-0.8
		SE	-2.4	-0.9
		S-SW	12.2	-0.5
		W-NE	-2.5	-1.0
	ABOVE	E	-1.1	-0.4
		SE	1.9	-0.5
		S-SW	4.9	-0.3
		W-NE	-1.3	-0.5
LS	BELOW	E	1.1	2.3
		SE	-2.2	-1.6
		S-SW	-1.6	-1.4
		W-NE	1.9	1.6
	ABOVE	E	4.6	0.8
		SE	-0.1	-1.2
		S-SW	-1.3	-0.7
		W-NE	-2.7	-1.3

Table S5-1. Standardized deviates for snow,vegetation type,slope and aspect,Watana Creek, period 2, 1983.

SLOPE	VC	ASP	CSNOW ABSENT	CSNOW PRESENT
0-3	OF	NE-S-SW	4.7	-1.4
		NW	-2.7	0.7
		N	-4.1	-2.5
	WF-SCRUB	NE-S-SW	-2.9	-3.4
		NW	-2.7	4.2
		N	0.6	0.7
	LS	NE-S-SW	11.6	-1.1
		NW	-2.0	-1.1
		N	3.6	-1.6
3-10	OF	NE-S-SW	1.8	-2.4
		NW	2.1	-0.8
		N	-2.4	4.6
	WF-SCRUB	NE-S-SW	-4.0	-2.7
		NW	2.5	1.5
		N	3.7	4.5
	LS	NE-S-SW	-1.9	-1.6
		NW	-1.6	-0.9
		N	-2.6	-1.6
10-30	OF	NE-S-SW	10.0	-1.7
		NW	-2.3	-0.1
		N	-4.3	-2.4
	WF-SCRUB	NE-S-SW	-4.5	-3.0
		NW	-1.5	11.0
		N	1.9	7.7
	LS	NE-S-SW	-2.9	-1.6
		NW	-1.5	-0.8
		N	-2.9	-1.6

Table S6-1. Standardized deviates for snow, vegetation type, slope, and aspect, Fish Creek, period 2, 1983.

SLOPE	ELEV	ASP	CSNOW ABSENT	CSNOW PRESENT
0-3	BELOW	E-S-W	2.2	-1.9
		NW-NE	-2.1	-1.6
	ABOVE	E-S-W	1.0	9.4
		NW-NE	-3.2	-0.2
3-10	BELOW	E-S-W	-0.8	-2.6
		NW-NE	0.5	-0.7
	ABOVE	E-S-W	5.0	1.1
		NW-NE	-3.9	1.4
10-30	BELOW	E-S-W	-2.3	-2.7
		NW-NE	6.3	1.8
	ABOVE	E-S-W	-4.1	-1.9
		NW-NE	-1.6	4.7

ble S6-2. Standardized deviates for snow, aspect, elevation, and vegetation type, sh Creek, period 2, 1983.

VC	ELEV	ASP	CSNOW ABSENT	CSNOW PRESENT
CF-OF	BELOW	E-S-W	1.0	-3.2
		NW-NE	5.3	0.2
	ABOVE	E-S-W	-1.7	3.9
		NW-NE	-7.3	-1.2
WF	BELOW	E-S-W	-2.4	-1.5
		NW-NE	-6.0	-2.4
	ABOVE	E-S-W	12.2	3.6
		NW-NE	-1.7	7.0
TS-LS	BELOW	E-S-W	-1.2	-2.1
		NW-NE	2.6	1.2
	ABOVE	E-S-W	-4.6	-1.6
		NW-NE	3.4	2.7

Table S7-7. Standardized deviates for snow, slope, elevation, and aspect, Kosina Creek, period 2, 1983.

SLOPE	ELEV	ASP	CSNOW ABSENT	PRESENT
0-3	BELOW	S-W	3.0	-2.6
		NW-N	1.7	1.1
	ABOVE	S-W	-2.9	-1.4
		NW-N	-3.2	-1.3
3-10	BELOW	S-W	4.2	-3.8
		NW-N	-0.8	0.7
	ABOVE	S-W	-0.7	-2.4
		NW-N	-2.9	1.4
10-30	BELOW	S-W	-3.3	-3.7
		NW-N	-2.0	4.0
	ABOVE	S-W	6.2	-2.1
		NW-N	-2.0	15.0

Table S7-2. Standardized deviates for snow, vegetation type, elevation and aspect, Kosina Creek, period 2, 1983.

VC	ELEV	ASP	CSNOW ABSENT	CSNOW PRESENT
CF-OF	BELOW	S-W	10.2	-3.8
		NW-N	-2.9	-1.7
	ABOVE	S-W	-2.8	-2.4
		NW-N	-5.4	-2.2
WF-TS	BELOW	S-W	-4.9	-3.1
		NW-N	3.6	10.7
	ABOVE	S-W	-3.5	-1.7
		NW-N	-1.0	7.9
LS	BELOW	S-W	-4.8	-3.2
		NW-N	-1.5	-1.6
	ABOVE	S-W	10.8	-1.8
		NW-N	-0.6	13.3

Table S8-1. Standardized deviates for snow, slope, elevation, and vegetation type, Clarence Creek, period 2, 1983.

SLOPE	VC	ELEV	CSNOW ABSENT	CSNOW PRESENT
0-3	OF-WF	BELOW	0.2	-1.0
		ABOVE	0.1	-1.5
	SCRUB-LS	BELOW	0.4	0.2
		ABOVE	0.5	0.9
3-10	OF-WF	BELOW	-3.3	-2.9
		ABOVE	0.6	1.6
	SCRUB-LS	BELOW	6.7	-2.7
		ABOVE	-0.9	-0.3
10-30	OF-WF	BELOW	0.2	-0.9
		ABOVE	-1.3	5.2
	SCRUB-LS	BELOW	2.2	-0.5
		ABOVE	-2.2	-1.9

APPENDIX B

1983 OVERWINTERED BERRY AVAILABILITY TABLES

Table B1-1. Standardized deviates for berries, aspect, elevation, and vegetation type, Devil Creek, period 5, 1983.

VC	ELEV	ASP	BERRIES	
			NONE	PRESENT
CF	BELOW 46	E-SE	-1.0	-0.3
		S	-0.9	-0.3
		SW	13.5	-0.3
		W	9.8	-0.3
		NW-NE	-2.2	-0.6
	ABOVE 46	E-SE	-1.4	-0.4
		S	-1.2	-0.4
		SW	-0.6	-0.4
		W	-1.2	-0.4
		NW-NE	-2.9	-0.8
OF-SCRUB	BELOW 46	E-SE	0.3	-1.0
		S	4.3	-0.9
		SW	-1.4	-1.0
		W	-3.1	-0.9
		NW-NE	-2.2	-0.2
	ABOVE 46	E-SE	2.3	-1.3
		S	3.6	-0.3
		SW	0.2	-0.6
		W	3.9	0.5
		NW-NE	-2.2	0.4
TS-LS	BELOW 46	E-SE	3.8	-1.0
		S	-2.8	-0.9
		SW	3.0	-1.0
		W	-3.1	-0.9
		NW-NE	1.0	-2.1
	ABOVE 46	E-SE	-3.5	-1.3
		S	-3.4	-1.2
		SW	-3.2	-1.3
		W	-0.5	-1.2
		NW-NE	2.8	7.7

Table B4-1. Standardized deviates for berries, elevation, vegetation type, and aspect, Watana Slide, period 5, 1983.

***** STANDARDIZED DEVIATES = (OBS - EXP)/SQRT(EXP) FOR ABOVE MODEL

VC	ELEV	ASP	BERRIES NONE	BERRIES PRESENT
OF	BLOW 765	SE	-0.1	-0.4
		S-SW	2.5	1.6
		W	0.9	-1.2
		NW-E	-0.9	0.2
	ABV 765M	SE	1.2	-1.2
		S-SW	-0.6	-0.5
		W	-3.1	-0.8
		NW-E	-1.8	0.1
WF-SCRB	BLOW 765	SE	3.1	-0.5
		S-SW	0.5	-1.8
		W	-0.1	0.5
		NW-E	-2.0	-0.6
	ABV 765M	SE	-3.5	-0.4
		S-SW	0.7	-1.3
		W	2.3	1.5
		NW-E	-0.7	1.1
LOWSHRB	BLOW 765	SE	1.3	-1.8
		S-SW	0.3	-2.0
		W	-1.2	-1.3
		NW-E	-3.2	-1.5
	ABV 765M	SE	-1.9	-0.6
		S-SW	-3.1	-1.3
		W	1.8	0.1
		NW-E	6.6	14.7

Table B5-1. Standardized deviates for berries, slope, vegetation type, and aspect, Watana Creek, period 5, 1983.

SLOPE	VC	ASP	BERRIES	
			NONE	PRESENT
0-3	OF-WF	E-W	-0.5	-1.7
		NW	-4.0	-0.4
		N	0.3	-0.7
		NE	-4.4	0.6
	SCRB	E-W	0.8	-1.0
		NW	-1.9	-0.5
		N	1.2	-1.0
		NE	2.9	-0.8
	LS	E-W	3.3	1.2
		NW	4.0	-0.7
		N	5.8	-1.3
		NE	-2.0	-1.0
3-10	OF-WF	E-W	-2.8	-0.4
		NW	4.8	-0.2
		N	1.5	-0.7
		NE	2.3	5.0
	SCRB	E-W	-3.0	-0.8
		NW	-1.7	-0.5
		N	-0.5	0.2
		NE	4.0	-0.7
	LS	E-W	0.1	-1.1
		NW	-2.2	-0.6
		N	-3.5	-1.2
		NE	-0.4	0.3
10-30	OF-WF	E-W	6.6	-0.0
		NW	0.5	1.6
		N	-1.1	0.3
		NE	-2.3	1.5
	SCRB	E-W	-2.2	-0.6
		NW	-1.3	-0.4
		N	-2.0	-0.7
		NE	2.2	11.6
	LS	E-W	-2.5	-0.8
		NW	0.2	1.7
		N	-3.1	-0.9
		NE	-1.8	0.9

ble B6-1. Standardized deviates for berries, elevation, vegetation type, and spect, Fish Creek, period 5, 1983.

***** STANDARDIZED DEVIATES = (OBS - EXP)/SQRT(EXP) FOR ABOVE MODEL

VC	ELEV	ASP	BERRIES NONE	BERRIES PRESENT
DF	BLW 765M	E-S	0.3	-0.0
		SW	1.3	0.7
		W-NE	3.6	-1.1
	ABV 765M	E-S	2.6	3.7
		SW	-4.0	-1.4
		W-NE	-5.2	-1.8
WF-SCRB	BLW 765M	E-S	-5.5	-1.1
		SW	0.7	0.3
		W-NE	-0.8	-1.8
	ABV 765M	E-S	3.6	6.3
		SW	7.0	6.0
		W-NE	-4.5	-1.4
LOWSHRB	BLW 765M	E-S	-1.3	-1.5
		SW	-1.1	-1.4
		W-NE	1.5	-1.6
	ABV 765M	E-S	-2.6	-0.3
		SW	-4.0	-1.1
		W-NE	8.4	0.3

Table B7-1. Standardized deviates for berries, elevation, vegetation type, and aspect, Kosina Creek, period 5, 1983.

ELEV	ASP	VC	BERRIES NONE	BERRIES PRESENT
BLW 675M	E-SW	CF-OF	4.6	2.8
		WF-SCRB	-0.6	1.0
		LOWSHRB	-6.3	-2.2
	W-N	CF-OF	-0.3	-1.2
		WF-SCRB	3.8	1.8
		LOWSHRB	-1.8	-2.1
ABV 675M	E-SW	CF-OF	-2.7	-1.4
		WF-SCRB	-3.4	-0.4
		LOWSHRB	8.9	0.4
	W-N	CF-OF	-5.3	-1.4
		WF-SCRB	-3.0	-1.2
		LOWSHRB	6.7	4.0

Table B8-1. Standardized deviates for berries, elevation, vegetation type, and slope, Clarence Creek, period 5, 1983.

SLOPE	VC	ELEV	BERRIES NONE	BERRIES PRESENT	
0-3	OF	BLOW 765	0.5	-0.5	
		ABV 765M	4.8	5.8	
	WF-SCRB	BLOW 765	-0.2	-0.9	
		ABV 765M	-1.5	0.8	
	LOWSHRB	BLOW 765	-1.4	-0.7	
		ABV 765M	-1.7	-0.8	
3-10	OF	BLOW 765	-1.8	-1.0	
		ABV 765M	2.0	0.5	
	WF-SCRB	BLOW 765	-1.6	-0.6	
		ABV 765M	-1.1	-1.5	
	LOWSHRB	BLOW 765	7.7	-1.3	
		ABV 765M	-1.9	-0.8	
10-30	OF	BLOW 765	-2.5	-0.9	
		ABV 765M	-0.7	-0.1	
	WF-SCRB	BLOW 765	3.1	3.6	
		ABV 765M	0.4	-1.2	
	LOWSHRB	BLOW 765	-3.1	-1.1	
		ABV 765M	0.1	1.0	
GR30	OF	BLOW 765	-1.8	-0.6	
		ABV 765M	-0.5	0.6	
	WF-SCRB	BLOW 765	0.6	-0.2	
		ABV 765M	0.7	0.3	
	LOWSHRB	BLOW 765	-2.3	-0.8	
		ABV 765M	1.0	3.4	

LOWSHRB	BLOW 765	0	0 I	0
	ABV 765M	11	5 I	16
	TOTAL	11	5 I	16

APPENDIX H

1983 HORSETAIL AVAILABILITY TABLES

Table H1-1. Standardized deviates for equisetum, aspect, elevation, and vegetation type, Devil Creek, period 5, 1983.

VC	ELEV	ASP	HEQSTM NONE	HEQSTM PRESENT
CF	BELOW 46	E-SE	-1.1	-0.2
		S	-0.9	-0.2
		SW	12.3	4.1
		W	9.6	-0.2
		NW-NE	-2.2	-0.5
	ABOVE 46	E-SE	-1.4	-0.3
		S	-1.3	-0.3
		SW	-1.4	2.9
		W	-1.3	-0.3
		NW-NE	-3.0	-0.7
OF-SCRUB	BELOW 46	E-SE	0.2	-0.8
		S	4.1	-0.7
		SW	-1.8	0.5
		W	-3.2	-0.7
		NW-NE	-2.7	2.0
	ABOVE 46	E-SE	1.3	2.8
		S	3.5	0.2
		SW	0.3	-1.0
		W	3.5	2.3
		NW-NE	-2.3	1.0
TS-LS	BELOW 46	E-SE	3.6	-0.8
		S	-2.8	-0.7
		SW	2.5	0.5
		W	-3.1	-0.7
		NW-NE	0.8	-1.6
	ABOVE 46	E-SE	-3.6	-1.0
		S	-3.5	-0.9
		SW	-3.3	-1.0
		W	-0.6	-0.9
		NW-NE	5.1	-0.8

Table H2-1. Standardized deviates for equisetum,slope,vegetation type, and elevation,Tsusena Creek, period 5, 1983.

SLOPE	VC	ELEV	HEQSTM	
			NONE	PRESENT
0-3	OF	BLW 465M	2.7	1.5
		ABV 465M	-6.8	-2.6
	WF-SCRB	BLW 465M	5.7	0.5
		ABV 465M	-1.2	-1.1
	LOWSHRB	BLW 465M	3.2	-1.4
		ABV 465M	2.2	-1.3
3-10	OF	BLW 465M	-2.1	3.4
		ABV 465M	0.2	5.9
	WF-SCRB	BLW 465M	-1.8	-0.7
		ABV 465M	0.1	-0.6
	LOWSHRB	BLW 465M	-2.1	-0.8
		ABV 465M	1.7	-0.7
10-30	OF	BLW 465M	-5.0	-1.9
		ABV 465M	10.8	0.5
	WF-SCRB	BLW 465M	-2.1	-0.8
		ABV 465M	-2.0	-0.8
	LOWSHRB	BLW 465M	-2.5	-0.9
		ABV 465M	-2.3	-0.9

Table H3-1. Standardized deviates for equisetum, aspect, vegetation type, and slope, Fog Creek, period 5, 1983.

VC	SLOPE	ASP	HEQSTM NONE	HEQSTM PRESENT
CF-OF	0-3	SOUTH	-1.5	-0.8
		NORTH	3.3	6.8
	3-10	SOUTH	-2.1	-0.8
		NORTH	-1.5	-0.9
	10-30	SOUTH	-1.4	-0.3
		NORTH	1.8	-0.4
WF-SCRB	0-3	SOUTH	-4.9	-1.3
		NORTH	5.4	5.5
	3-10	SOUTH	1.2	-0.6
		NORTH	-1.7	-1.6
	10-30	SOUTH	-1.7	-0.5
		NORTH	-1.3	-0.6
LOWSHRB	0-3	SOUTH	2.0	-1.3
		NORTH	-5.4	-1.5
	3-10	SOUTH	6.9	-0.5
		NORTH	-2.2	-0.9
	10-30	SOUTH	-2.4	-0.5
		NORTH	4.9	-0.6

able H4-1. Standardized deviates for equisetum,elevation,vegetation type, and spect,Watana Slide, period 5, 1983.

			NONE	PRESENT
OF	BLOW 765	SE	0.6	-1.3
		S-SW	2.4	1.4
		W	0.7	-0.1
		NW-E	0.4	-2.2
	ABV 765M	SE	1.1	-0.2
		S-SW	-1.8	1.5
		W	-2.7	-1.7
		NW-E	-1.2	-1.3
WF-SBRB	BLOW 765	SE	1.9	2.3
		S-SW	0.2	-0.4
		W	1.4	-2.3
		NW-E	-1.1	-2.2
	ABV 765M	SE	-3.1	-1.5
		S-SW	-0.7	1.8
		W	4.1	-1.7
		NW-E	0.7	-1.9
LOWSHRB	BLOW 765	SE	-2.4	5.4
		S-SW	-1.6	2.1
		W	-3.3	2.6
		NW-E	-3.9	-0.1
	ABV 765M	SE	-0.8	-2.6
		S-SW	-1.6	-2.4
		W	3.2	-1.8
		NW-E	11.8	0.3

Table H5-1. Standardized deviates for equisetum, slope, vegetation type, and aspect, Watana Creek, period 5, 1983.

SLOPE	VC	ASP	HEQSTM NONE	HEQSTM PRESENT
0-3	OF-WF	E-W	-3.3	5.4
		NW	-3.5	-1.8
		N	0.0	0.0
		NE	-3.9	-1.3
	SCRB	E-W	1.1	-1.4
		NW	-1.8	-0.8
		N	1.2	-0.8
		NE	3.3	-1.1
	LS	E-W	4.0	-0.6
		NW	3.2	2.0
		N	3.4	5.4
		NE	-1.8	-1.4
3-10	OF-WF	E-W	-2.8	-0.6
		NW	4.0	2.2
		N	1.4	-0.1
		NE	4.8	-2.2
	SCRB	E-W	-2.9	-1.2
		NW	-1.6	-0.7
		N	0.1	-1.3
		NE	4.4	-1.0
	LS	E-W	0.4	-1.5
		NW	-2.1	-0.9
		N	-3.3	-1.7
		NE	0.2	-1.2
10-30	OF-WF	E-W	3.7	7.6
		NW	1.5	-1.2
		N	-0.1	-2.3
		NE	-1.3	-1.6
	SCRB	E-W	-2.1	-0.9
		NW	-1.2	-0.5
		N	-1.9	-1.0
		NE	6.0	-0.7
	LS	E-W	-2.4	-1.1
		NW	1.0	-0.7
		N	-3.0	-1.3
		NE	-1.2	-0.9

Table H6-1. Standardized deviates for equisetum,elevation,vegetation type, and aspect,Fish Creek, period 5, 1983.

VC	ELEV	ASP	HEQSTM NONE	HEQSTM PRESENT
OF	BLW 765M	E-S	0.1	0.6
		SW	1.2	1.0
		W-NE	2.5	2.7
	ABV 765M	E-S	3.4	0.9
		SW	-3.8	-2.1
		W-NE	-5.0	-2.4
WF-SCRB	BLW 765M	E-S	-5.2	-1.8
		SW	1.1	-1.1
		W-NE	-1.0	-1.0
	ABV 765M	E-S	.5.9	-1.4
		SW	9.2	-1.3
		W-NE	-4.5	-1.5
LOWSHRB	BLW 765M	E-S	-1.2	-1.6
		SW	-1.8	1.1
		W-NE	-1.5	8.3
	ABV 765M	E-S	-2.3	-1.3
		SW	-3.9	-1.2
		W-NE	9.0	-1.4

Taple H7-1. Standardized deviates for equisetum,elevation,vegetation type, and aspect,Kosina Creek, period 5, 1983.

ELEV	ASP	VC	HEQSTM	
			NONE	PRESENT
BLW 675M	E-SW	CF-OF	2.4	7.8
		WF-SCRB	-0.3	-0.2
		LOWSHRB	-8.3	2.7
	W-N	CF-OF	0.6	-3.1
		WF-SCRB	5.3	-2.1
		LOWSHRB	-1.3	-2.8
ABV 675M	E-SW	CF-OF	-3.1	-0.3
		WF-SCRB	-2.9	-1.8
		LOWSHRB	9.0	0.8
	W-N	CF-OF	-5.1	-2.0
		WF-SCRB	-2.7	-1.7
		LOWSHRB	8.5	-1.2

able H8-1. Standardized deviates for equisetum, elevation, vegetation type, and lope, Clarence Creek, period 5, 1983.

SLOPE	VC	ELEV	HEQSTM NONE	HEQSTM PRESENT
0-3	OF	BLOW 765	-0.2	1.6
		ABV 765M	5.8	3.2
	WF-SCRB	BLOW 765	-0.7	0.4
		ABV 765M	-1.2	0.2
	LOWSHRB	BLOW 765	-1.4	-0.6
		ABV 765M	-1.7	-0.7
3-10	OF	BLOW 765	-2.2	0.2
		ABV 765M	2.5	-1.0
	WF-SCRB	BLOW 765	-1.3	-1.5
		ABV 765M	-1.5	-0.6
	LOWSHRB	BLOW 765	7.2	-0.3
		ABV 765M	-2.2	0.2
10-30	OF	BLOW 765	-2.5	-0.8
		ABV 765M	-1.1	1.3
	WF-SCRB	BLOW 765	4.5	-0.6
		ABV 765M	-0.8	2.4
	LOWSHRB	BLOW 765	-3.2	-1.0
		ABV 765M	-0.6	3.3
GR30	OF	BLOW 765	-1.8	-0.6
		ABV 765M	-0.1	-0.6
	WF-SCRB	BLOW 765	0.8	-1.0
		ABV 765M	1.1	-1.1
	LOWSHRB	BLOW 765	-2.3	-0.7
		ABV 765M	2.4	-0.8

Table H9-1. Standardized deviates for equisetum, aspect, vegetation type, and elevation, Switchbacks, period 5, 1983.

VC	ELEV	ASP	HEQSTM NONE	HEQSTM PRESENT
CF-OF	BELOW675	S-SW	-2.7	3.0
		NW-E	4.0	3.0
	ABOVE675	S-SW	0.9	0.5
		NW-E	-3.3	-1.5
WF-SCRB	BELOW675	S-SW	-3.3	-1.1
		NW-E	3.6	5.5
	ABOVE675	S-SW	1.6	-0.2
		NW-E	-3.0	0.5
LOWSHRB	BELOW675	S-SW	0.1	-3.5
		NW-E	0.4	-2.3
	ABOVE675	S-SW	2.3	-1.1
		NW-E	-1.4	2.1