THE ECOLOGY AND SUCCESSIONAL TRENDS OF TUNDRA PLANT COMMUNITIES IN THE LOW ARCTIC SUBALPINE ZONE OF THE RICHARDSON AND BRITISH MOUNTAINS OF THE CANADIAN WESTERN ARCTIC.

by

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ABSTRACT

Prior to 1963 no previous vegetation studies had been undertaken in this region of the Low Arctic Subalpine/Foothill Zone of the Canadian Western Arctic, although several studies had been completed in similar regions in Arctic Alaska. This study was initiated in 1965 to obtain quantitative and qualitative data on vegetation and environmental relationships, including soil data for characterization of Low Arctic Subalpine/Foothill Zone soils. With these basic data it was considered possible to analyze, integrate and interpret community and soil relationships and to propose a usable classification system for the recognizable ecosystematic units in this portion of the zone.

Initial criteria for selecting communities were based on uniformity and discreteness. Vegetation in each community was studied by the single plot method employing phytosociological techniques of the Zürich - Montpellier School as modified by Krajina (1933). Data on environmental conditions collected for each of 166 communities included degree of slope, profile, pattern of topography, exposure, altitude and wind influence.

Coefficients of similarity between communities were computed using the formula $\frac{2W}{A + B} \times 100$, where A is the sum of all measures (abundance and presence) for one community, B is the sum of all measures for another community, and W is the sum of the lower values for each species which the two communities have in common. To determine the degree of affinity and relative hiatus points between groups of communities cluster analysis using the weighted pair - group method was employed. A two-dimensional dendrogram illustrated the individual plots and succeeding clusters.

One soil pit was dug in every analyzed plot to either permafrost, water table, coarse ice shattered parent material or bedrock. A total of 498 soil samples for laboratory analysis were collected from all recognizable horizons. Chemical analyses were undertaken to determine organic matter content, total nitrogen,

carbon/nitrogen ratio, absorbed phosphorus, exchangeable calcium, magnesium, potassium and sodium, cation exchange capacity pH. Because soil profiles showed considerable variation the results of the chemical analyses were averaged for the organic, organic - mineral and mineral horizons.

On the basis of similarity of species composition six orders, eight alliances, fourteen associations, ten subassociations and thirteen variations were distinguished. The order Betuletalia glandulosae dominated the two study areas, occurring on moderately to well drained mesic to xeric slopes. Community development within this order appeared stable under the present topographic and climatic conditions. The Vaccinio - Betuletum glandulosae closely approximated the climatic climax in mesic habitats. Successional concepts on upper slopes appeared of limited value because communities tended to be discrete. Communities dominant on the lower slopes and in the wetlands were characterized by a narrow active, poor to impeded drainage conditions and more intensive frost action. Classification was more difficult in such areas because communities appeared to be less stable. Successional development in such areas with permanent seepage was toward the Betulo - Eriphoretum vaginati. Snow bed habitats were characterized by the order Petasitetalia frigidii, which was distinguished for the first time in North America, and included the previously undescribed Salicetum chamissonis. Sharp environmental gradients between chionophilous and chionophobous communities suggested that the climate had undergone no significant change in the recent past. Similarities between the Low Arctic Subalpine/Foothill Zone communities and those in other arctic regions, especially Scandinavia, were shown to occur.

Twelve soil types were distinguished. In all but two cases each soil type was associated with a particular plant association. A form of podzolization previously described in Arctic Alaska was recognized in the Arctic Brown soils. Gleization, however, appeared to be the major soil forming process in this region of the zone. It was associated with both chionophobous and chionophilous

vegetation. In the former, it was favoured by poor drainage, a shallow active layer and intensive frost action; in the latter, it appeared related to materials deposited on the snow that were later incorporated into the soil following snow melt. The high organic content and cation exchange capacity and the low acidity and base saturation were concluded to be important chemical characteristics of these soils.

Final results using classification methods showed that the present position of the communities in this region of the Low Arctic Subalpine/Foothill Zone were related to elevation, exposure, soil moisture, thickness of the active layer, duration of snow cover, congeliturbation and topography.

Table of Contents

Pages

Abstract ... ii

Table of Contents ... v

List of Tables ... viii

List of Figures ... x

Acknowledgment ... xii

1 Introduction ... 1

2 Description of the Area ... 4
Environment ... 4
Topography ... 4
Geology ... 8
Climate ... 9
Soils ... 15
Permafrost - The effects on vegetation and soil ... 22

3 Microclimate Analysis and Synthesis ... 27

4 Vegetation ... 33
Methods of analysis ... 33
Problems in vegetation synthesis ... 34
Vegetation synthesis - Cluster analysis ... 36
Results of cluster analysis ... 39

5 Description of Vegetation Units ... 41
Chionophobous (Terrestrial) plant communities ... 41
Salicetum phlebophyllae ... 41
Lupino - Dryadetum *alaskensis ... 44
lupino - dryadetosum *alaskensis (depauperatum) ... 44
dryado - salicetosum reticulatae - glaucae ... 46
Betulo - Ledetum decumbentis ... 49
betulo - ledetosum decumbentis ... 50
casslopeetosum tetragonae ... 52
Vaccinio - Betuletum glandulosae ... 55
vaccinio - betuletosum glandulosae (fruticulosum) ... 56
vaccinio - betuletosum glandulosae (fruticosum) ... 58
Betulo - Chamaemoretum ... 61
betulo - chamaemoretosum ... 61
alnetosum crispae ... 62
Betulo - Eriophoretum vaginati ... 63
eriophoretosum vaginati ... 64
salicetosum reticulatae ... 67

Aquatic plant communities ... 69
Arctophiletum fulvae ... 69

Semi-Terrestrial plant communities ... 71
Eriophoretum angustifolii ... 72
eriophoretosum angustifolii ... 72
salicetosum pulchrae ... 73

Caricetum aquatilis.. 75
caricosum aquatilis.. 75
salicosum arbutifoliae.. 76
Eriophoretum scheuchzeri.. 77
Caricetum rariflorae.. 78
Chionophilous plant communities.. 79
Salicetum pseudopolaris.. 80
Salicetum chamissonis.. 81
salicosum chamissonis.. 82
equisetosum arvensis.. 84
festucosum altaicae.. 85
caricosum montanensis.. 85
arctagrostidosum latifoliae.. 86
salicosum pulchrae.. 86
Salicetum pulchrae.. 87
salicosum pulchrae.. 87
betulosum glandulosae.. 90
salicosum richardsonii.. 91

7 Classification and Description of the Soils..100
Sub-Aquatic Soils..101
Sub-Aquatic not peat forming..101
Oligotrophic Gyttja..101
Sub-Aquatic peat forming..101
Carex Fen..102
Low-Centered Polygon Mire..103
Brown Moss..103
Peat Moss..104
Semi-Terrestrial (Groundwater) Soils..105
Semi-Terrestrial Raw Soils..105
Snow Basin Rutmark..105
Anmoor-like Soils..106
Snow Basin Anmoor..106
Tundra Anmoor..108
Semi-Terrestrial Peat Soils..109
Tundra Moss..109
Peat Anmoor..112
Terrestrial Land Soils..113
Terrestrial Raw Soils..113
Arctic Rawmark..114
Ranker-like Soils..115
Tundra Ranker..115
Rendzina Soils..116
Arctic Brown shallow phase..116
Brown Earths..117
Arctic Brown normal phase..118
Soil-Vegetation Relationships..121

8 Description of Higher Units of Classification..123

9 Tundra Mudflows..127

10 Vegetation, Environmental and Successional Relationships..129

11 Summary and Conclusions..150

12 Bibliography..156

Appendix I Annoted Species list

Appendix II Average daily climatic data for all nine weather stations

Appendix III Explanatory notes for vegetation and environment synthesis tables

LIST OF TABLES

Table 1: Summary of average temperatures and relative humidity data for microclimatic stations at Canoe Lake, July and August 1966.

2(a): Summary of vegetation data for Salicetum phlebophyllae.
(b): Summary of environmental data for Salicetum phlebophyllae.

3(a): Summary of vegetation data for Lupino - Dryadetum *alaskensis.
(b): Summary of environmental data for Lupino - Dryadetum *alaskensis

4(a): Summary of vegetation data for Betulo - Ledetum decumbentis.
(b): Summary of environmental data for Betulo - Ledetum decumbentis.

5(a): Summary of vegetation data for Vaccinio - Betuletum glandulosae.
(b): Summary of environmental data for Vaccinio - Betuletum glandulosae.

6(a): Summary of vegetation data for Betulo - Chamaemoretum
(b): Summary of environmental data for Betulo - Chamaemoretum

7(a): Summary of vegetation data for Betulo - Eriophoretum vaginati
(b): Summary of environmental data for Betulo - Eriophoretum vaginati.

8(a): Summary of vegetation data for Arctophiletum fulvae.
(b): Summary of environmental data for Arctophiletum fulvae.

9(a): Summary of vegetation data for Eriophoretum angustifolii.
(b): Summary of environmental data for Eriophoretum angustifolii.

10(a): Summary of vegetation data for Caricetum aquatilis.
(b): Summary of environmental data for Caricetum aquatilis.

11(a): Summary of vegetation data for Eriophoretum scheuchzeri.
(b): Summary of environmental data for Eriophoretum scheuchzeri.

12(a): Summary of vegetation data for Caricetum rariflorae.
(b): Summary of environmental data for Caricetum rariflorae.

13(a): Summary of vegetation data for Salicetum pseudopolaris.
(b): Summary of environmental data for Salicetum pseudopolaris.

14(a): Summary of vegetation data for Salicetum chamissonis.
(b): Summary of environmental data for Salicetum chamissonis.

15(a): Summary of vegetation data for Salicetum pulchrae.
(b): Summary of environmental data for Salicetum pulchrae.

16: Summary of soil chemical analyses of the organic, organic-mineral and mineral horizons.

17: Provisional soil classification for the Low Arctic Subalpine/ Foothill Zone.

LIST OF TABLES (CONTINUED)

18: Classification of plant communities of the Low Arctic Subalpine/ Foothill Zone on the basis of characteristic species combinations.

19: Classification of plant communities of the Low Arctic Subalpine/ Foothill Zone (variation, subassociation and association).

20: Classification of plant communities of the Low Arctic Subalpine/ Foothill Zone (association, alliance and order).

LIST OF FIGURES

Figure 1: The major physiographic zones of the Arctic Slope of Alaska, Yukon Territory and Northwest Territories.

2: General view of the Canoe Lake area looking northwest.

3: General view of the Trout Lake area looking north.

4(a): Stratigraphic cross-section of the area bordering Canoe Lake (E-W).

4(b): Stratigraphic cross-section of the area bordering Trout Lake (N-S).

5: Climatic data for the Arctic Slope. Average monthly temperatures plotted and precipitation at Barrow, Alaska, Umiat, Shingle Point, Yukon and Inuvik, Northwest Territories.

6: Late snow bed habitat, Canoe Lake.

7: Location of nine weather stations established in the Canoe Lake area and operational during July and August, 1966.

8: Weather station No. 4 in a Cassiope tetragona dominated sites, Canoe Lake 1966.

9: Dendrogram of plot similarities indicating major associations and subassociations.

10: Salix phlebophylla dominated depression on exposed ridge, west side of Canoe Lake, showing evidence of frost heaving.

11: Exposed ridge south of Trout Lake dominated by Dryas octopetala and Salix phlebophylla.

12: Southwest facing upper slope, Canoe Lake, dominated by Dryas octopetala and Lupinus arcticus.

13: Betula glandulosa and Ledum decumbens dominated slope, Canoe Lake, with evidence of frost heaving and downslope movement of surface materials.

14: Slightly chionophilous depression habitat on east facing slope, Canoe Lake, dominated by Cassiope tetragona.

15: East facing dip slope east of Canoe Lake dominated by prostrate Betula glandulosa and Vaccinium uliginosum with Carex lugens on raised mounds.

16: Depression habitat on lower east facing slope, Canoe Lake, dominated by shrub (B_2) Betula glandulosa and Vaccinium uliginosum.

17: Eriophorum vaginatum tussocks with Sphagnum lenense dominating in the wet depressions, present on lower slopes.

18: Northwest facing upper slope dominated by Eriophorum vaginatum and bordered by exposed Dryas octopetala dominated slope.

Figure 19: Lake shore vegetation, Canoe Lake. The emergent aquatic *Arctophila fulva* bordered by *Eriophorum scheuchzeri*.

20: Drainage pathway on lower slope, Canoe Lake, dominated by *Eriophorum angustifolium*.

21: Sedge meadow in virtually obliterated aquatic habitat, Trout Lake, dominated by *Carex aquatilis*.

22: Very late snow bed habitat, Canoe Lake, dominated by *Salix pseudopolaris*.

23: Amphitheatre, Canoe Lake, with snow still present in early August.

24: Late snow bed habitat dominated by *Salix chamissonis* with *Sibbaldia* procumbens and *Arnica lessingii*.

25: Slightly chionophilous Salicetum pulchrae indicating dense C layer.

26: Snow Basin Rutmark soil associated with Salicetum pseudopolaris.

27: Snow Basin Anmoor soil associated with Salicetum chamissonis.

28: Tundra Moss soil associated with Betulo - Chamaemoretum.

29: Arctic Brown normal phase soil associated with Vaccinio - Betuletum glandulosae (fruticulosum).

30: Massive tundra mudflow scar on slope south of Canoe Lake.

31: Isolated islands of vegetation just below tundra mudflow scar.

32: Early stages of revegetation on tundra mudflow.

33: Terminal area of tundra mudflow.

34: Distribution of plant communities on east facing slope, Canoe Lake, indicating approximate permafrost level and snow depth.

35: Distribution of semi-terrestrial communities in area of impeded drainage indicating approximate permafrost depth and snow depth.

36: Distribution of chionophilous and slightly chionophilous communities indicating approximate permafrost depth and snow depth.

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INTRODUCTION

The arctic tundra occupies a considerable portion of Canada's continental land mass north of the tree line. Relatively few synecological studies have been undertaken in this vast region and not one in the low arctic subalpine or alpine zones in the northwestern regions of the Northwest Territories and Yukon Territory. Many botanists, scientific personnel and other visitors to the north have collected plants extensively so that our knowledge of arctic floristics is considerable. The vegetation is affected by severe environments that have, over a prolonged period of time, selected a relatively small flora tolerant of these extreme conditions. Temperature is an important limiting factor, having a profound effect on metabolic processes as they relate to plant growth and development. Furthermore, the low summer temperatures result in intensive frost action or congeliturbation in the thin active layer or upper soil horizons. Propagation is retarded and restricted primarily to vegetative reproduction.

The arctic flora in general is circumpolar. Several species, however, have developed geographical subspecies or races, while the majority have broad ranges of amplitude. Most arctic botanists and phytogeographers consider the arctic flora to be very old (Hulten, 1937, Porsild, 1951, and Love, 1962). During successive ice advances in the Pleistocene the arctic flora is considered to have persisted in unglaciated refugia. Each interglacial period appears to have been of sufficient duration to allow a complete redistribution of the flora. Porsild (1951) divided arctic North America into four distinct phytogeographical regions. They are: 1) Arctic parts of Alaska and Yukon; 2) Arctic parts of continental Northwest Terrirories and Ungava; 3) Arctic Archipelago; 4) Greenland. The arctic Alaska and Yukon region possesses the most varied flora (over 600 species). This region is largely unglaciated and rich in endemic and disjunct species. In western arctic North America little attention has been given to vegetation and environmental relationships. However, these relationships have been discussed in general terms as they relate to arctic tundra (Benninghoff, 1952, 1963 and Britton, 1957) and arctic and alpine tundras (Churchill and Hanson, 1958, and Bliss, 1962). With the exception of quantitative studies by Hanson (1953) in northwestern Alaska, Churchill (1955) in the Umiat region of Alaska and Spetzman (1959) on the arctic slope of Alaska, little attention has been paid to this unique area. A comparison has been made by Bliss (1962) of plant development in microenvironment on the northern arctic slope of Alaska and the Mount Washington (alpine) tundra. Elsewhere, the literature includes only phytogeographical notes in relation to local flora with no ecological information.

Information on soils has been gathered extensively over the past seventeen years in northern Alaska. This work has been carried out by Tedrow and his students (1955-62) from Rutger's University, New Jersey. Climatic data have increased with the opening of the Distant Early Warning (D.E.W.) line stations along the arctic coast. Microclimatic data are limited, the major study being by Conover (1960) on the macro- and microclimatology of the arctic slope of Alaska. With the exception of comparative climatic data from the D.E.W. line stations along the coast no other environmental information is available for the unglaciated low arctic subalpine and alpine regions of the northern Yukon and adjacent Northwest Territories west of the Mackenzie Delta.

Prior to 1963 when Krajina and colleagues analyzed several communities from the Richardson Mountains in the vicinity of Canoe Lake no previous quantitative or qualitative studies had been undertaken in this region. This study was initiated in 1965 to obtain detailed information on vegetation and environmental relationships as they pertained to this low arctic Subalpine/Foothill Zone. Suitable areas for study were numerous, however; their accessibility was limited by the lack of lakes. Only two were large enough to accommodate aircraft, they were Canoe Lake, Richardson Mountains, NWT, and Trout Lake, British Mountains, Yukon.

The field season in 1965 extended from early June to late August. Only three weeks during July were spent at Trout Lake, the remainder of the time being spent at Canoe Lake. In 1966, between late June and late August, investigations were carried out only in the Canoe Lake area.

The principal objectives were to obtain quantitative and qualitative data for a description of the identifiable vegetation units. At the same time, similar type data were obtained for characterization of the soils. With these basic data it is possible to analyze, integrate and interpret community and soil relationships and to propose a classification for the recognizable ecosystematic units in this region of the Subalpine/Foothill Zone.

This dissertation follows the coenotic approach in classification in which associations are abstracted from large samples by grouping individual communities together on the basis of similarity. It is believed that the present study contributes new information concerning low arctic subalpine plant communities and their environmental relationships as well as presenting original data on previously undescribed low arctic subalpine chionophilous meadows.

AREA DESCRIPTION

Environment

The Arctic Slope of western North America extends from the crests of the Brooks, British, and Richardson Mountains northward to the Arctic Ocean and from just west of the Mackenzie Delta to Cape Lisburne, Alaska. It extends more than 750 miles east-west and from 150-200 miles north-south.

The Arctic Slope (Figure 1) is divided into three physiographic regions (Payne and others, 1951 and Bostock, 1961): the coastal plain, the foothills or Arctic Plateau (Subalpine) and the northern slopes of the mountains (Alpine). Each region differs in topography, geology, climate, soil and vegetation.

The Subalpine/Foothill Zone in northern Canada is 10-110 miles in width, being narrow in front of the British and Richardson Mountains and extending inland between these two ranges toward the Old Crow Plain in central northern Yukon for a considerable distance. The Subalpine and Alpine Zones have been above sea level since Early Cretaceous and are considered to have been largely free of glacial ice. The topography is variable consisting of well to moderately drained slopes as well as poorly drained wetlands. Permafrost is continuous except under the few larger, deeper lakes. Many large rivers transect the mountain ranges while the local topography is dissected by a myriad of drainage pathways.

Topography

The terrain in the Canoe Lake area is very irregular. The range in elevation is from 1050-2400 ft. Two major cuestas dominate the area, one on each side of the lake. The lake, three miles long and half a mile wide, lies in a shale basin formed by the erosion of the shale. The cuestas are asymmetrical and have a north-south strike with scarps facing due west. The backslope of the eastern cuesta is low and continuous, dropping from 1500 ft to 800 ft in approximately two and a half miles. The scarp face drops 500 ft to lake level in less than a quarter of a mile. On the east facing slope (scarp face) of the

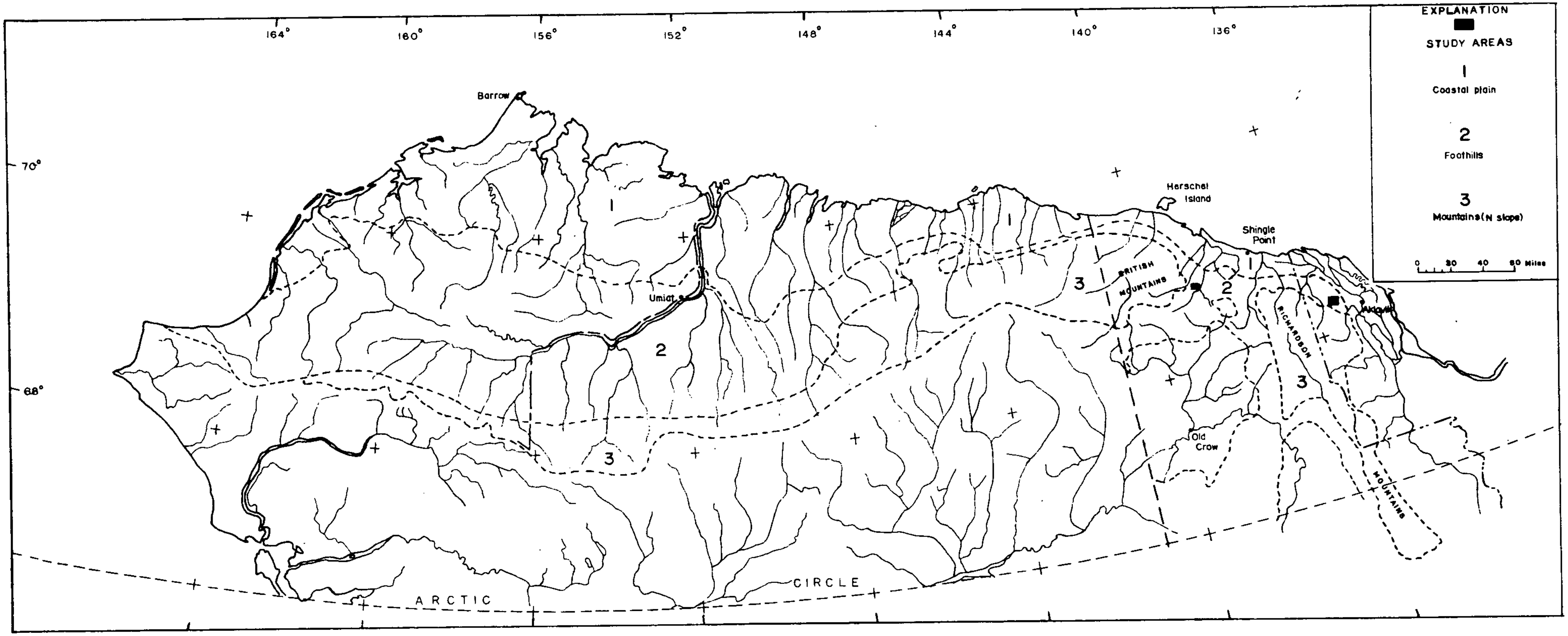

Figure 1. The major physiographical zones of the Arctic Slope of Alaska, Yukon Territory and Northwest Territories (Payne and others, 1951 and Bostock, 1961).

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western cuesta felsenmeer[1] is exposed for about two and a half miles at 1500 ft and only three quarters of a mile from the lake. (Figure 2) Above the felsenmeer the slope rises to 2100 ft, where exposed bedrock is dominant. This cuesta beginning just south of the lake extends northward for approximately five miles. Opposite the south end of the lake on the western cuesta at 1500 ft is a prominent amphitheatre or draw with an easterly exposure. Snow persists here for over eleven months of the year.

Figure 2. North end of Canoe Lake (1050 ft) looking northwest and rising to 2100 ft. The exposed parent rock and felsenmeer is at approximately 1500 ft. Dark green areas on east facing slope indicate shrub communities, on west facing slope indicate drainage pathways with prostrate shrub species. (Photo by Krajina).

On both slopes of the cuestas the general topography is hummocky and remains moist throughout the summer. On the scarp faces the increased slope results in better drainage and the terrain is less hummocky. Sheltered sites

1. Exposed frost broken loose rock

among the felsenmeer support a thick carpet of vegetation.

The major drainage channel south of the lake is a creek into which the surrounding slopes drain. The creek cuts through the eastern cuesta and drains due east into the Mackenzie Delta just west of Aklavik. A short cuesta due south of the creek rises to 1900 ft and has a rim plateau of ice-shattered blocks. Between this cuesta and the western cuesta are three raised rim plateaus that are separated by drainage pathways - probably erosional.

The lowland between the south end of the lake and the creek is very wet, a result of poor drainage derived from a general accumulation of organic matter. In this area is what appears to be a closed system pingo. Low-centered polygons predominate around the pingo, with numerous drainage pathways encircling them. Canoe Lake is drained by a small creek at its north end. The outflow is very slow and the surrounding vegetation is continually encroaching.

Tundra mudflows are common in the area. Previous mudflows in different stages of revegetation are evident all around the lake and on several steep slopes bordering the creek south of it. These movements are a result of surface heaving during the autumn in which the vegetation mat is separated from the mineral soil. The following spring during the thaw the saturated soil flows downslope leaving islands of vegetation scattered throughout the mudflow.

The terrain around Trout Lake is more regular than that around Canoe Lake, however, at no time does it approach the gently rolling condition prevalent on the Coastal Plain. The area immediately east of Trout Lake is bordered by the Babbage River. To the west and north Philip Creek forms a natural boundary. Both water courses drain northward and have cut deeply into the bedrock so that terraces and escarpments are conspicuous features.

The range in elevation in the study area is from 500 ft to 1600 ft. The dominant feature is a very low dip, Trout Lake is in the middle, surrounded by a myriad of drainage pathways. The tilted bed, itself, is very low and in all probability is not a true strike but an escarpment. South of Trout Lake (at 600-700 ft) are tilted beds that dip to the north. The beds at the eastern end are low with low scarps while at the western end the scarps are higher and the slopes more pronounced. South of these low exposed beds is a prominent cuesta rising to 1600 ft. Drainage on the dip of this cuesta runs east-west, while on the low beds to the north the drainage is to the north. (Figure 3).

Figure 3. Trout Lake (600 ft) looking north. Babbage River in the background. Light green areas in foreground are drainage pathways. Exposed E-W strikes may be recognized by lack of vegetation. (Photo by Lambert).

The regularity of the topography is related to the homogeneity of the bedrock. Several cutcrops of black shale are exposed along the west bank of the Babbage River and at the south end of Trout Lake. The lake, itself, probably lies on a shale bed. Drainage from the scarp of the south cuesta results in an almost continual run of water during the summer. On the lower reaches of the scarp are what appear to be deposits from erosional runoff.

The more elevated regions are dry with only a sparse cover of vegetation. The low east-west beds just to the north are well drained and the depressions between them, where snow accumulates, drain relatively early in the summer. West of Trout Lake, below the escarpment, is an extensive lowland where low-centered polygons predominate. The meandering stream that drains Trout Lake passes through this area and drains into Philip Creek. The terrace face on the west bank of the Babbage River has a slope of over 65° and is unvegetated in many areas.

Several lakes in the area are drying up and so provide valuable sites for tracing successional trends.

Topographically, the two study areas are dissimilar, however, environmental conditions appear to be similar. The majority of the plant community types are common to both areas and, therefore, criteria for considering them as both part of the Foothills region.

Geology[1]

Two cuestas, one on each side of Canoe Lake, with a north-south strike and an east dip dominate the immediate area. (Figure 4a). They consist of two sandstone beds with a thick shale interval separating them. The western cuesta, exposed at 2050 ft, is Upper Jurassic, while the eastern cuesta, at 1500 ft, is Lower Cretaceous. On the lower reaches of the scarp of the western cuesta is exposed Permian rock. The vegetation was not studied at this level.

The sandstones are clean, quartzose, fine to medium grained and medium bedded. The shales form the dip slopes of both cuestas. The shales are black, soft, carbonaceous and rich in organic material. The vegetation in the area is generally confined to areas underlain by shale, the tops of the ridges where the sandstones outcrop are sparsely covered.

1. The following geological description of the two study areas is based on information supplied by Mr. W.E. Mroszczak, Party Chief, Imperial Oil Enterprises, Inuvik, Northwest Territories, during the summer of 1966.

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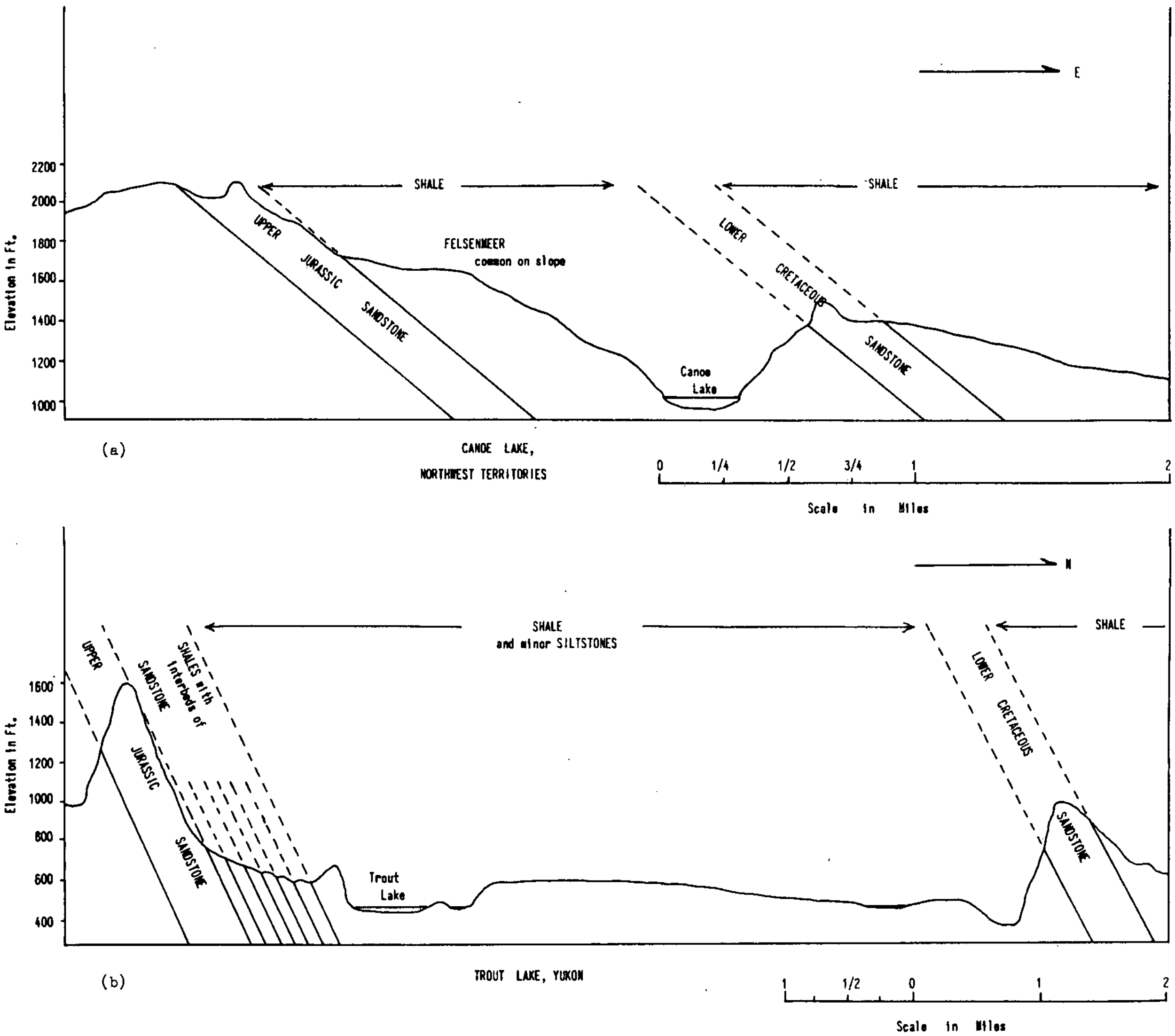


Figure 4 (a)&(b) . Stratigraphic cross-sections of major study areas. Information supplied by Mr.W.E.Mroszczak,Party Chief, Imperial Oil Enterprises,Inuvik,N.W.T.1966.

The topography is governed by the differences in resistance to erosion of the principal rock types, the sandstones forming the ridges, and the soft shales forming the valleys between. This is quite general throughout the area, since these rock units outcrop in this part of the Richardson Mountains. Exposed rock at the 1500 ft level on the western side of Canoe Lake is generally level and can be related to the general warping that occurs when cuestas originate. Large sandstone boulders and felsenmeer scattered over this slope are probably a result of exposure and excessive freezing and thawing.

At Trout Lake (Figure 4b) the geology resembles that at Canoe Lake, with Upper Jurassic and Lower Cretaceous sandstones forming the ridges and shale intervals forming the flat valleys between. The shale overlies the Upper Jurassic sandstone with a gradational contact, i.e. there is a zone of interbedded shales and sandstones grading to a pure shale as found exposed at the south end of Trout Lake. This shale is quite hard, with some silt sized material, splintery, and with some siltstone interbeds. Organic content is thought to be quite high. The rocks in this area have been considerably folded and metamorphosed to a slightly higher degree than at Canoe Lake.

To the northwest of Trout Lake the ridges are formed by resistant, light grey Mississippian limestones. The vegetation on this rock type, as well as that on the Lower Cretaceous (to the north), was not studied as both were inaccessible on foot.

Climate

Climatic data for the coastal regions of arctic North America have been continuous since the opening of the Distant Early Warning (D.E.W.) line in 1957. In the interior, climatic data are very incomplete with records available only from Umiat, Alaska. In western arctic Canada no climatic records are available. Records are available for Aklavik and Inuvik in the Mackenzie Delta. Both these settlements are considered to be within the subarctic zone as they are 30 miles south of the tree line (Mackay, 1963).

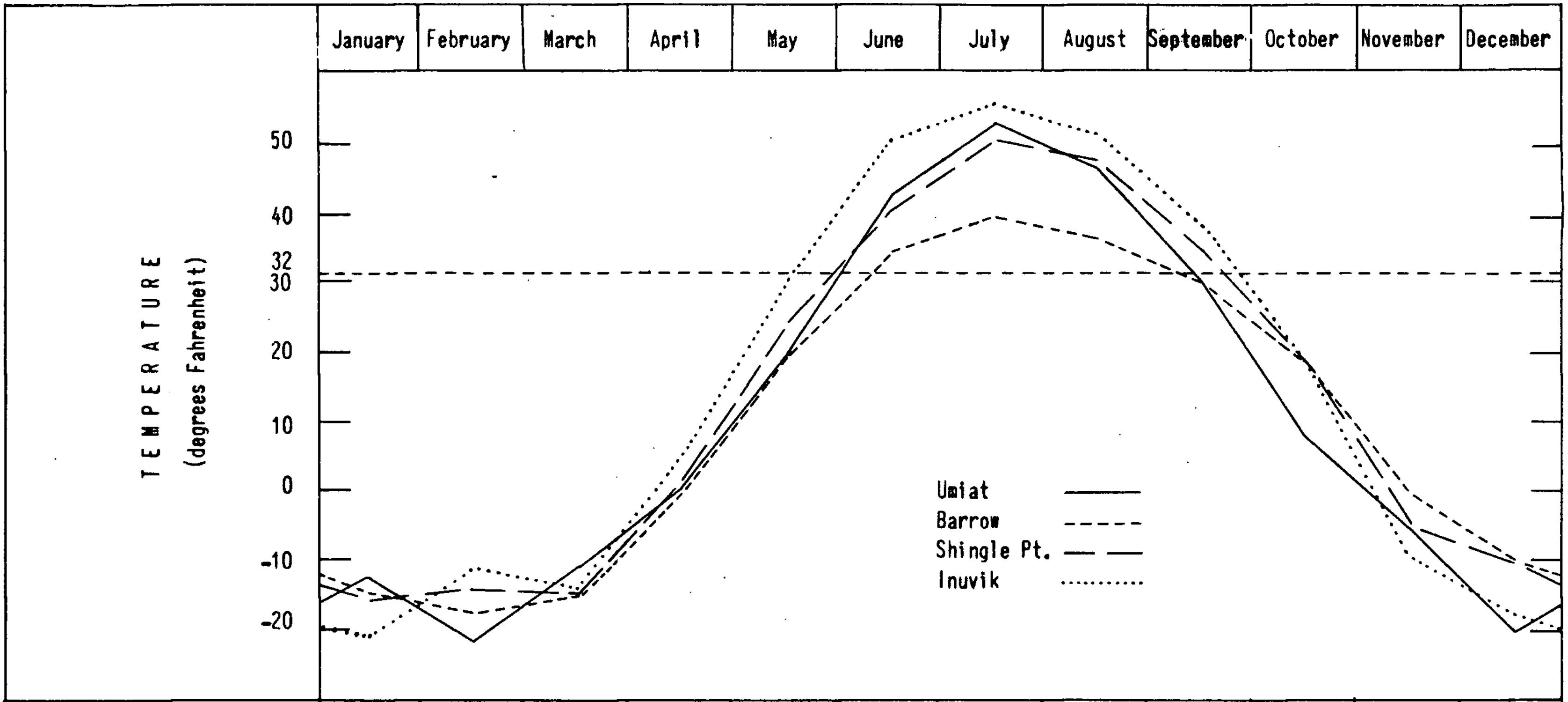
At present, only the climatic data from one D.E.W. line station, Shingle Point, can be used for comparison with Inuvik data and with that collected in the field. This station is 60 miles N.W. of Canoe Lake and 38 miles E.N.E. of Trout Lake.

Throughout the arctic slope the climate is severe, characterized by long cold winters and short cool summers with frequent cloud and fog cover (Britton, 1957). The coldest month at Barrow and Umiat, Alaska, is February; on the 29 year record the former is -24°F, the latter -18°F. At Shingle Point and Inuvik the coldest month is January; at the former between 1960-1964 the average was -15.5°F, and at the latter between 1957-1964 it was -21.9°F. (Figure 5).

The warmest period, when mean temperatures are above freezing, is from June to August. Temperatures have been recorded in the high 70's and low 80's along the coast and in the high 80's in the interior. Temperatures rise rapidly in the spring and drop as rapidly in the autumn. This rise and fall is more pronounced in the interior where a continental climate exists.

The growing season, or snow free period, not to be confused with the frost free period, is longer and warmer in the foothills than at the coast. Growth conditions are, therefore, considered more favourable in the interior. The warmest month during the growing season is July followed by August and June.

Frost frequently occurs during the height of the growing season and can be accompanied by snow. Such periods are usually of short duration and appear to have little effect on the vegetation. The frost free period in 1966 at Canoe Lake lasted 37 days. During most of the growing season there is a potential 24 hour photoperiod, but this is not always attained due to periods of cloud cover, local fog and degree cardinal exposure of slope. Prolonged



PRECIPITATION (inches)	January	February	March	April	May	June	July	August	September	October	November	December
Umiat	0.34	0.17	0.17	0.87	0.14	0.61	0.40	1.74	0.31	0.43	0.28	0.27
Barrow	0.15	0.13	0.12	0.10	0.12	0.26	0.84	0.75	0.51	0.53	0.27	0.20
Shingle Point	0.25	0.07	0.06	0.26	0.20	0.98	1.83	1.28	0.54	1.50	0.28	0.07
Inuvik	0.94	0.56	0.53	0.85	0.51	0.86	1.81	1.17	0.70	1.46	0.77	0.74

Figure 5. Climatic data for the Arctic Slope. Average monthly temperature and precipitation at Barrow, Alaska (29 year record) and Shingle Point, Yukon (4 year record) on the coastal plain, at Umiat, Alaska (3 year record) in the foothills and Inuvik, N.WT. (8 year record) in the sub-arctic. U.S. Weather Bureau (Spetzman, 1959) and D.O.T.M.B., Canada.

to follow page 10

periods of sunshine are infrequent. Clear days followed by nights with heavy mist and cloud cover provide a maximum of heating and consequent thawing of the active layer (Britton, 1957). Diurnal temperature extremes are considerable, and are accentuated on all north and south, east and west slopes and help to explain the diversity of plant communities encountered. Of the various environmental factors temperature is the most important limiting factor with regard to plant growth and development in the tundra. (Bliss, 1962).

Wind is an ever present environmental factor in the arctic tundra. Although wind speeds are reduced near the ground surface and within clumps of tundra plants, the prostrate condition of much of the vegetation does allow it to be efficient in reducing temperature. The reduction in air and leaf temperature will upset the favourable temperature microclimate of the low arctic vegetation (Warren Wilson, 1959). Prior to the complete disappearance of snow during the annual thaw, excessive transpiration can take place in the exposed branches of shrubs due to wind action. A condition of permanent wilting can then be reached before the lower portions have thawed and started to translocate water. A similar condition probably prevails in the autumn when an early freeze and snow fall are followed by strong winds and above freezing temperatures.

The prevailing wind at Trout Lake and Canoe Lake throughout the winter months is from the northwest, while in the summer it is from the west and northwest. During the summers of 1965 and 1966 there were many days from July to mid-August when southerly winds were also recorded during the "daylight hours". In late June and July many prolonged periods were recorded during the 24 hour period in which there was no discernable air movement. This was also the case in valleys as well as on ridge tops and tended to occur in the late afternoon. In late August high winds are more common in the Trout Lake area than at Canoe Lake, a result of the more regular topography and the close proximity of the Arctic Ocean.

Annual precipitation is generally low throughout the arctic; at Shingle

Point for the period 1960-1964 being only 7.32 inches, at Inuvik for the period 1957-1964, 10.57 inches. During the summer of 1966 considerably more rain fell in the Canoe Lake area than had fallen the previous summer. In 1965 only two days of light rain was recorded; while in 1966 between July 18-29th over eight inches of rain water was collected in the canoe at the lake (admittedly not an ideal rain gauge, nevertheless, a good indication of the amount of precipitation). Within the same period 1.28 inches were recorded at Inuvik and 0.61 inches at Shingle Point (D.O.T.M.B., 1966).

During the summers of 1965 and 1966 a phenomenum observed on most clear days at Canoe Lake was the build up of cumulus clouds that appeared each mid-day to the west over the Yukon Territory. These clouds are a result of warm air rising and cooling over the Old Crow Flats. Generally, these clouds move east and tend to dissipate before reaching Canoe Lake. In 1966, these air masses failed to break up until they reached the Mackenzie Delta, consequently precipitation fell on many days. At times 100% relative humidity was maintained for a week at a time.

Recent studies have shown that in general precipitation exceeds evapotranspiration by small amounts during the growing season (Mather and Thornthwaite, 1956). This is borne out by a comparative study of these relationships at stations along an environmental gradient extending from Point Barrow to the Meade River, a distance of 67 miles to the southwest and 28 miles from the coast, Clebsch (1957) demonstrated increasing values of average daily evaporation, transpiration and precipitation. At all stations precipitation exceeded evaporation.

Although the actual snowfall is light snow cover is an important ecological factor on the tundra. Snow provides a protective cover for vegetation and is a source of abundant water during the annual thaw. On irregular topography, snow accumulation in large drifts is favoured by strong winds. Porsild (1957) recognized two types of plant habitat related to snow cover, both of considerable prominence on the arctic landscape. The snowbed is defined as a site where large masses of snow accumulate each winter due to irregular topography. (Figure 6). This type of snow cover habitat is more prevalent in arctic-alpine regions. Plants growing in this type of site have to complete their vegetative life cycle in less than a month and so are adapted to a short growing season. In the two study areas discussed here snowbed sites were generally on sloping creek banks or old lake banks with a southerly or easterly exposure. In unfavourable seasons the snowcover will not disappear completely so that plants that emerge from it have insufficient time to flower or produce fruits.

Figure 6. Late snow bed habitat in the Canoe Lake area bordered on both sides by shrub (B_2) Salix pulchra. Photograph taken in early August shortly after snow melt. (Photo by Krajina).

The snowpatch habitat is a truly arctic phenomenum. It usually develops in shallow depressions where, owing to prevailing winds, a snowdrift forms each winter, affording protection for the vegetation beneath it. Snow melt in these depressions is completed shortly after that of the surrounding landscape so that in the summer such sites are fairly dry. Vascular plants associated with this habitat are predominantly woody, such as ground birch and heath, with mosses. In the study area, snowpatch communities were present at elevations above 1500 ft at Canoe Lake and above 700 ft at Trout Lake. Aeolian deposition of fine sands derived from surrounding outcrops of higher elevations results in dirt commonly accumulating on the snow in snowbed sites during each summer. Warren Wilson (1958) has suggested that it is partly this process that causes the build up of fine organic soils that prevail in such sites as well as being a source for the possible increase in soil nitrogen.

The mean annual snowfall at Shingle Point is 29.6 inches over 23 days and at Inuvik 68 inches over 100 days (D.O.T.M.B., 1966). Snow may fall any time during the summer months. In 1965 no snow was recorded from June 1st - August 23rd., while in 1966 snow was recorded on July 25, 26 and 28 and August 9 and 10. Snowfall increases in both frequency and amount in late August in the foothills and accumulation generally begins in September. By late October and early November snowfall ceases. Snow accumulates in certain sheltered sites due to strong winds and reaches its maximum depth by the following spring. Exposed ridge tops and escarpment edges may be bare during most of the winter due to wind action. On such sites vegetation is virtually non-existent because of the abrasive action of drifting sand and ice crystals.

Although no records are available indicating whether the snow depth was initially equal on opposite sides of the valley slopes, it was observed that in the two study areas west facing tundra slopes were free of snow at least two weeks before the east facing slopes. In the spring snow melt is variable but higher exposed elevations are usually free of snow by mid-May.

Light intensity, quality and duration are exceedingly important factors in the tundra environment. They affect not only soil and air temperatures, humidity and soil moisture, but also the energy flow within the ecosystem (Bliss, 1962). Few records are available on solar radiation, but it is generally accepted that the solar energy in the arctic may equal or exceed, for short durations, that received at mid-latitudes on a 24 hour basis.

The exposure and degree of a slope profoundly influence its air and soil temperature as well as the soil moisture of the microclimate. Along the coast where all slopes would receive about the same amount of heat energy sky radiation tends to moderate differences of exposure. However, the same cannot be said for the foothills where abrupt changes in topography frequently occur. Many steep slopes will be shaded some time during the 24 hour period. This was the case on some east and south facing slopes in the Canoe Lake area.

Soils

Soils of the Alaskan Arctic Slope have received considerable attention in the last fifteen years from Dr. J. C. F. Tedrow and his students. The vast amount of information that has been compiled on their genesis, morphology, chemical and physical properties has resulted in an arctic soil classification. This has been accomplished by arranging the soils in a drainage catena in a similar manner to those in other climatic regions. (Tedrow et al., 1958). The work of this group covers the Coastal Plains, Foothills and Brooks Mountain Range to an extent that all the major soils are known. Detailed mapping has been carried out on the coastal soils around Barrow (Drew, 1957) and the Northern Brooks range (Brown, 1962).

Few soils studies have been undertaken in the Canadian Arctic and none on the scale of those of Tedrow and his students. Feustal et al. (1939) reported laboratory data from 37 soil samples collected in Arctic Canada. Profile characteristics were poorly defined in these soils although analyses of the samples showed an accumulation of surface organic matter, a wide range of C/N ratios and hydrous mica as the dominant clay mineral. Since field relationships were not discussed by the authors, the soil materials were as "lithosol associates" of what is recognized as true tundra.

Leahey (1947) has described some characteristics of the soils adjacent to the Mackenzie River in the Northwest Territories. The thickness of partly decomposed organic matter on the surface varies with topography, the thinnest being on the knolls or ridges and the thickest on lower slopes and depressions. Drew (1957) interpreted this condition as similar to the peaty surfaced tundra soils of northern Alaska. Tedrow and Douglas (1964) described the soils in a small area of west central Banks Island. They concluded that the soils there were predominantly well-drained with many high arctic affinities. Because of the dry desert-like appearance of most of the soils they were designated collectively as polar desert rather than tundra. Many of the soils have salts accumulated at the surface. Day and Rice (1964) described the characteristics of some permafrost soils under different types of vegetation in the lower Mackenzie River, NWT. Two profiles were described from just east of Reindeer Station on the east side of the Mackenzie Delta. The first site represented the ridges and upper slopes and was classified as a regosol (Tedrow et al., 1958). The second site was at the base of a gentle slope and had characteristics closely related to those described by Tedrow et al. (1958) as belonging to the upland tundra soil group.

Smith (1956) in studies on Spitzbergen described the soils and arranged them in a broad drainage catena from the (dry) lithosols of the rugged elevated sites to the (wet) tundra soils of the lower polygonal and solifluction areas. Also described were the organic inclusions in the lower horizons and the mottled condition of the mineral material in the upper portion of the profile. The conclusions reached by Smith agree in general with current Russian theories.

The vast majority of arctic soil studies to date have been undertaken by Russian soil scientists. Tundra soils were first distinguished by Dokuchaev (Margulis, 1954) more than a century ago when he named the five natural soil zones. Middendorf (1864) recognized two types of tundra; a high tundra with relatively dry mineral soils and a low tundra with wet peat soils bearing a bog or marsh vegetation.

Sochava (1933) implies for the tundra soils of the Anabar River Basin a drainage sequence ranging from well drained soils supporting lichens to wet saturated gley soils with associated grasses and sedges. In the same region he detected podzol formation on sandy material in well drained positions. Sheludikova (1938) recognized in the Indigirka River Basin four tundra-soil vegetation associations ranging from shrub tundra through lichen, grassy tundra and marshy tundra.

There are still differences of opinion in the Russian literature on whether tundra soils represent a unique type of soil formation. Gorodkov (1931) suggested that there is no basis for considering Arctic regions unique in terms of pedologic processes. He presented evidence indicating that the difference between gleyey and podzolic-gleyey soils in the northern forest zone and the tundra is not qualitative but quantitative.

Filatov (1945), on the other hand, stated that the lack of widespread evidence of podzolization in the Arctic, coupled with the peaty surface gleyed condition and general water saturated nature of the soils, indicate that arctic soils should not be thought of geographically in terms of a podzolic process.

The genetic soils of Arctic Alaska have been classified as Lithosols, Regosols, Arctic Brown (shallow and normal phase), Upland Tundra, Meadow Tundra, Half Bog and Bog (Tedrow and Cantlon, 1958., Tedrow et al. 1958). Lithosols occur in the mountains and the foothills where, in exposed areas, excessive weathering by wind restricts the cumulative processes of soil formation. A thin layer of organic matter is sometimes present in the sheltered sites where depauperate vegetation survives, but such sites are very scarce. Regosols occur in youthful areas of well drained talus, alluvial and outwash deposits. Genetic profiles are generally absent because of their youthfulness. Such areas are generally major drainage pathways with excessive water passing over them during the early summer thaw. Because of this the permafrost table is always at a considerable depth, up to six feet (2 m).

Arctic brown soils are generally present on ridge tops, escarpment and terrace edges in the mountains and foothills, and on stablized dunes along the coast. These sites consist of coarse sands and gravelly material that, because of improved drainage and aeration, give rise to a thicker active layer. They are designated by Tedrow (1963) as the most developed soil although in his studies they constituted less than one per cent of the total area studied. The active layer may be of considerable thickness as much as three to five feet (1-1 3/4 m) and is always greater where sand is present. The arctic brown profiles generally display a narrow colour variation, the upper horizon of dark brown organic matter grading to yellow-brown and grey-brown with depth. Burrowing animals probably contribute to the characteristic brown colouration of the lower horizons by their use of vegetative materials for nesting. These well-drained soils possess an A-B-C horizon sequence. Tedrow and Hill (1955), in all the arctic brown soils studies, have found evidence of clay accumulation in the A and B horizons while in the C horizon there is more medium to fine sand. These soils thaw in late spring and remain in an unfrozen state throughout the summer at moisture levels considerably deeper than that of most soils on the Arctic Slope. (Tedrow and Hill, 1955). The organic matter concentration is greater in the upper A layers and decreases gradually with depth. Tedrow et al. (1958) have distinguished an arctic brown shallow phase that is generally found at higher elevations. There the bedrock is within 12-16 inches (30-45 cm) of the surface and the drainage is good. Both the normal and shallow soil types are formed under a cover of dwarf shrubs, herbs, sedges, grasses, mosses and lichens.

Kreida (1958) and other Russian workers have also noted the rare phenomenum of arctic brown soil but they conclude that it is a relic of ancient soil-forming processes at a period of climatic optimum. Because of improved drainage Tedrow and his co-workers (1958) contend that the arctic brown soil is nearer to a true zonal soil and that the gleyey tundra soil is an intrazonal (hydromorphic) soil. On the other hand, recent Russian workers (Kreida, 1958, Mikhaylov, 1961, and Karavayeva, 1965) suggest that because tundra soils are widespread they are zonal soils and that the arctic brown soils are transitional because of their limited distribution. This was also the view of earlier Russian investigators such as Glinka and Liverovskiy (Mikhaylov, 1961).

Of all the arctic soils studies to the present, tundra soils have received by far the greatest attention. Kreida (1958), in his studies on tundra soils of the northern U.S.S.R., described their formation as due to the interaction of biochemical and leaching processes coupled with frost displacement. In recent years tundra soils have been studied to a considerable depth; both the active layer and the upper portion of the permafrost table were investigated. Some interesting morphological features were revealed, the most important being the inclusion of concentrations of organic matter in the upper portion of the permafrost. (Mackay, 1958., and Tedrow, 1965).

Tundra soils are by far the most widespread of the arctic soils. They are always poorly drained mainly because of the impervious permafrost, low temperatures and natural precipitation, and are active for only two to four months of the summer. One characteristic common to these poorly drained soils is the gleying that occurs in the upper mineral horizon despite the persistent presence of carbonates throughout many tundra profiles. The organic layer at the surface is from 2-10 inches (5-25 cm) thick, moderately to strongly acidic, which tends to increase with depth.

On the basis of profile morphology of the tundra soils of arctic Alaska, Tedrow and Cantlon (1958) have recognized both an upland and a meadow tundra. The upland tundra which occurs on relatively drier slopes and rounded hilltops, has less organic matter and greater oxidation than the meadow tundra soils.

Vegetation cover is usually less with more xerophytic species being present. Improved drainage gives rise to a thicker active layer.

Meadow tundra sites are more frequent on the lower reaches of the foothills and coastal plain where drainage is generally poorer. Profiles in this type show considerable variation. Local factors, such as the complex pattern of ground ice in the form of ice wedges, veins and lenses, and the amount and character of the organic matter at the surface, leave their marks on the profile morphology (Tedrow et al., 1958). At any time and place tundra soil morphology reflects two sets of processes. One relates to soil formation and involves organic matter production and a mild acid-glei process; the other is the destructive physical process of frost action including solifluction.

In the poorly drained areas of the lowlands, patterned ground influences the distribution of moisture and results in saturation, often with standing water present throughout the summer months. Soils formed under such restricted drainage are characterized by a heavy accumulation of organic matter in which decomposition is impeded. Generally, the organic layer is thick, consisting of Sphagnum - Carex mixtures that overlay a mineral layer. The organic soils are subdivided: half-bog with organic accumulations approximately 6-12 inches (15-30 cm) in thickness, and bog with an organic layer at times exceeding 4 ft (120 cm) (Tedrow et al. 1958). The pH values of these bog soils is generally mild to strongly acid.

In poorly drained soils the development of patterned ground influences the distribution of moisture by breaking up the generally smooth topography and giving rise to a microrelief where soil morphology is variable. Low-centred polygons have pools of standing water; the peripheral tussock rims are mostly narrow, prominent and drier. The organic layer in the low-centered polygon, while thick, has a narrow active layer due to poor drainage. The high-centered polygons are peaty and covered with low shrubs and herbs and sedges. The fissures are wet and vegetated by sedges and mosses. The active layer in the high-centered polygon is greater under the mounds than under the fissures. This is related to improved drainage on the mound, and the insulating effect of the thick moss cover in the fissures, which prevents heat penetration during the thaw period.

The transition from low-centered to high-centered polygons is accomplished through a widening of the peaty ridges, the growth of peat and peaty mounds in the low centers, and the subdivision of the larger polygons into smaller ones (Mackay, 1963). From this may be seen a transition from the bog (low-centered polygon) to the half-bog (high-centered polygon). On those better drained half-bog soils vegetation becomes established that closely resembles communities normally found on meadow and occasionally upland tundra sites.

In referring to frost-action several authors have implied that solifluction and mechanical stresses and tensions developed in tundra soils during the freezing are responsible for so much "mixing" in tundra soils that no classification scheme is applicable when based on genetic morphology. Gorodkov (1931) recognized the danger in producing a fundamental classification of tundra soils from the standpoint of frost caused features. His work involved a genetic classification of Arctic soils and recognized naturally occurring soil bodies resulting from the weathering of parent material under the influence of climate, drainage and associated living organisms.

In developing a classification for the Alaskan Coastal Plain soils, Drew (1957) found it necessary to use microrelief as well as soil morphology. Detailed studies in poorly drained soils showed that patterned ground influences the distribution of soil moisture and organic and mineral material within the soil. In developing high-centered polygons the center and fissure (trough) soil profile may be similar. The soil morphology is slow to reflect the change in moisture conditions, instead the differences are clearly shown in the species composition of the plant communities.

Tedrow et al. (1958) have basically followed Gorodkov's fundamental classification, but at the same time have recognized the effect of permafrost, frost-action and patterned ground (where applicable) in their determination of the major genetic soils of northern Alaska.

Probably the most complete of all soil classification texts is The Soils of Europe, Kubiena (1953). While the work is restricted to the most important European soil formations it does include detailed information on the Finnish Arctic and nearby Arctic Islands as well as the identification of Alpine Soils. Many soil characteristics outlined by Kubiena are readily recognized in the Low Arctic Subalpine Zone of western North America.

Permafrost - The Effects on Vegetation and Soil

The tree line, as indicated in the Atlas of Canada, approximates the southern limit of continuous permafrost (Brown, 1960) between the Hudson's Bay and the Yukon-Alaska boundary. This southern limit lies between the -3.9°C (25°F) and -1.1°C (30°F) annual isotherms. The greatest depths of permafrost are found under severe climatic conditions where annual precipitation is light. The depth of permafrost and the thickness of the active layer are dependent on mean annual temperature and the type and density of the vegetation on the ground (soil) surface. Vegetation has a direct influence on the permafrost by its thermal properties which determine the quantity of heat that enters and leaves the ground in which permafrost is present. In the high arctic and arctic-alpine regions vegetation has little influence on the actual thickness of permafrost because of its sparseness and short vegetative season (Brown, 1963).

The organic matter or peaty layer present in the upper soil horizon of the tundra soils is very hygroscopic. During the early summer, the peaty horizon, because of a high ice content, owing to its large thermal capacity, prevents the warming of the underlying soil horizon. The heat is consumed in thawing the ice and evaporation of the water. After a drying period the upper surface of peat prevents the warming and drying out of the lower layers because of its low thermal conductivity.

The insulating peat layer that dries out during the summer has a high ice content on freezing in winter. Water present in this layer comes from autumn rain and snow. It becomes a good heat conductor and offers little resistance to cooling of the lower horizons. In summer the heat is consumed in melting the ice and evaporating and warming the water, in winter there is only cooling and freezing. Consequently, the peat offers less resistance to the cooling of the soil in the winter than to warming in the summer. In this way, it contributes to the predominance of winter cooling over summer thawing (Tyrtikov, 1959). This implies that freezing increases soil conductivity as ice is a better conductor of heat than water. The net losses in winter, when soil is frozen, will be greater than summer gains through the unfrozen surface, for the same temperature differential.

The effects of permafrost on vegetation and the reverse are quite drastic. Permafrost impedes soil development by affecting moisture relationships, leaching, temperature and root depth. On the arctic slope, depth of permafrost depends on the type of parent material, microtopography, macrotopography, climate and vegetation cover and other related factors. Since the permafrost table is impervious to water that accumulates with the thawing active layer and low precipitation, drainage water moves mainly laterally downslope throughout the thawed surface layer. This drainage water finds its way to the myriad of drainage pathways that transect the slopes and eventually flows into major streams. Drainage is virtually non-existent in the flat lowlands and water loss is mainly through transpiration and evaporation.

The saturated condition of the active layer in sites of poor drainage leads to reduced aeration and impoverishment of nutritive substances that may be related to limited microbial activity considered to take place during the summer (Boyd, 1958). This condition leads to an increase in the accumulation of organic matter.

On sloping surfaces where the active layer is thicker and silt-rich soils overlain by peat and turf predominate, surface drainage is impeded by the vegetation as well as by permafrost. Where the slopes are greater than 20-30°, this results in a downslope movement (solifluction) of superficial soil and debris. This results mainly from the expansion of the soil normal to the slope during the heating and freezing and is followed by vertical subsidence upon cooling and thawing (Sigafoos and Hopkins, 1952). This phenomenum is most evident during the autumn freezing cycle. Hopkins and Sigafoos (1951) in a study of the role of frost thrusting in the formation of tussocks[1] concluded these were formed only by the differential upward movement of the soil beneath the tussock. Downslope movement was shown to be in the autumn during the freeze-thaw periods prior to the winter freeze. Individual tussocks studied during the summer showed that the living roots beneath the culm base extended vertically downward from the rootstock. The brown dead roots of the previous seasons were contorted and twisting indicating that after the roots died strong pressures were exerted upward through the mound against the roots and rootstocks. The adherence of the root mass to the mineral soil and the physical resistance of the root mass to soil movement prevents any downslope movement during the prolonged periods of thaw. Additionally, the tussock vegetation extracts water from the soil thereby helping to keep it less fluid (Hopkins and Sigafoos, 1954).

Root systems are typically mat-like where permafrost is close to the surface and develop primarily in the horizontal plane. The roots within this narrow active layer are entwined and assist in giving additional anchorage to the plants.

Removal of the vegetative cover permits greater heat penetration, increase in surface air circulation and an increase in depth of thaw. This results in

1. A tussock is a single plant that grows on a small mound of mineral soil. The root stock forms a cap around the mineral soil.

the melting of the permafrost ice which can lead to rapid erosion, sink holes and other types of thermokarst forms of relief. Gregory (1957) has stated that the vegetative cover, which acts as an insulating cover, is often in ecological balance with the level of permafrost in the ground. The thick mats of mosses that are present in wet sites indicate their insulating properties during the summer by a very shallow active layer beneath the mat.

The diurnal and seasonal range of soil temperatures in bog, and to a degree in meadow tundra soils, is narrower than that of the deeper thawed arctic brown soils. The fibrous peaty insulating surface and restriction of drainage by permafrost keeps these soils at high moisture levels during the thaw period.

Permafrost levels in the major soils of the Alaska slope vary due to moisture content of the soil. Tedrow et al. (1958, 1959) during their extensive studies have determined for the major soils an average depth for the permafrost at the end of the summer thaw. On ridges and escarpments where arctic brown soils form, the permafrost table may be 3-5 ft (1-2 m) deep. In lithosols, where there is only a shallow soil, the underlying bedrock and/or coarse material is still considered permafrost because the mean annual temperature is below -1.0°C.

Topographically, the tundra soil slopes are very irregular, consisting of hummocks and depressions. The surface pattern of the permafrost is usually a mirror image of the soil surface. Where there is a surface rise there is a permafrost hollow. The poorly drained organic mineral tundra soils that cover vast areas of the arctic usually have a permafrost table at a depth of less than 2 ft (60 cm). The upper portion of the frozen layer has inclusions of organic matter and organic stained ice. At a depth of 2-4 ft (60-130 cm) below the permafrost surface the mineral material is free of organic staining (Tedrow et al., 1958). In bog soils the frozen surface is generally higher than in the tundra soils, and may be only 1-2 ft (30-65 cm) deep. Although regosols consist of fine material and show little development, they generally have a deep permafrost table. This can be attributed to the fact that they are well drained and have water moving over them continuously during much of the summer. On the higher slopes, where there is less alluvium, the permafrost is closer to the surface because there is less water movement than on the lower slopes, lake edges and creeks.

Benninghoff (1963) has suggested that plant ecologists who have undertaken recent studies of northern vegetation have appeared too confident in their ability to evaluate the intensity of frost action or permafrost in soils based on the nature of the vegetation on the site. However, while the study of permafrost, as related to both vegetation and soil, has received little study, considerable information can be forthcoming providing plant ecological studies are confined to reasonably small areas. In this manner, valuable information can be obtained on the thickness of the active layer and its rate of thaw under different plant communities during the vegetative season.

MICROCLIMATE

Microclimatic Synthesis

The irregular topography at Canoe Lake has given rise to many sharply defined habitats. The communities associated with these habitats usually reflect sharp differences in soil moisture. However, no quantitative data were collected to substantiate this hypothesis. In order to determine what other environmental factors might be related to these sharp boundaries climatic data were collected from selected sites. Microclimatic comparisons would then be possible between different community types.

Nine weather stations (Figure 7) were established on July 1st, 1966, and operated continuously until August 28th, 1966, to obtain quantitative and qualitative data on temperature and relative humidity. One Fuess hygro-thermograph was placed in each of ten previously analyzed communities across the valley. The instruments were in collapsible screens, similar to the Stevenson type, and placed on boards directly on the ground. (Figure 8). The communities ranged in elevation from 1050-2100 ft, and had either west facing, east facing or total exposures. A complete summary of the maximum and minimum temperatures and relative humidity for all stations are presented in Appendix II. No records were kept of actual precipitation during this period.

While microclimatic differences were not abrupt in this area there were some notable differences. These were a result largely of variations in vegetative cover, topography, slope, exposure and probably the combined effect of the insolation-radiation balance. However, no data are available on the latter. Based on daily temperature readings all stations show rather uniform patterns.

Degree of slope and slope exposure have a profound influence upon air and soil temperatures as well as on soil moisutre and humidity of the microclimate. The winter winds in the Canoe Lake area are predominantly from the northwest so that little snow accumulation on the scarp slopes of the north-

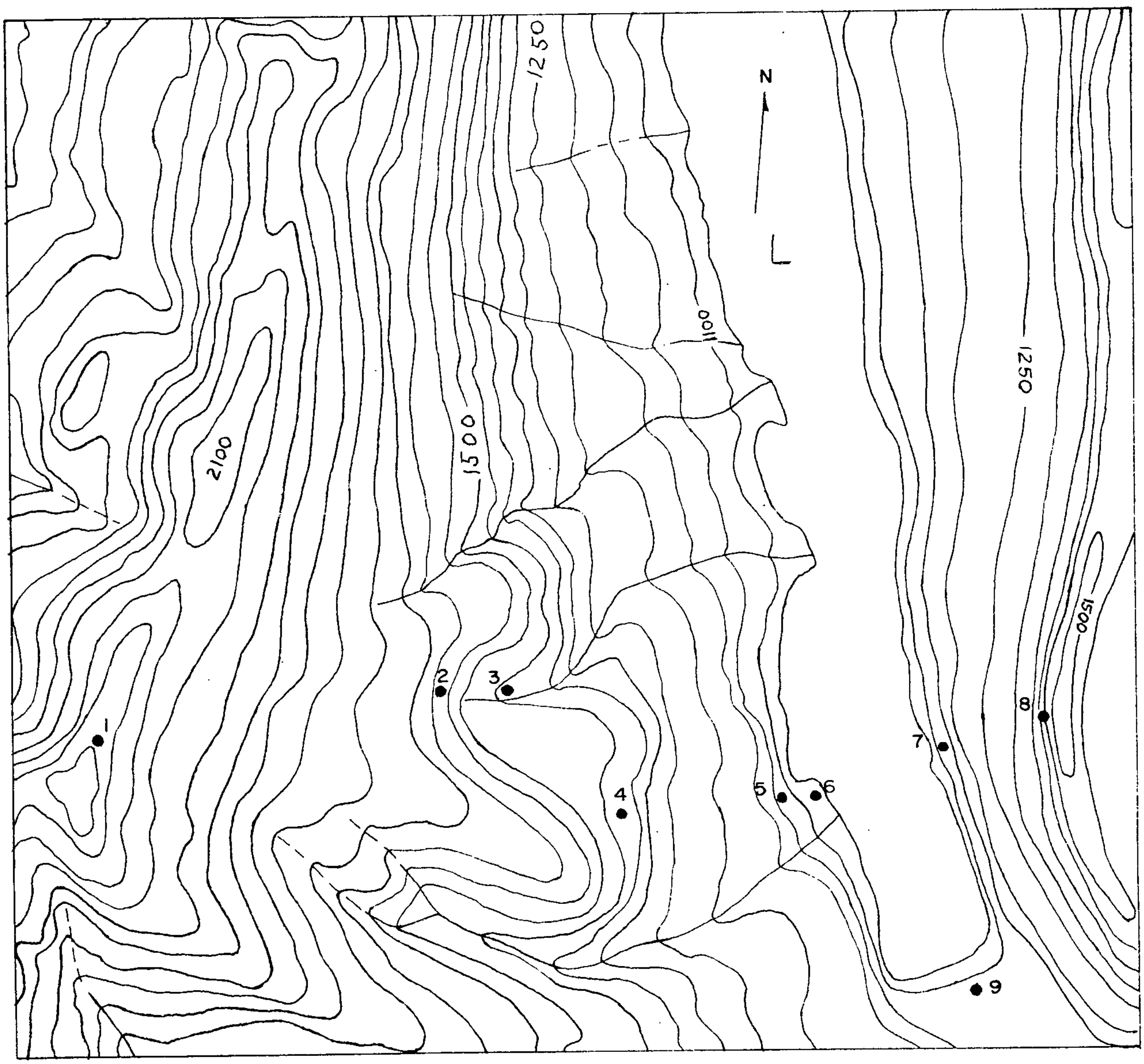


Figure 7. Location of the nine weather stations established in the Canoe Lake study area, and operational for July and August 1966.

south cuestas. Whether actual snow depth on the east facing slopes was greater than the west facing slopes was not determined. However, the large number of drainage pathways on the east facing slopes, with increasingly taller *Salix* communities at lower elevations, were prime sites for snow accumulation during the winter. During the early summer thaw snow disappears more rapidly from the west facing slopes than on the opposite slopes. In 1965 the west facing slopes were clear of snow by May 27th, while the east facing slopes were not clear until June 6th, or later.

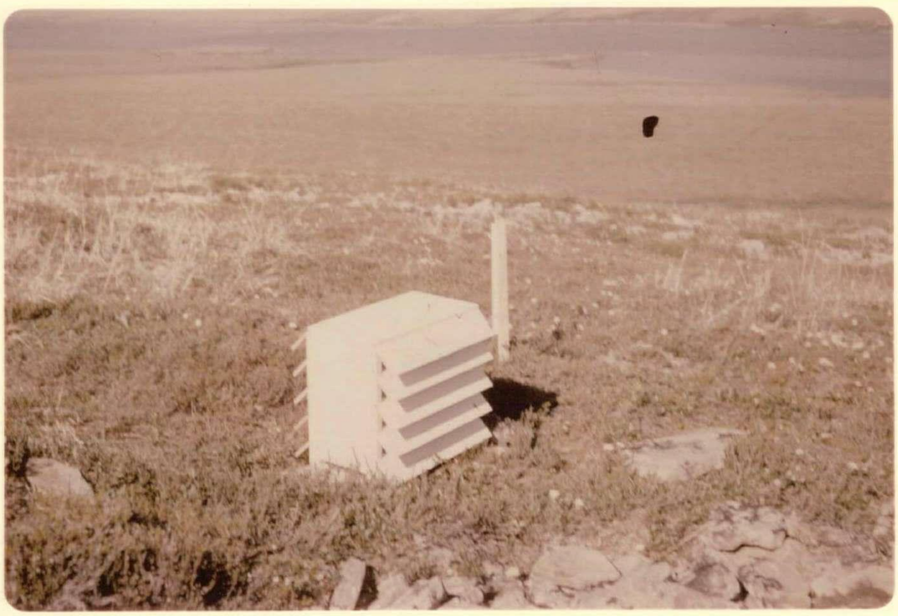


Figure 8. Weather station No. 4 in a *Cassiope tetragona* dominated site on the east facing slope west of Canoe Lake. (Photo by Lambert)

Microclimatic differences are mainly a result of the balance between direct insolation, diffuse sky radiation and terrestrial radiation (Bliss, 1956). There is a difference of 15° between the scarp slope of the cuesta on the east side of Canoe Lake and the dip slope of the western cuesta. The latter cuesta is 700 ft higher than the east cuesta so that after June 21st the midday angle of incidence on the east facing slope is reduced daily. During June and early July, shading has little or no effect on climatic patterns for those communities lacking shrub cover, because the sun never dropped below the ridges of either cuesta. In late July and August diurnal temperature ranges are affected; increasing hours of darkness and a decrease in the angle of insolation reduce the total daily insolation for communities on the lower slopes. While the east facing slope was receiving considerable less direct insolation, due to the narrower angle of incidence, than the west facing slope, the August temperatures were higher on the more shaded east facing than the west facing slopes. Reasons for this difference can only be speculative. However, the fact that the west facing slopes are more exposed to increasingly colder northwest winds as winter approaches is probably a major factor.

The weather data for July and August are summarized in Table 1. During July, for comparable sites, the average temperature at 1100 ft for Station 7 on the west facing slope was 53.7°F and 53.9°F for Station 5 on the east facing slope. Both these sites are in upland tundra dominated by Eriophorum vaginatum. At 1450 ft the average temperature in a Betula glandulosa dominated community (Station 8), on the west facing slope, was 54.8°F. On the opposite slope, in a Cassiope tetragona dominated community (Station 4), the average temperature was 53.5°F. Average diurnal ranges were the same for the two stations at 1100 ft. At 1450 ft the range was greater by 3° on the west facing slope. The highest temperature recorded during this period was 85°F on July 12th, at Station 8, on the upper limits of the west facing slope.

The exposed lowland station, dominated by Eriophorum scheuchzeri, at the south end of the lake, had the lowest monthly averages for temperature and relative humidity. Local fog and cloud cover seldom filled the valley completely and high relative humidity values were recorded only during periods of precipitation. The diurnal range here was the highest for all stations, the

TABLE 1

Summary of average Temperature and Relative Humidity data for microclimatic stations at Canoe Lake for July and August 1966

Station and Dominant species	Elevation Feet	Temperature °F July Min.	Max.	Avg.	Diu. Avg.	August Min.	Max.	Avg.	Diu. Avg.	Relative Humidity July	August
1 Salix phlebophylla	2100	41.7	62.8	52.3	21	36.1	53.5	45.8	15	72.2	72.1
2 Salix pulchra (B2 shrub)	1575	40.7	62.8	51.7	22	35.2	55.8	45.5	20	85.4	84.1
3 Salix pulchra (B2 shrub)	1440	42.1	64.0	53.1	22	35.9	56.5	46.2	21	74.9	86.9
4 Cassiope tetragona	1440	42.1	64.9	53.5	23	39.7	60.3	50.0	21	70.8	69.5
5 Eriophorum vaginatum	1130	42.2	65.6	53.9	23	36.8	59.4	48.1	23	69.9	70.0
6 Salix pulchra (B1 shrub)	1050	44.9	61.0	52.9	17	37.3	54.7	45.9	17	78.9	82.9
7 Eriophorum vaginatum	1130	42.1	65.4	53.7	23	36.8	59.9	47.8	23	69.1	68.7
8 Betula glandulosa	1420	41.9	67.7	54.8	26	37.4	60.5	48.9	23	73.8	75.0
9 Eriophorum scheuchzeri	1060	36.4	63.4	49.9	27	28.4	58.5	45.9	30	64.5	63.8

to follow page 29

average for July being 27° and 30° for August. The explanation for this high range can be related to 'nocturnal' cooling in that the cooler air on the ridge tops flows downslope and collects in this lowland region. On the basis of temperature this would be the only site that could be classified as arctic tundra because the highest monthly average temperature was below 50°F. (Trewartha, 1954).

The amphitheatre or draw between 1440-1575 ft on the western cuesta has higher average temperatures at the base (Station 3) than above (Station 2). The diurnal range for these two stations averaged the same (22° and 20°) for July and August. During July the relative humidity was greater at the upper than the lower station. In August this was reversed. Local fog and cloud cover at higher elevations during July were responsible for the difference. The upper reaches of the western cuesta were frequently covered by clouds while the highest points on the eastern cuesta, at 1500 ft, were covered for only short, infrequent periods.

Station 6, in a tall shrub (B1) Salix pulchra community on the west bank of the lake, had temperature and relative humidity values comparable to those of Station 3 at the base of the draw in a low shrub (B2) Salix pulchra community. The shielding effect of the sides of the draw help to reduce air turbulence while the steep sides of the draw result in a reduction of the angle of incidence and total insolation. The dense canopy coverage of the lakeside Salix community definitely affected the overall microclimate at the ground level so that diurnal temperature ranges were reduced. The shrub crowns act as a filter of radiation so that the percentage of incident light reaching the ground is greatly reduced. In forested stands in the sub-alpine zone of British Columbia, Brooke (1966) reported that since the dense crowns acted as an insolation-radiation exchange surface, temperature gradients were commonly reduced below the crown space than they were in non-forested sites.

Station 7 in a Salix phlebophylla dominated community on the summit of the western cuesta had temperatures and relative humidity averages slightly below those of stations at lower positions on the slopes. Due to its exposed position the angle of incidence was considerably greater than at any other station. However, a higher frequency of wind and cloud cover combined to reduce the effect of increased solar radiation. During July diurnal temperature ranges were similar to other sites. In August, in line with a general cooling that is related to increased wind and precipitation, diurnal ranges were considerably lower than any other site.

During July, the warmest summer month, microclimatic readings at the base of the amphitheatre compared favourably with Station 4 (Cassiope tetragona community) at the same elevation on an exposed slope just to the south. However, in August with a shorter daylight period and the sheltered position of the amphitheatre, maximum and minimum temperatures averaged 4° below that of Station 4. Colder air masses from the northwest are more prevalent so that during the night cold air flows downslope into the depression. Geiger (1957) has suggested that temperatures in this type of draw are mainly the result of reduction in air turbulence.

The quantitative data generally substantiates the observations discussed earlier as well as those made by other workers in similar areas of northern Alaska. Because of the orientation of the cuestas (north-south) the east facing dip slopes are somewhat sheltered from the prevailing northwest winds. Vegetative growth is initiated on the west facing slopes at least one week before that on the east facing slopes. Average temperatures for July were higher on the west than the east facing slopes, in August they were approximately the same. Drainage pathways are more abundant on east facing slopes and are sites for snow accumulation. Salix communities increase in height at lower elevations and because of their dense canopies the diurnal ranges at the ground level are narrower than in surrounding communities on the meadow tundra slopes.

Temperature patterns illustrate the influence of nocturnal cooling even though the sun was above the horizon from the start of recording until July 10th. Two stations (5 and 6) had low average diurnal ranges. The former because of its exposed ridge top position and the latter because of the dense crown canopy. Lowest temperatures were recorded between midnight and 6 a.m. (PST). Temperatures rose gradually with the highest readings being recorded between midday and 6 p.m. (PST). Rapid drops in temperature could, and did, occur at any time during the 24 hour period, and were always associated with snow or freezing rain. Below freezing temperatures were recorded in July and August, but there appeared to be little or no effect on the plants. Monthly average relative humidities were higher at the mid-elevations, between 1400-1800 ft, and in the shrub (B1) communities. Relative humidity at Canoe Lake for July and August would have been higher in 1966 than 1965, as considerably more precipitation was observed; averages over a longer period of years would doubtless lower the averages recorded in 1966. Microclimatic differences appear negligible between communities on the east and west facing slopes. Elevated and lowland sites generally had lower average daily temperatures than those on the slopes. Minimum daily temperatures were lower in the low-centered polygon community than the ridge top. This is related to the downslope movement of cooler air at night that settles in depressions. In contrast, warmer air moves upslope during the day.

VEGETATION

The initial criteria for selecting communities were based on their uniformity and discreteness. The communities were studied by means of sample plots which were located where the vegetation was homogeneous. Any one of the environmental factors might result in a habitat of very small size and completely different from those surrounding it.

Where communities covered extensive areas, or were composed of dense shrubs, the sample plot was 100 sq. m. Small discrete communities were analyzed using either a 16 or 25 sq.m. plot. One sample plot was selected and analyzed to represent each community.

The vegetation in each plot was analyzed employing qualitative and quantitative phytosocialogical techniques of the Zürich-Montpellier School as modified by Krajina (1933). An initial survey was made of the sample plot in which the presence of all vascular plants, bryophytes and lichens was recorded. Percent coverage was estimated for each strata. Evaluations of species significance and sociability were then made of all species for the following strata where present.

B_1	layer	Shrubs over 6 ft
B_2	layer	Shrubs 6 inches to 6 ft
C	layer	Herbaceous plants and woody plants under 6 inches (this included woody plants that were recorded as shrubs in other communities).
D	layer	Bryophytes and lichens (terricolous and saxicolous).

Samples of all plant species were collected in every plot during the summer of 1965 for positive identification. In 1966 vascular plants of uncertain identity, crustose lichens and all bryophytes were collected. At least one sample of every plant entity has been deposited in the University of British Columbia Herbarium. During later identification of the bryophytes many unlisted species, especially of Hepaticae, were determined and added to the species list of the appropriate community.

Qualitative and quantitative data on environmental conditions collected for each community included degree of slope profile, pattern of topography, exposure, altitude and wind influence. A complete list of all species collected are included in Appendix I. A total of 166 communities were analyzed.

Problems in Vegetation Synthesis

Considerable discussion has taken place over the past seventeen years regarding the value of classifying or ordinating vegetation in North America. A major part of the controversy centered around these two schools of thought, and one that has not always been stressed is that classification and ordination are founded on two different philosophies which cannot substitute each other. The followers of the Zürich-Montpellier School consider classification to be the primary aim, while those of the Wisconsin School look for, and stress, the continuous nature of vegetation. Cottam and Curtis, founders of the Wisconsin School of Ordination, following Gleason (1926) refute the existence of discrete natural units (associations) in vegetation on the basis that vegetation can only be considered as a multitude of associated species each possessing different amplitudes of tolerance.

The association-unit adherent would not disagree with the concept behind this statement or with vegetation being thought of as a continuum. Followers of the Zürich-Montpellier School grant that associations intergrade extensively (Becking, 1957). However, in ecologically similar sites the plant/habitat information can be aggregated and defined as the nodum (Poore, 1964).

Classification must eliminate transitions if the units are to become well crystallized and differentiated. Detailed studies are then restricted to the units around the noda. Ordination, on the other hand, looks for all possible transitions by arranging communities (stands), species and environments in a way in which it is hoped will reveal maximum information about relationships among them. Arbitrary divisions along the continuum may then be made which will reveal classes as they exist (McIntosh, 1967). In this study all plots, including several considered transitional, are used to determine the major associations, because of this several associations are less differentiated.

A statistical analysis of samples is possible (Becking, 1957, Dagnelie, 1960, Von Groenewoud, 1965) where primary concern has been classification, but it has not been used in most studies. The subjective synthesis of data is accomplished by associating environmental parameters with floristic structure. Communities are arranged according to similarity which generally implies initial separation along a moisture gradient. The floristic structure is the primary basis for classification, but it is organized into environmental and physiognomic groups. In the preliminary synthesis tables the communities are grouped by environmental relationships and/or dominant species. Presence values are determined for all species and the species are rearranged according to relative presence and abundance (species significance). Some species of intermediate presence value may be recognized to form differential species groups.

The suggestion that dominance-types are poorly suited to the formal hierarchy classification of vegetation has been made by Whittaker (1962) on the basis that it leads to community types of differing heterogeneity and inclusiveness. At the same time, he does admit that they do have a distinct practical advantage. The major problem, therefore, facing the ecologist in a discussion of the end results of classification and ordination is how valuable and/or useful are the final conclusions to a particular study. It would appear that the value of classification is that it brings together common information to enable abstractions of species groups to be made efficiently. These abstractions are of value in forestry, range management and vegetation mapping. Ordination has an academic appeal which the classification adherent can appreciate, but it has no appeal at the practical level to those involved in land management. In the present study the dominant species, characteristic combination of species and a complex of environmental factors are criteria for determining a plant association (Krajina, 1960).

Vegetation Synthesis

In the initial synthesis communities were grouped using only dominant vascular species. As the bryophyte and lichen identifications were completed they, too, were added to their respective communities in the tables. This tabulation of plot data was started after the first summer's field work. Following the completion of field work more complete synthesis tables were prepared following standard methods of the Zürich-Montpellier School. Environmental values were included to represent topography, soil, exposure, slope and elevation. While it is apparent from the synthesis tables that no two plots of the 166 analyzed are exactly identical, comparisons of vegetation and environmental data reveal that certain plots appear to have many similarities in both floristic and habitat characteristics.

Statistical analyses of subjectively collected data has been seldom attempted by phytosociologists. When used, it has been primarily to facilitate decisions as to the placing of new individuals, and to the extraction of groups at successive levels of relationship (Lambert and Dale, 1964). The exhaustive number of comparisons that must be made between floristic and environmental values of a community and other similar communities can give rise to innumerable errors. Because of the errors likely to be encountered and the large number of species (over 400) that were present in one or more of the 166 communities studied, a computer program was deemed more practical. The fact that the computer can operate objectively, without error and considerably faster than the individual makes it more practical. The primary objective of the statistics[1] program was to consider the vegetation on a plant/plant basis. In a majority of studies where a computer program has been used only the dominant species, or, as in the case of ordination adherents, only the dominant trees and herbaceous species have been considered. In this study, both dominants and

1. Statistics is defined here in the older sense of the word to include the non-probabilistic methods of data simplification and generation of hypotheses.

non-dominants (vasculars, bryophytes and lichens) are considered. Becking (1957) has reviewed the mathematical equations developed by most of the earlier workers for the determination of floristic similarity between two vegetation units.

The field data here have been analyzed using a program developed by Ream (1965) and modified by Borden (1967). Comparisons were made by means of the Index of Similarity between any one community and every other community. The index is basically a correlation coefficient used when a number of different, qualtitatively expressed measures are available for the two communities being compared. Similarity here has been based initially on presence and abundance of individual species. The formula used is $\frac{2W}{A + B} \times 100$, where A is the sum of all the measures (abundance and presence) for one community, B is the sum of all measures for the other community and W is the sum of the lower values for each, or the amount which the two communities have in common. The Index of Similarity may vary from zero for two communities which have no measures in common to 100 percent for two quantitatively identical communities.

Following the determination of indices of similarity between each of the 166 communities a method of objectively determining the degree of affinity and relative hiatus points between groups of communities was sought. Cluster analysis using the weighted pair - group method was selected over factor analysis on the basis that it can be used to relate units based on high similarity coefficients for defining groups among entities. The usefulness of factor analysis is limited by the amount of computation necessary to produce a simple cluster using only a small number of species and communities. Basically then, cluster analysis initially groups together communities in which the major species present are common to all communities in the group. This type of procedure for ecological studies was first described by Sorensen (1948). However, he used only presence and absence and was forced to choose arbitrary values to draw his clusters. Developments in the field of theoretical ecology and taxonomy following the rapid developments in electronic computers have allowed the ecologist to be more objective in the synthesis of field data.

The various methods of cluster analysis have been discussed by Sokal and Sneath (1963). In their opinion, the weight pair - group method gives the highest correlation with the original correlation coefficients. This method permits only the most highly correlated communities to join at each cycle. The new plot formed by these pairs has for its similarity index in respect to any other plot the simple average of its component or similarity indices $\frac{S^1{}_1 + S1_2}{2} = S1_2$, . This weighted pair - group method shows less distortion of the original similarity coefficient matrix and is considered to be devoid of any arbitrary criterion of group formation (Sokel and Sneath, 1963).

When species data for a large number of similar type communities are analyzed the cluster analysis is biased in that it produces discrete clusters. This may be viewed, however, as an advantage because it allows natural communities to be objectively classified at any level from the individual to the total range of vegetation over which the samples are considered to be representative.

The most convenient means of representing the weighted pair - group clusters is by the two - dimensional dendrogram method. Communities are represented on the abscissa, while the level of similarity is shown on the ordinate. Similarity coefficient values between highly similar communities are indicated by the position of the highest vertical lines that connect the communities represented by horizontal lines. Additional communities or groups of communities are included in the clusters by computations of similarity coefficients and, thereby, determine the basic form of the dendrogram. The larger groups of communities, as well as the more diverse, are associated at lower levels of similarity. This can then be considered as a measure of vegetational homogeneity as determined by the levels of similarity between successive clusters across the gradient.

Results of Cluster Analysis

The level of similarity between plots is comparatively less for xeric, hydric and hygric plots than those in the intermediary mesic positions as indicated in the dendrogram (Figure 9). Taking all plots into account the coefficient of similarity between individual plots ranges from 21-73 percent. In deriving associations or higher units levels of similarity must be selected. West (1966) has defined such levels as coenons. Within each coenon there may be several different but recognizable vegetation units. A horizontal line drawn across the dendrogram at the 30 percent level of similarity creates twenty-one 30-coenons (following Sokal and Sneath, 1964). At this level vegetation units may be recognized for all but the semi-terrestrial (chionophobous)) habitats. The reason for this will be discussed later. At lower levels of similarity subassociations and associations are grouped together and fewer units are present in each successive coenon.

The moderately drained or mesic habitats on the slopes dominated by Betula glandulosa, Ledum decumbens and Eriophorum vaginatum, include a total of 61 plots (3 associations), are joined together at the 28 percent level of similarity. The well drained or xeric sites are characterized by 22 plots (2 associations) and are joined at the 24 percent level of similarity. The poorly drained sites include a total of 28 plots (6 associations) and are associated at the 6 percent level. The snow bed or chionophilous habitats dominated by Salix chamissonis (14 plots) have a coefficient of similarity of 37 percent, the very late snow bed (Salix pseudopolaris) with five plots are joined at the 31 percent level of similarity. However, all three associations are joined at only the 8 percent level. It may be concluded that the mesic vegetation is comparatively more similar and covers a wider area than the more transitional or unstable and less extensive vegetation types found on the more

Figure 9

Dendrogram of plot similarities

RELATIVE LEVEL OF SIMILARITY
0
10
20
30
40
50
60
70
80
90
INDIVIDUAL PLOTS
Arctophiletum fulvae
Eriophoretum angustifolii
e.a.
caricosum
Caricetum aquatilis
Caricetum rariflorae
Eriophoretum scheuchzeri
Caricetum aquatilis
s.a.
Eriophoretum angustifolii
s.p.
Betulo - Chamaemoretum
b.c.
a.c.
b.g.
Salicetum pulchrae
s.p.
Salicetum chamissonis
Salicetum pseudopolaris
Vaccinio - Betuletum glandulosae
f.
Salicetum pulchrae
s.r.
s.r.
Betulo - Eriophoretum vaginati
b.-e.v.
fruticosum
Vaccinio - Betuletum glandulosae
fruticulosum
cassiopetosum tetragonae
Betulo - Ledetum decumbentis
b.-l.d.
d.-s.r.-g.
Lupino - Dryadetum *alaskensis
d.
Salicetum phlebophyllae

APPENDIX II

SUMMARY OF DAILY MAXIMUM - MINIMUM TEMPERATURE AND RELATIVE HUMIDITY DATA AT GROUND LEVEL FOR CANOE LAKE MICROCLIMATIC STATIONS. JULY AND AUGUST 1966

(^{o}F and %)

JULY

Station		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1	Temp. Max.	78	80	62	66	72	63	62	62	61	60	77	76	70	69	60	77	73	73	47	57	71	64	66	48	46	32	44	37	58	62	64
	Temp. Min.	50	44	34	32	52	48	47	46	44	48	47	53	56	48	49	56	57	34	32	38	48	46	48	42	30	28	29	32	31	44	44
	R.H. Max.	68	88	100	100	76	100	100	100	100	100	97	80	77	76	97	69	72	98	98	97	80	87	100	100	98	96	100	98	98	74	75
	R.H. Min.	38	34	49	43	34	55	61	100	40	58	33	44	42	40	47	47	45	52	64	66	37	62	59	83	71	90	58	87	44	51	44
2	Temp. Max.	78	76	61	65	69	60	61	56	60	60	76	77	68	69	71	76	72	75	48	57	73	65	67	50	48	57	48	41	60	61	64
	Temp. Min.	56	44	39	31	43	46	40	44	43	45	39	44	51	45	40	45	56	35	34	36	45	47	48	43	31	29	35	33	25	35	36
	R.H. Max.	100	100	100	100	100	100	100	100	100	100	100	92	92	100	100	94	87	100	100	100	100	100	100	100	100	100	96	100	100	98	100
	R.H. Min.	50	57	75	69	61	79	83	100	73	79	56	66	69	65	64	62	60	68	82	81	54	80	64	92	82	87	71	93	61	74	72
3	Temp. Max.									60	58	74	74	64			75	73	72	53	62	73	64					47	47	60	65	67
	Temp. Min.									41	45	42	52	54				57	37	36	38	47	49					36	36	28	39	37
	R.H. Max.										100	92	86	80	98	100	80	85	100	95	95	95	90					80	96	94	97	95
	R.H. Min.										60	36	43	42	41	41	58	55	66	76	72	58						67	78	56	67	66
4	Temp. Max.	76	78	62	68	74	63	63	54	62	58	75	80	71	70	71	74	76	77	50	59	75	70	69	50	49	37	48	47	66	69	72
	Temp. Min.	54	46	33	31	46	47	42	43	42	44	40	50	51	45	42	49	56	36	35	38	47	48	49	43	31	29	31	36	30	47	44
	R.H. Max.	100	98	100	100	100	100	100	100	100	100	100	100	71	78	100	66	71	100	100	100	100	93	100	100	100	100	90	100	100	72	89
	R.H. Min.	35	31	54	40	31	53	63	100	49	48	26	34	36	35	40	33	32	40	62	57	23	48	42	76	63	85	49	71	29	38	42
5	Temp. Max.		80	64	68	75	68	64	56	64	60	77	78	71	70	72	78	76	77	52	61	76	70	72	53	52	43	51	42	65	67	68
	Temp. Min.		50	37	33	43	50	52	49	47	50	38	52	58	49	39	43	54	37	36	38	42	50	50	43	32	32	34	36	26	38	37
	R.H. Max.		75	100	100	100	100	100	100	100	93	100	94	97	68	100	98	65	100	91	95	85	100	98	96	91	95	70	91	98	90	96
	R.H. Min.		29	58	45	33	55	63	89	48	51	28	38	38	38	38	35	34	42	53	53	26	50	38	64	54	68	46	68	46	68	34
6	Temp. Max.		72	56	57	60	57	53	49	62	62	73	76	72	71	74	72	70	68	51	58	68	65	67	54	49	42	49	42	58	62	62
	Temp. Min.		47	36	31	39	45	39	42	42	53	48	57	62	55	49	59	56	42	40	42	46	52	52	49	37	35	36	40	30	39	39
	R.H. Max.									100	92	98	100	100	76	100	98	98	100	100	100	100	100	100	100	100		100	98	100	100	100
	R.H. Min.									54	57	48	40	39	38	50	54	37	57	100	76	38	58	60	85	68		70	86	56	72	70

SUMMARY OF DAILY MAXIMUM - MINIMUM TEMPERATURE AND RELATIVE HUMIDITY DATA AT GROUND LEVEL FOR CANOE LAKE MICROCLIMATIC STATIONS. JULY AND AUGUST 1966

(^{0}F and %)

JULY

Station			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
7	Temp.	Max.		78	65	66	73	66	63	55	64	59	78	80	72	71	73	80	76	75	52	60	76	69	73	52	50	41	50	43	64	68	69
		Min.		50	36	33	42	51	40	48	47	45	37	52	54	50	40	44	54	38	38	39	42	50	49	45	34	32	34	37	27	38	38
	R.H.	Max.		68	100	100	100	96	100	100	100	89	92	85	85	78	100	94	77	100	93	94	95	89	94	100	100	93	89	91	98	94	96
		Min.		26	47	36	25	49	52	79	40	53	30	37	38	36	35	34	37	43	53	52	28	49	50	66	57	68	49	74	35	42	41
8	Temp.	Max.		76	65	66	71	66	59	52	64	63	84	85	80	78	81	81	84	74	54	64	83	72	75	52	53	45	53	43	68	71	70
		Min.		47	55	33	46	47	41	45	43	46	42	51	54	46	46	50	54	35	35	38	44	47	48	42	31	30	32	35	28	44	42
	R.H.	Max.		70	100	100	90	96	100	90	98	94	95	88	85	85	96	90	95	100	95	96	93	95	100	95	96	95	94	92	95	79	88
		Min.		26	44	36	33	44	55	81	40	49	45	52	51	50	50	52	50	61	69	66	46	50	65	77	70	79	65	77	48	54	56
9	Temp.	Max.										56	77	77	71	69	70	79	77	76	50	57	86	66	68	52	49	37	48	43	64	65	68
		Min.										40	32	44	45	44	33	38	47	34	34	35	36	45	42	42	30	29	32	31	22	34	33
	R.H.	Max.										92	96	90	90	91	100	92	78	100	86	92	94	82	95	95	92	90	67	86	94	91	92
		Min.										42	22	30	30	30	30	24	26	33	44	45	16	42	27	57	46	77	49	52	27	40	37

AUGUST

Station			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1	Temp.	Max.	62	58	63	67	58	62	60	46	35	31	44	46	50	51	50	58	58	57	54	57	58	59	60	61	46	46	58				
		Min.	46	45	46	46	42	40	44	30	29	28	26	31	31	32	34	40	45	42	40	41	40	44	46	31	32	35	43				
	R.H.	Max.	60	95	100	98	100	95	98	100	95	95	95	88	93	98	95	65	80	98	98	100	80	57	81	98	97	94	78				
		Min.	41	54	60	43	62	57	57	68	95	52	62	55	41	48	48	40	47	46	55	62	40	45	49	65	52	75	46				
2	Temp.	Max.	62	60	61	69	61	61	61	48	35	34	50	49	52	52	50	61	60	60	55	59	59	63	61	54	50	46	62	68			
		Min.	40	41	37	41	41	41	39	30	29	28	25	30	27	25	34	33	44	38	38	38	40	40	44	32	30	30	34	37			
	R.H.	Max.	84	100	100	100	100	100	100	100	100	100	100	98	100	100	100	97	86	100	100	100	92	88	98	100	100	100	995	95			
		Min.	62	80	79	61	72	75	76	83	100	66	71	70	68	67	69	60	66	64	80	62	57	62	67	82	66	92	62	57			
3	Temp.	Max.	64	64	64	70	62	65	64	52	39	34	50	49	57	55	53	60	58	58	55	60	58	61	58	51	48	47	60	65			
		Min.	38	43	37	42	44	42	40	32	81	30	22	31	27	26	31	31	44	42	38	39	41	38	43	41	32	29	36	35			
	R.H.	Max.	93	98	96	96	97	96	96	96	94	94	100	90	98	97	96	93	77	100	100	97	92			100	100	100					
		Min.	57	74	72	55	67	69	69	75	92	92	67	67	64	62	64	58	60	62	77	71	54				66	82		62			

SUMMARY OF DAILY MAXIMUM – MINIMUM TEMPERATURE AND RELATIVE HUMIDITY DATA AT GROUND LEVEL FOR CANOE LAKE MICROCLIMATIC STATIONS. JULY AND AUGUST 1966 (°F and %)

AUGUST

Station			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
4	Temp.	Max.	69	66	68	77	66	69	69	53	38	37	50	52	60	60	58	65	66	65	60	64	64	67	64	57	53	49	63				
		Min.	49	45	42	47	45	43	47	32	31	31	27	35	32	31	35	39	50	42	41	43	44	42	48	43	35	33	39				
	R.H.	Max.	59	100	100	100	100	100	100	100	100	100	98	88	98	100	100	77	63	100	100	100	88										
		Min.	30	53	50	28	57	45	32	51	100	91	48	42	36	32	33	27	33	33	57	48	26										
5	Temp.	Max.	66	64	66	75	64	66	66	52	42	40	52	53	56	56	56	64	63	63	58	61	65	66	63	56	53	49	63	66			
		Min.	41	44	40	40	45	44	40	42	32	32	28	31	26	24	34	42	48	38	34	35	44	38	45	40	33	33	35	33			
	R.H.	Max.	87	100	100	98	98	96	96	97	95	90	88	85	96	98	95	91	73	100	98	96	80	86	100	100	100	100	96	96			
		Min.	34	55	52	32	46	44	45	52	66	71	45	42	38	37	38	30	38	37	53	50	32	36	42	55	71	74	37	42			
6	Temp.	Max.	61	58	60	60	52	63	60	50	39	38	48	50	50	50	52	60	52	50	55	55	57	61	59	56	49	48	60	62			
		Min.	40	42	41	40	44	44	41	35	35	32	32	34	29	26	34	32	43	41	36	36	45	38	42	42	35	35	36	34			
	R.H.	Max.	98	98	98	100	98	98	100	96	98	97	92	87	97	98	96	100	98	96	100	98	92	95	98	100	100	100	100				
		Min.	57	71	74	72	82	75	71	75	88	85	65	69	60	66	62	60	53	57	75	92	52	53	57	70	57	85	66				
7	Temp.	Max.	68	65	66	71	63	67	66	53	39	39	51	52	56	57	56	66	64	60	60	62	65	66	63	56	53	50	62	64			
		Min.	40	43	37	39	46	44	40	34	33	30	28	34	25	24	33	30	43	41	35	44	42	38	40	37	36	33	35	34			
	R.H.	Max.	68	95	100	98	94	97	96	95	96	100	98	94	92	96	94	94	82	98	97	90	72	71	100	98	97	96	95	94			
		Min.	32	48	49	40	50	44	43	53	65	49	52	44	40	34	35	30	28	43	53	37	31	37	44	55	40	70	50	47			
8	Temp.	Max.	73	70	68	71	58	71	70	50	38	38	53	54	57	59	60	63	71	62	59	60	66	71	63	56	55	49	66	64			
		Min.	46	44	40	44	44	42	44	32	30	30	25	33	29	28	34	36	44	40	40	40	40	40	44	34	33	31	36	44			
	R.H.	Max.	67	96	96	94	93	92	94	96	98	92	86	93	95	91	77	80	94	94	93	87	73	96	94	95	93	94	93	93			
		Min.	47	58	60	58	76	56	65	83	77	61	56	54	48	48	48	47	54	65	65	46	58	57	70	57	79	52	55	62			
9	Temp.	Max.	65	62	64	71	64	65	64	49	37	34	50	52	56	56	54	65	65	60	59	60	65	68	64	58	53	50	65	63			
		Min.	34	40	34	32	42	39	34	31	28	27	22	30	20	22	28	26	37	38	30	34	38	32	38	34	30	30	32	35			
	R.H.	Max.	77	90	100	90	91	96	93	90	88	86	82	78	92	90	94	93	85	94	100	92	72	86	98	92	95	96	92	92			
		Min.	27	45	44	32	39	39	40	48	70	58	39	37	33	29	31	31	27	31	47	28	20	27	34	47	33	63	28	22			

7. Strata Coverage (%) refers to the area covered by the indicated strata as a percentage of the plot area. Strata are defined: B layer (shrub layer), C layer (herb layer), D layer (ground surface layer, including mosses and lichens). The symbol Dr refers to coverage of lichens on rocks.

8. Plot coverage (%) refers to the area covered by water or rock as a percentage of the plot area.

9. Drainage is an estimate determined from observation and refers to the moisture condition of the plots prior to the first autumn snowfall.

10. Hygrotope classes refer to the moisture regime status of the plots studied in the Low Arctic Subalpine/Foothill Zone. They are related to moisture conditions during the snow free period and not conditions immediately following snow melt. The classes are related to topography, soil profile characteristics, thickness of the active layer, drainage and levels of watertable in the profile if present. Descriptions of the six classes used are as follows:

Hygrotope class	Description
Xeric	Ridge tops and escarpments. Active layer very deep, although actual soil layers are shallow and well drained.
Sub-xeric	Upper exposed slopes. Soils well drained with some seepage in late spring. Active layer deep.
Mesic	Medium textured soils with good drainage, seepage in lower part of profile during the summer. Depth of active layer variable, deeper under hummocks than depressions.
Moist	Snow bed habitats with moderately drained soils. Gleying is evident in the soil profile and seepage occurs. Active layer always deep.
Hygric	Moderately to imperfectly drained soils on lower slopes. Gleying is evident in moderately drained soils. Water below surface during latter part of summer. Seepage always present. Active layer very shallow to shallow.
Hydric	Soils with impeded drainage. Active layer very shallow. Water level may be at, or near, the surface during the summer.

11. Chemical analyses

Chemical properties present in the tables represent average values for the organic, organic - mineral and mineral layers. The number of samples for each layer was determined on the basis of percent organic matter present in each sample (i.e. organic layer over 32 percent, organic - mineral layer between 2 and 35 percent and mineral layer from 0.0 to 10 percent).

APPENDIX III

APPENDIX III

EXPLANATORY NOTES FOR VEGETATION AND ENVIRONMENT SYNTHESIS TABLES

A. Vegetation Tables (Numbers 2a - 15a)

1. Nomenclature of the units follows standard phytosociological practice. Phytosociological designations are modified from the generic name of the species and in some cases the specific name appears in the genitive case.

Orders:	-talia
Alliances:	-ion
Associations:	-etum
Subassociations:	-etosum
Variations:	-osum

2. Species ratings for individual plots follow the Domin-Krajina scales (see Krajina, 1933) for species significance and Lambert for sociability and are given by two figures (i.e. 3.1)

Species significance (combined scale for abundance and dominance)

+	Very sparsely present, dominance very small
1	Sparsely present, dominance small
2	Very scattered, dominance small
3	Scattered to plentiful
4	Often, dominance 1/20 to 1/10 of plot
5	Often, dominance 1/5 to 1/4 of plot
6	Any number of individuals, dominance 1/4 to 1/3
7	Any number of individuals, dominance 1/3 to 1/2
8	Any number of individuals, dominance 1/2 to 3/4
9	Any number of individuals, dominance over 3/4
10	Any number of individuals, dominance 100% of plot

Sociability

+	Growing singly
1	Grouped or tufted, up to 16 sq. m
2	Group, 1/3 to 2/3 sq. m
3	Group, 1 to 2 sq. m
4	Group, 5 to 20 sq. m
5	Group, 25 to 50 sq. m

3. Plots are arranged horizontally across the table by increasing elevation from left to right.

4. Species are arranged vertically for each table as follows:

a) by strata

B layer	B_1	Shrubs over 6 feet in height
	B_2	Shrubs 6 inches to 6 feet in height
C layer		Small woody plants less than 6 inches in height and all herbaceous plants
D layer		Bryophytes, lichens and all seedlings.

b) by decreasing presence value within strata

c) by decreasing cover value within strata

5. Constancy and average cover value ratings are listed in the synthesis tables for all species except those listed as "Sporadic species". For species occurring in two, or more, strata, only one rating was made. Average cover values for individual species were determined by totalling their species significance values and dividing by the number of plots sampled in the association. Constancy was rated on a linear scale of 5 classes as indicated below.

Species occurring on % of plots	Constancy scale of 5 classes
81-100	V
61- 80	IV
41- 60	III
21- 40	II
1- 20	I

B. Environment Tables (Numbers 2b - 15b)

Nomenclature of the units and organization of the plots within any ecosystematic unit is described in note A no. 1.

1. Locality is designated as follows:

Richardson Mountains, Northwest Territories		
	Canoe Lake	CL
	Divided Lake	DL
British Mountains, Yukon Territory		
	Trout Lake	TL

2. Land form describes the old land surface topography (i.e. depression, ridge top, exposed slope, river bank, old drainage pathway or lake edge).

3. Relief: Profile describes the surface shape of the sample plot (i.e. concave, convex, straight, flat or hummocky).

4. Exposure (°) refers to the topographic position of the plot in relation to a particular cardinal point (i.e. 90 - facing due east).

5. Slope gradient (°) refers to the average inclination of the ground surface from the horizontal plane.

6. Snow duration (months) is an estimate determined from observations and refers to the length of time between snowfall remaining in the autumn and complete melt from the plot surface in late spring or at any time during the summer.

xeric or hydric ends of the gradient.

Because of the large number of plots used in the cluster analysis it is to be expected that not all would be neatly clustered into associated units. A plot which is a component of one cluster may be included with an adjacent cluster. While the individual plot may have the same dominant species as the cluster it is arbitrarily grouped with, its degree of similarity with all the plots in that cluster is less than with those it is objectively grouped with. Such an example may be found with plots 163 and 166. Both are clustered with Vaccinio - Betuletum glandulosae fruticulosum but subjectively associated with Betulo - Ledetum decumbentis cassiopeetosum tetragonae on the basis of their dominant species - <u>Cassiope tetragona</u>.

Due to the complex nature of the environmental factors encountered in the Arctic, it appears impossible to attain a smooth bell-shaped curve for individual species distribution. Whereas ordination illustrates only gradients such a dendrogram as shown here produces synecological units, on a species presence/ absence basis only, that are necessary for practical synecological programs. A detailed discussion of the vegetation units as related to environmental phenomena is presented in the following chapters.

DESCRIPTION OF VEGETATION UNITS

Synthesis tables providing full details of the vegetation-environmental relationships are presented for each association, and where applicable, sub-associations and variations. Listed in Appendix I are 419 taxa, including vascular plants, bryophytes and lichens. The major floristic and environmental features which characterize these units are outlined in this section. The descriptions are presented so that relationships between related units will be evident.

A. Chionophobous plant communities with snow duration averaging nine months or less.

Terrestrial plant communties

1. Salicetum phlebophyllae   Table 2 (a) & (b)   (Figure 10)

Salix phlebophylla is the dominant species in plots on the exposed well drained upper limits of ridges and felsenmeer slopes where vegetation is very sparse. These sites are on predominantly north - northwest facing slopes. They range in elevation from 1450-2025 ft at Canoe Lake and are present at the 1150 ft level at Trout Lake. Spetzman (1959) in his studies on the Alaskan Slope had found S. phlebophylla to be common along the mountain front between 2000-4000 ft. There is little snow accumulation because of the exposed position so that snow persistance in this association is generally short, seldom more than 7 1/2 months per year. Such areas are well drained and their soils are free from frost in the summer, and because of their convex profile are without seepage water. The soils are generally shallow, although the thickness of the active layer is greatly increased by the coarseness of the underlying ice shattered rock materials. Exposed rock is estimated to cover between 30-80 percent of the surface area. Physical weathering is important in contrast to chemical weathering. Mechanical breakdown of parent materials is by frost cleavage during the freeze-thaw cycles and wind action. These two factors are responsible for restricting colonization of additional microhabitats.

Table No. 2 b

Salicetum phlebophyllae

Plot No.		62	15	13	4	1
Plot size (m^2)		16	16	16	16	16
Date Analyzed		13/7 1965	15/6 1965	14/6 1965	10/6 1965	9/6 1965
PLOT DATA						
Locality		TL	CL	CL	CL	CL
Elevation		1150	1450	1550	1880	2025
PHYSIOGRAPHY						
Land form		Ridge side	Ridge top	Exposed slope	Ridge side	Ridge side
Relief: Profile		Cvx	Flat	....Convex....		Stg
Exposure (°)		200	Total	0	270	270
Slope gradient		8	0	20	37	14
CLIMATE						
Snow duration		.............$7\frac{1}{2}$ months				
STRATA COVERAGE (%)						
B_1 layer						
B_2 layer						
C layer		40	20	20	35	25
D layer	Moss	5	5	2	5	25
	Lichen	15	20	23	30	15
	Dr	15	40	60	15	15
Total D		35	65	85	50	55
PLOT COVERAGE (%)						
by rock		35	80	95	40	30
by water						
SOIL						
Drainage		.............Well drained				
Hygrotope		...............Xeric				
Depth of active layer		............Undetermined				
CHEMICAL ANALYSIS						
No.of samples		1	2	1	2	2
Organic - Mineral layer	OM	2.0	2.5	3.1	4.1	3.0
	N%	.09	.07	.14	.17	.07
	C/N	12.9	20.7	12.8	14.0	24.9
	P ppm	5	5	8	6	10
	Na	.42	.72	.85	.72	1.07
	K	.1	.11	.14	.33	.18
	Ca	1.1	.9	1.1	1.9	.9
	Mg	.1	–	.1	.9	.3
	CEC	11.8	46.1	19.3	17.3	7.4
	pH	4.7	4.6	4.8	5.1	4.3
Mineral layer	OM		.2		1.5	.9
	N%		.05		.08	.04
	C/N		2.3		10.9	13.1
	P ppm		6		6	13
	Na		.81		.8	.83
	K		.07		.17	.09
	Ca		.9		.7	.9
	Mg		–		.3	–
	CEC		17.3		11.8	7.4
	pH		5.1		4.9	4.9

Table No. 2 a

Salicetum phlebophyllae

Number of Plots	1	2	3	4	5		
Plot No.	62	15	13	4	1		
Plot size (m^2)	16	16	16	16	16		
Elevation (ft)	1150	1450	1550	1800	2025		
C layer						Constancy	Avg. Cover
1 Salix phlebophylla	4.2	4.2	4.2	6.3	4.2	V	4.4
2 Hierochloe alpina	1.1	2.1	2.1	1.1	1.1	V	1.4
3 Arenaria arctica	+.+	1.1	2.1	1.1	1.1	V	1.2
4 Oxytropis nigrescens	3.1	2.1	-	+.+	3.2	IV	1.8
5 Dryas octopetala	4.2	1.1	-	1.1	1.1	IV	1.6
6 Carex podocarpa	-	1.1	3.1	1.1	1.1	IV	1.2
7 Antennaria neoalaskana	2.1	+.+	-	1.1	1.1	IV	1.0
8 Douglasia arctica	1.1	1.1	1.1	-	2.1	IV	1.0
9 Selaginella sibirica	1.1	+.+	1.1	-	1.1	IV	.8
10 Arctostaphylos alpina	-	1.1	-	1.1	+.+	III	.6
11 Artemisia arctica	-	1.1	-	-	1.1	II	.4
12 Luzula confusa	-	-	-	1.1	+.+	II	.4
13 Smelowskia calycina	+.+	1.1	-	-	-	II	.4
D layer (Bryophytes)							
14 Gymnomitrion corallioides	+.1	1.1	-	2.1	4.2	IV	1.6
15 Polytrichum piliferum	2.1	2.2	+.+	-	-	III	1.0
16 Polytrichum juniperinum	-	-	1.1	-	5.2	II	1.2
17 Rhacomitrium lanuginosum	1.1	-	-	2.2	-	II	.6
(Lichenes)							
18 Cornicularia divergens	2.1	3.1	4.2	2.1	3.1	V	2.8
19 Alectoria miniscula	2.1	2.1	+.+	1.1	1.1	V	1.4
20 Parmelia separata	1.1	2.1	2.1	1.1	1.1	V	1.4
21 Parmelia omphalodes	+.+	1.1	1.1	1.1	1.1	V	1.0
22 Sphaerophorus globosus	1.1	+.+	1.1	+.+	1.1	V	1.0
23 Rhizocarpon geographicum	1.1	2.1	3.1	4.1	-	IV	2.0
24 Haematomma lapponicum	1.1	2.1	4.2	-	2.1	IV	1.8
25 Cetraria nivalis	1.1	1.1	2.1	2.1	-	IV	1.2
26 Cetraria chrysantha	1.1	1.1	-	2.1	+.+	IV	1.0
27 Alectoria ochroleuca	2.1	1.1	1.1	+.+	-	IV	1.0
28 Thamnolia vermicularis	-	1.1	+.+	+.+	1.1	IV	.8
29 Umbilicaria proboscidea	-	4.+	5.+	+.+	-	III	2.0
30 Alectoria nigricans	-	3.1	3.2	-	3.1	III	1.8
31 Umbilicaria hyperborea	1.+	-	2.+	-	4.+	III	1.4
32 Ochrolechia frigida	+.+	2.1	-	3.2	-	III	1.2
33 Cetraria nigricascens	-	2.1	1.1	2.1	-	III	1.0
34 Pertusaria coriacea	-	1.1	-	3.2	+.+	III	1.0
35 Cetraria cucullata	1.1	-	-	2.1	+.+	III	.8
36 Hypogymnia subobscura	1.1	+.+	-	-	+.+	III	.6
37 Parmelia alpicola	-	-	4.2	1.1	-	II	1.0
38 Parmelia stygia	+.+	-	1.1	-	-	II	.4
39 Cetraria scholanderi	-	1.1	1.1	-	-	II	.4
40 Lecidea flavocaerulescens	-	-	1.1	1.1	-	II	.4
TOTAL SPECIES (incl. sporadics)	33	38	42	37	29		

Sporadic species

C layer

41 Diapensia lapponica 4(1.1)
42 Vaccinium vitis-idaea 4(+.+)
43 Ledum decumbens 4(+.+)
44 Kobresia myosuroides 15(2.1)
45 Salix brachycarpa 15(1.1)
46 Saxifraga tricuspidata 15(+.+)
47 Potentilla vahliana 15(1.1)
48 Draba nivalis 62(+.+)
49 Lupinus arcticus 62(+.+)
50 Poa arctica 62(1.1)
51 Tofieldia coccinea 62(1.1)

D layer (Bryophytes)

52 Encalypta rhaptocarpa 1(1.1)
53 Pogonatum capillare 4(+.+)
54 Hypnum cupressiforme 13(1.1)
55 Pohlia nutans 15(+.+)

D layer (Lichenes)

56 Cetraria tilesii 1(1.1)
57 Cetraria hepatizon 4(1.1)
58 Toninia cumulata 4(1.1)
59 Pertusaria panyrga 4(+.+)
60 Cladonia chlorophaea 4(+.+)
61 Lecanora polytropa 4(+.+)
62 Cladonia mitis 13(1.1)
63 Buellia atrata 13(1.1)
64 Lecidea lapicida 13(1.1)
65 Parmelia almquistii 13(1.1)
66 Cladonia pleurota 13(+.+)
67 Lecidea atromarginata 15(5.2)
68 Stereocaulon rivulorum 62(1.1)
69 Solorina crocea 62(1.1)

Organic matter is present only under the vegetative mats.

In comparison with all other communities the Salicetum phlebophyllae develops on sites with only the slightest protection from desiccating winds. These sites are formed by movements of surface rock and materials due to freeze-thaw cycles. While no non-sorted polygons are recognized, there is a sorting of substrate, leaving coarse materials exposed and the finer materials covered with vegetation. Due to the exposed position of the community the majority of the species tend to have a prostrate form. The vegetation is dominated by woody species that are characterized by their ability to form mats. These mats, however, never form a closed system. As much as 40 percent of each mat consists of dead leaves, twigs and stems.

Figure 10. Depression on exposed ridge (1500 ft) with Arctic Hamada west side of Canoe Lake, dominated by Salix phlebophylla with scattered Betula glandulosa. Sandstone fragmented by freeze-thaw action with evidence of frost heaving in foreground. (Photo by Krajina)

Flowering occurs earlier in this association than in any other, and has generally been completed before species on the lower slopes have started to bud. Porsild (1951) and others have described the phenomena of the arctic plants being frozen and covered with ice crystals in the early morning and thawing a few hours later and showing no apparent sign of frost damage.

Associated with Salix phlebophylla but with lower coverage values are such mat forming species as Arenaria arctica, Oxytropis nigrescens, Douglasia arctica, Selaginella sibirica and scattered Dryas octopetala spp. alaskensis. In more sheltered positions Hierochloe alpina, Antennaria neoalaskana and Carex podocarpa are present, but with very low coverage values. In the five plots representing this community there are only three vascular plants constantly present: Salix phlebophylla, Arenaria arctica and Hierochloe alpina. An indication of the exposed position of these plots is the presence of the liverwort Gymnomitrion corallioides. This species occurs only in areas exposed to the wind and is associated with Polytrichum piliferum, P. juniperinum and Rhacomitrium lanuginosum.

The lichen flora in this association is rich and has a high total percent cover value in relation to the vascular and bryophyte flora. Saxicolous species include Alectoria miniscula, Parmelia separata, P. stygia, Rhizocarpon geographicum, Haematomma lapponica, Umbilicaria hyperborea, U. proboscidea, Lecidea flavocaerulescens and L. atromarginata. Species growing among the mats and mosses include Cornicularia divergens, Cetraria cucullata, C. nivalis, C. chrysantha, Sphaerophorus globosus, Thamnolia vermicularis, Alectoria ochroleuca and A. nigricans. There are few species present on dead plant material and bare soil due to the instability of these substrates. However, Ochrolechia frigida, Pertusaria coriacea, Hypogymnia subobscura and Cetraria nigricascens are occasionally present.

While there are few constant species in this association there appears to be no lack of species able to tolerate such adverse conditions. Approximately sixty five species, including vascular plants, bryophytes and lichens, are present in the Salicetum phlebophyllae.

2. Lupino - Dryadetum *alaskensis Table 3(a) & (b)

In contrast to the exposed sparsely vegetated sites discussed earlier are the slightly more sheltered Dryas dominated slopes. These floristically rich habitats contain a larger number of species and show more variation than any other association in the study region. They are comparable to the Dryadetum in Sweden (Gjaerevoll and Bringer, 1965) and the Dryas punctata - Salix reticulata in Scotland (McVean, 1964). With a decrease in exposure the amount of bare soil and rock is reduced and vegetation becomes more compact. However, snow cover in winter is still scanty so that the mat-forming species are constantly being eroded by wind. The bare areas are generally populated by such crustose lichen as Pertusaria, Ochrolechia and Lecidea.

Two subassociations are distinguished in this subalpine zone, the depauperatum and the dryadeto - salicetosum reticulatae - glaucae.

(a) dryadetosum *alaskensis (depauperatum) (Figure 11)

This subassociation is characterized by strongly acid soils and is found on very well drained upper convex-straight felsenmeer slopes. In the Canoe Lake area all sampled plots have westerly exposures and are between 1450-2000 ft elevation. At Trout Lake the one plot analyzed was at 600 ft with an easterly exposure. Slope gradients are all gentle between 5-14°. Exposed rock in these plots was estimated to cover between 10-30 percent of the surface area. Snow cover and accumulation is slightly greater than the Salicetum phlebophyllae but not necessarily 100 percent. Duration of snow is estimated to be longer by approximately two weeks. Drainage during the annual thaw is rapid with xeric conditions prevailing throughout most of the summer. The soil profile while generally shallow does indicate some genetic development. Physical and chemical weathering are probably equally important. Fine soil is blown from the areas where it is exposed and not held by plant cover. Rock fragments

Table No. 3 b

	73	137	25	2	77	61	10	136	9	146	133	178	7	104
	Lupino - Dryadetum *alaskensis													
	depauperatum				dryado - salicetosum reticulatae - glaucae									
Plot No.	73	137	25	2	77	61	10	136	9	146	133	178	7	104
Plot size (m^2)	............25............				..............................50..............................									
Date Analyzed	15/7 1965	11/7 1966	19/6 1965	9/6 1965	15/7 1965	12/7 1965	13/6 1965	11/7 1966	13/6 1965	14/7 1966	10/7 1966	12/8 1966	11/6 1965	11/8 1965
PLOT DATA														
Locality	TL	CL	CL	CL	TL	TL	CL	CL	CL	CL	CL	CL	CL	CL
Elevation (ft)	600	1450	1650	2000	450	1100	1500	1500	1600	1600	1775	1900	2125	2390
PHYSIOGRAPHY														
Land form	Depre-ssion	Ridge top	Stone stripe	Ridge side	River bank	..Sheltered.. slope		Ridge side	Ridge top	...........Ridge - leeside.........				
Relief: Profile	Cnv	Stg	...Convex....		...Straight..		Stg-Hum	Stg	Flat	......Convex........			..Straight..	
Exposure (°)	45	270	315	315	135	90	180	270	0	200	315	250	65	270
Slope gradient (°)	7	5	5	14	67	72	16	10	0	15	4	20	12	12
CLIMATE														
Snow duration	..........8 months.........				..............................8 months..............................									
STRATA COVERAGE (%)														
C layer	65	70	70	85	100	100	60	80	55	95	85	90	95	65
D layer Moss	25	25	15	20	15	30	35	5	10	40	55	25	10	10
Lichen	15	15	40	20	10	15	45	30	25	25	20	55	20	25
Dr	10	15	12	2			1	10	15	2	1	5	10	10
PLOT COVERAGE (%)														
by rock	20	35	20	5			2	20	45	10	5	10	20	30
SOIL														
Drainage	.......Well-drained.........				..............................Well-drained..............................									
Hygrotope	...........Xeric...........				..............................Xeric..............................									
Depth of soil profile (cm)	27	42	52	12	30	50	20	32	18	40	48	28	22	50
CHEMICAL ANALYSIS														
No.of samples						1	1	1	NT	2	1	1	NT	1
Organic layer OM						67.7	64.9	70.9		62.3	79.5	92.3		63.5
N%						1.61	1.8	1.1		.91	1.08	1.9		2.31
C/N						24.4	20.9	36.9		39.7	40.8	31.5		15.9
P ppm						3	13	30		28	32	26		16
Na						.54	.8	.98		1.12	1.06	.93		.8
K						1.06	.47	.73		1.51	.49	1.03		1.47
Ca						28.7	35.0	16.0		23.8	19.0	26.3		65.3
Mg						12.4	1.8	3.0		6.1	20.3	3.6		9.0
CEC						183.0	117.0	36.9		67.4	95.8	132.7		83.8
pH						5.4	6.1	6.7		6.3	5.6	5.8		7.3
No.of samples	2	1	1		1	1			1				1	
Organic - Mineral layer OM	9.1	13.0	22.8		33.2	16.6			23.3				18.0	
N%	.08	.29	.78		.93	.51			.79				.66	
C/N	84.1	26.0	17.0		20.7	18.9			17.1				15.8	
P ppm	6	10	37		13	13			24				8	
Na	.42	.84	.72		.52	.61			.74				.73	
K	.33	.34	1.18		.63	.33			.55				.23	
Ca	9.2	8.4	15.4		24.2	10.3			20.0				19.2	
Mg	.9	.6	7.1		4.6	2.5			1.4				1.0	
CEC	27.1	14.6	78.9		67.1	74.9			46.0				38.4	
pH	4.8	6.2	6.3		5.5	5.3			7.0				6.8	
No.of samples	1	2	1	2	1	1		2	1	2	2	1	1	4
Mineral layer OM	3.0	1.0	2.5	2.8	6.6	1.7		2.0	4.6	4.1	1.9	.0	3.8	5.6
N%	.26	.03	.08	.1	.17	.03		.08	.17	.25	.08	.04	.16	.12
C/N	6.7	23.2	18.1	13.7	22.5	32.9		14.5	15.7	9.3	13.4	.0	63.8	29.3
P ppm	3	8	10	11	5	6		12	6	13	10	5	5	12
Na	.44	.84	.76	.74	.49	.5		.77	.71	1.02	.76	.78	.72	.62
K	.16	.1	.22	.16	.15	.08		.34	.41	.87	.49	.41	.14	.25
Ca	3.8	1.1	1.6	1.1	4.6	4.1		2.0	13.5	17.6	14.6	4.5	12.8	8.2
Mg	.3	.4	.5	.3	1.4	1.4		.5	.5	3.8	12.8	.2	.8	1.4
CEC	15.2	9.6	16.3	5.7	30.0	19.7		14.4	23.4	37.9	33.5	13.6	18.1	26.9
pH	4.8	4.8	5.0	4.6	4.9	5.6		7.6	7.4	6.8	6.5	6.1	7.6	5.8

Table No. 3a

	depauperatum				dryado - salicetosum reticulatae - glaucae											
	Lupino - Dryadetum *alaskensis															
Number of Plots	1	2	3	4	1	2	3	4	5	6	7	8	9	10		
Plot No.	73	137	25	2	77	61	10	136	9	146	133	178	7	104		
Plot size (m^2)	25	25	25	25	50	50	50	50	50	50	50	50	50	50		
Elevation (ft)	600	1450	1650	2000	450	1100	1500	1500	1600	1600	1775	1900	2125	2390		
C layer															Constancy	Avg. Cover
1 Dryas octopetala	4.1	7.2	6.2	6.2	5.2	4.1	7.2	8.3	8.3	8.3	7.2	9.3	8.3	7.3	V	6.6
2 Lupinus arcticus	-	1.1	1.1	1.1	4.1	3.1	2.1	1.1	5.1	5.1	3.1	5.1	-	4.1	V	2.6
3 Hierochloe alpina	2.1	1.1	2.1	2.1	1.1	2.1	-	1.1	1.1	-	2.1	4.1	3.1	1.1	V	1.6
4 Arenaria arctica	1.1	1.1	+.+	1.1	-	1.1	1.1	1.1	2.1	2.1	2.1	1.1	1.1	2.1	V	1.2
5 Polygonum viviparum	-	+.+	1.1	1.1	1.1	-	1.1	+.+	+.+	1.1	1.1	2.1	2.1	+.+	V	.9
6 Vaccinium uliginosum	-	-	-	2.1	7.2	6.2	6.2	-	3.1	3.1	5.2	1.1	1.1	1.1	IV	2.4
7 Salix phlebophylla	3.1	5.2	5.2	2.1	-	4.2	-	1.1	1.1	2.1	+.+	-	2.1	2.1	IV	2.0
8 Betula glandulosa	5.2	-	1.1	2.1	2.1	5.2	1.1	-	-	1.1	1.1	-	+.+	-	IV	1.3
9 Saxifraga tricuspidata	-	2.1	2.1	2.1	-	2.1	-	+.+	3.1	2.1	-	-	2.1	3.1	IV	1.3
10 Oxytropis nigrescens	3.1	1.1	2.1	1.1	-	+.+	-	1.1	4.2	-	-	-	2.1	4.2	IV	1.3
11 Luzula confusa	-	1.1	1.1	2.1	-	-	1.1	+.+	-	1.1	1.1	3.1	2.1	1.1	IV	1.0
12 Carex podocarpa	-	-	2.1	1.1	-	-	1.1	2.1	-	1.1	1.1	4.1	1.1	1.1	IV	1.0
13 Oxytropis maydelliana	1.1	-	1.1	-	-	1.1	1.1	+.+	-	2.1	1.1	3.1	1.1	-	IV	.9
14 Senecio fuscatus	-	1.1	1.1	-	1.1	1.1	-	+.+	1.1	1.1	-	2.1	2.1	1.1	IV	.9
15 Saxifraga reflexa	-	+.+	+.+	-	1.1	1.1	-	-	1.1	2.1	-	1.1	+.+	2.1	IV	.8
16 Arctostaphylos alpina	5.2	-	5.2	3.1	3.2	-	5.2	-	3.1	2.1	-	-	-	1.1	III	1.9
17 Salix reticulata	-	-	-	-	-	-	4.1	-	4.2	4.2	5.2	3.1	+.+	1.1	III	1.6
18 Poa arctica	-	-	2.1	2.1	-	1.1	-	-	1.1	3.1	+.+	2.1	2.1	-	III	1.0
19 Antennaria neoalaskana	+.+	2.1	1.1	-	-	-	-	1.1	-	1.1	-	2.1	1.1	3.1	III	.9
20 Kobresia myosuroides	1.1	2.1	1.1	-	-	-	1.1	-	-	1.1	-	3.1	2.1	-	III	.8
21 Anemone narcissiflora	-	2.1	-	2.1	-	-	-	1.1	+.+	1.1	+.+	1.1	1.1	-	III	.7
22 Carex scirpoidea	-	-	-	-	-	-	1.1	1.1	1.1	1.1	1.1	3.1	1.1	-	III	.7
23 Tofieldia coccinea	-	-	-	-	-	1.1	1.1	2.1	1.1	2.1	1.1	1.1	1.1	-	III	.7
24 Bupleurum americanum	+.+	+.+	2.1	-	1.1	-	-	-	3.1	-	-	-	-	+.+	III	.7
25 Poa glauca	1.1	+.+	-	-	1.1	-	1.1	1.1	1.1	-	-	-	1.1	1.1	III	.6
26 Saxifraga punctata	-	-	-	1.1	-	-	1.1	-	-	1.1	1.1	2.1	+.+	-	III	.5
27 Douglasia arctica	-	-	+.+	1.1	-	-	-	1.1	-	1.1	-	1.1	1.1	1.1	III	.5
28 Artemisia arctica	1.1	+.+	1.1	-	2.1	1.1	-	-	-	1.1	-	-	-	-	III	.5
29 Luzula nivalis	-	-	1.1	-	-	-	-	+.+	-	1.1	1.1	2.1	1.1	-	III	.5
30 Salix glauca	-	-	-	-	6.2	3.1	1.1	-	-	4.2	4.2	-	+.+	-	II	1.2
31 Cassiope tetragona	-	-	-	-	-	-	4.2	3.2	-	-	3.2	-	3.1	-	II	.9
32 Rhododendron lapponicum	-	-	-	-	-	-	2.1	2.1	3.2	3.1	-	-	-	-	II	.7
33 Arnica alpina	-	3.1	-	-	1.1	-	-	-	1.1	1.1	-	+.+	1.1	-	II	.6
34 Silene acaulis	-	-	-	-	-	-	-	1.1	2.2	2.2	-	1.1	1.1	-	II	.6
35 Saxifraga bronchialis	-	-	-	-	2.1	2.1	-	-	-	1.1	-	-	-	2.1	II	.5
36 Pedicularis capitata	-	-	-	-	-	2.1	-	+.+	+.+	-	1.1	1.1	-	-	II	.4
37 Papaver macounii	-	-	-	-	-	-	1.1	-	-	1.1	3.1	1.1	-	-	II	.4
38 Saxifraga flagellaris	-	-	-	-	-	-	1.1	-	-	1.1	-	3.1	1.1	-	II	.4
39 Castilleja raupii	-	3.1	-	-	1.1	1.1	-	+.+	-	-	-	-	-	-	II	.4
40 Astragalus umbellatus	-	-	-	-	-	-	-	-	-	1.1	1.1	4.2	-	-	II	.4
41 Arctagrostis latifolia	-	-	-	2.1	-	-	1.1	-	-	1.1	1.1	-	-	-	II	.3
42 Saxifraga hieracifolia	-	-	-	-	-	-	1.1	-	-	1.1	+.+	1.1	-	-	II	.3
43 Cerastium beeringianum	-	-	-	-	-	-	-	-	1.1	+.+	-	2.1	-	+.+	II	.3
44 Saxifraga hirculus	-	-	-	-	-	-	1.1	-	-	-	-	3.1	1.1	-	II	.3
45 Salix arctica	-	-	-	1.1	-	-	-	-	-	-	2.1	1.1	-	-	II	.3
46 Pedicularis lanata	-	-	1.1	-	-	-	1.1	-	-	-	1.1	1.1	-	+.+	II	.3
47 Pedicularis arctica	-	-	-	+.+	-	-	1.1	-	+.+	-	-	-	1.1	-	II	.3
48 Trisetum spicatum	-	-	-	-	-	-	1.1	1.1	1.1	+.+	-	-	-	+.+	II	.3
49 Polygonum bistorta	-	-	-	1.1	-	-	1.1	-	-	1.1	+.+	-	-	-	II	.3
50 Stellaria longipes	-	-	1.1	1.1	-	-	-	-	-	1.1	1.1	-	-	-	II	.3
51 Saussurea angustifolia	-	-	-	-	-	-	1.1	-	-	1.1	+.+	+.+	-	-	II	.3
52 Carex capillaris	-	-	1.1	-	-	-	-	+.+	-	+.+	1.1	-	-	-	II	.3
53 Stellaria ciliatosepala	-	-	-	-	1.1	2.1	-	-	-	1.1	1.1	-	-	-	II	.3
54 Campanula uniflora	-	-	-	-	-	1.1	-	1.1	-	1.1	-	-	-	2.1	II	.3
55 Potentilla nivea	-	+.+	-	-	-	2.1	-	-	2.1	-	-	-	-	-	II	.3
56 Festuca brachyphylla	-	-	+.+	-	-	-	-	-	2.1	-	-	2.1	-	-	II	.3
57 Senecio resedifolius	-	-	-	-	-	-	-	1.1	2.1	-	-	-	-	1.1	II	.2
58 Senecio atropurpureus	-	-	-	1.1	-	-	-	-	-	-	+.+	-	-	+.+	II	.2
59 Selaginella sibirica	-	-	+.+	-	1.1	+.+	-	-	-	-	-	-	-	-	II	.2
60 Parrya nudicaulis	-	-	-	-	-	-	1.1	-	-	-	1.1	1.1	-	-	II	.2
61 Astragalus australis	-	-	-	-	-	-	-	-	4.2	-	-	-	3.1	-	I	.5
62 Diapensia lapponica	-	-	-	3.2	-	-	-	-	-	-	-	-	-	1.1	I	.4
63 Salix brachycarpa	-	2.1	-	-	-	-	-	1.1	-	-	-	-	-	-	I	.2
64 Carex lugens	-	-	-	-	-	-	1.1	-	-	-	-	-	-	-	I	.1
65 Lagotis glauca	-	-	-	-	-	-	1.1	-	-	-	+.+	-	-	-	I	.1
66 Vaccinium vitis-idaea	2.1	-	-	1.1	-	-	-	-	-	-	-	-	-	-	I	.1
67 Petasites frigidus	-	-	-	+.+	-	-	-	-	-	-	-	1.1	-	-	I	.1
68 Saxifraga davurica	-	-	-	-	-	-	-	-	1.1	-	-	-	+.+	-	I	.1
69 Kobresia hyperborea	-	-	-	-	-	-	-	-	1.1	-	-	-	1.1	-	I	.1
70 Arenaria rossii	-	-	-	-	-	-	-	+.+	-	+.+	-	-	-	-	I	.1
D layer (Bryophytes)																
71 Rhytidium rugosum	4.2	3.2	+.+	1.1	3.1	2.1	-	-	-	5.2	-	-	1.1	1.1	IV	1.5
72 Aulacomnium turgidum	-	-	-	1.1	-	4.2	4.2	-	2.1	1.1	4.2	4.1	-	-	III	1.6
73 Dicranum fuscescens	-	-	-	-	-	-	2.1	1.1	-	4.2	4.2	4.2	-	+.+	III	1.1
74 Polytrichum juniperinum	4.2	-	4.1	2.1	-	2.1	-	-	+.+	-	-	2.1	-	-	III	1.1
75 Distichium capillaceum	-	-	-	-	-	1.1	-	+.+	1.1	2.1	+.+	1.1	+.+	+.+	III	.7
76 Dicranum elongatum	-	-	+.+	1.1	-	-	-	-	-	-	5.2	-	1.1	1.1	II	.7
77 Abietinella abietina	-	-	+.+	-	1.1	2.1	-	-	-	3.2	-	-	-	-	II	.5
78 Ceratodon purpureus	-	-	+.+	4.2	-	1.1	-	-	-	-	-	-	-	+.+	II	.5
79 Dicranum mühlenbeckii	-	-	-	2.1	1.1	-	-	-	1.1	-	-	-	1.1	+.+	II	.4
80 Polytrichum piliferum	-	-	+.+	-	-	-	-	1.1	+.+	-	-	-	-	3.2	II	.4
81 Bryum sp.	-	-	1.1	-	-	1.1	-	2.1	-	-	-	-	-	1.1	II	.3
82 Encalypta rhaptocarpa	-	-	-	-	-	-	-	-	+.+	+.+	-	1.1	-	+.+	II	.3
83 Bryum pseudotriquetrum	-	-	-	-	1.2	1.1	-	-	-	1.1	-	-	-	-	II	.2
84 Mnium orthorrhynchum	-	-	-	-	-	-	+.+	-	+.+	-	+.+	-	-	-	II	.2
85 Pohlia sp.	-	-	-	1.1	1.1	1.1	-	-	-	-	-	-	-	-	II	.2
86 Hylocomium splendens	-	-	-	-	-	-	4.2	-	-	3.2	-	-	-	-	I	.5
87 Aulacomnium palustre	-	-	-	-	-	-	3.1	-	-	1.1	-	-	-	-	I	.3
88 Dicranum angustum	-	-	-	-	-	3.1	-	-	1.1	-	-	-	-	-	I	.3
89 Dicranum groenlandicum	-	-	-	-	-	-	-	-	-	-	-	1.1	-	1.1	I	.1
90 Eurhynchium pulchellum	-	-	-	-	-	-	-	-	+.+	-	+.+	-	-	-	I	.1
91 Blepharostoma trichophyllum	-	-	-	-	-	-	1.1	1.1	-	-	-	-	-	-	I	.1
92 Rhacomitrium lanuginosum	1.1	-	-	-	-	-	-	-	-	-	-	-	1.1	-	I	.1
93 Tetraplodon urceolatus	+.+	-	-	-	-	-	-	-	-	-	-	-	1.1	-	I	.1
94 Myurella julacea	-	-	+.+	-	-	-	-	-	-	-	-	-	-	+.+	I	.1
(Lichenes)																
95 Cetraria cucullata	1.1	1.1	2.1	1.1	1.1	1.1	5.2	2.1	2.1	1.1	4.1	3.1	1.1	1.1	V	1.8
96 Cetraria nivalis	1.1	-	1.1	+.+	-	1.1	3.1	1.1	2.1	2.1	+.+	1.1	1.1	1.1	V	.9
97 Cetraria chrysantha	-	1.1	1.1	1.1	-	-	2.1	1.1	3.2	-	1.1	5.2	1.1	1.1	IV	1.2
98 Thamnolia vermicularis	1.1	1.1	2.1	-	-	1.1	1.1	1.1	+.+	2.1	2.1	-	1.1	1.1	IV	1.0
99 Hypogymnia subobscura	1.1	-	2.1	1.1	-	-	-	+.+	3.2	-	1.1	1.1	+.+	1.1	IV	.9
100 Pertusaria panyrga	-	-	5.2	2.1	-	1.1	+.+	-	-	-	-	6.2	3.2	-	III	1.3
101 Pertusaria coriacea	-	-	+.+	2.1	-	-	+.+	4.2	-	-	-	6.2	2.1	-	III	1.1
102 Cornicularia divergens	2.1	-	1.1	-	-	1.1	1.1	-	2.1	2.1	-	-	1.1	2.1	III	.9
103 Cetraria richardsonii	-	-	-	-	1.1	-	2.1	-	-	3.1	1.1	-	1.1	+.+	III	.7
104 Physcia muscigena	-	2.1	+.+	2.2	-	1.1	-	1.1	1.1	-	-	-	-	2.2	III	.7
105 Rhizocarpon geographicum	2.1	-	1.1	1.1	-	-	-	-	1.1	-	-	-	1.1	4.1	III	.7
106 Nephroma expallidum	-	1.1	+.+	+.+	-	-	1.1	1.1	-	-	-	2.1	-	+.+	III	.6
107 Cetraria islandica	+.+	-	-	-	-	1.1	2.1	-	-	1.1	-	1.1	1.1	-	III	.5
108 Peltigera canina	-	-	-	1.1	1.1	1.1	1.1	-	-	-	-	1.1	+.+	+.+	III	.5
109 Ochrolechia upsaliensis	-	-	+.+	-	-	-	-	4.2	1.1	4.2	-	-	-	4.2	II	1.0
110 Alectoria nitidula	1.1	-	4.2	-	-	-	-	2.1	-	-	-	4.2	-	-	II	.8
111 Lecanora epibryon	-	3.2	1.1	-	-	-	-	-	-	-	5.2	1.1	+.+	-	II	.7
112 Cetraria tilesii	-	-	-	-	-	-	+.+	1.1	1.1	-	-	3.1	-	2.1	II	.6
113 Alectoria ochroleuca	2.1	-	-	-	-	-	-	1.1	-	2.1	-	-	-	+.+	II	.5
114 Stereocaulon alpinum	-	-	-	-	1.1	+.+	2.1	-	+.+	-	-	-	+.+	-	II	.5
115 Parmelia omphalodes	-	-	2.1	-	-	-	-	-	+.+	-	-	1.1	-	2.1	II	.5
116 Leptogium saturninum	-	1.1	+.+	-	-	-	-	+.+	1.1	-	1.1	-	-	-	II	.4
117 Peltigera aphthosa	-	+.+	-	2.1	-	-	1.1	1.1	-	-	-	-	-	-	II	.4
118 Ochrolechia frigida	-	-	-	-	-	-	-	-	1.1	-	3.2	-	+.+	-	II	.4
119 Sphaerophorus globosus	1.1	-	1.1	-	-	-	-	-	-	-	-	-	1.1	1.1	II	.3
120 Dactylina arctica	-	-	-	2.1	-	-	1.1	-	-	-	-	-	+.+	-	II	.3
121 Alectoria nigricans	-	-	1.1	-	1.1	-	-	-	1.1	-	-	-	1.1	-	II	.3
122 Cornicularia aculeata	1.1	-	-	-	-	-	1.1	-	1.1	-	-	-	-	1.1	II	.3
123 Alectoria miniscula	-	-	1.1	-	-	-	-	-	1.1	-	-	-	-	2.1	II	.3
124 Umbilicaria hyperborea	1.+	-	2.+	-	-	-	-	-	-	-	-	-	1.+	-	II	.3
125 Cladonia gracilis	-	-	-	2.1	-	1.1	-	-	-	-	-	-	-	+.+	II	.3
126 Psoroma hypnorum	-	1.1	-	-	-	-	-	-	-	-	-	1.1	-	+.+	II	.2
127 Cetraria nigricascens	-	-	+.+	1.1	-	-	-	-	+.+	-	-	-	-	-	II	.2
128 Cladonia amaurocraea	+.+	-	-	-	+.+	-	1.1	-	-	-	-	-	-	-	II	.2
129 Lecanora anseris	-	-	-	-	-	-	-	-	3.2	-	-	-	1.1	-	I	.3
130 Lecidea atromarginata	-	-	-	-	-	-	+.+	-	3.2	-	-	-	-	-	I	.3
131 Solorina saccata	-	-	-	-	-	+.+	-	-	+.+	-	-	-	-	-	I	.1
132 Cladonia uncialis	-	-	-	+.+	-	-	1.1	-	-	-	-	-	-	-	I	.1
133 Parmelia separata	1.1	-	1.1	-	-	-	-	-	-	-	-	-	-	-	I	.1
134 Pertusaria dactylina	-	-	-	-	-	-	+.+	-	1.1	-	-	-	-	-	I	.1
135 Umbilicaria proboscidea	1.+	-	+.+	-	-	-	-	-	-	-	-	-	-	-	I	.1
136 Arctomia delicatula	-	-	+.+	-	-	+.+	-	-	-	-	-	-	-	-	I	.1
137 Lecanora polytropa	-	-	+.+	-	-	-	-	-	+.+	-	-	-	-	-	I	.1
TOTAL SPECIES (incl. sporadics)	37	33	64	49	37	50	60	52	65	64	51	55	68	68		

Sporadic species

C layer

138 Ledum decumbens 2(2.1)
139 Calamagrostis purpurascens 7(2.1)
140 Draba nivalis 7(+.+)
141 Saxifraga oppositifolia 7(1.1)
142 Gentiana propinqua 9(1.1)
143 Equisetum arvense 25(1.1)
144 Sedum rosea 61(1.1)
145 Smelowskia calycina 61(+.+)
146 Woodsia alpina 61(+.+)
147 Woodsia glabella 61(+.+)
148 Cardamine microphylla 73(+.+)
149 Aconitum delphinifolium 77(+.+)
150 Antennaria pedunculata 77(2.1)
151 Carex williamsii 77(1.1)
152 Potentilla fruticosa 77(1.1)
153 Eriophorum vaginatum 133(+.+)
154 Koeleria cairnesiana 136(1.1)
155 Luzula wahlenbergii 136(1.1)
156 Stellaria monantha 136(1.1)
157 Festuca baffinensis 146(2.1)

D layer (Bryophytes)

158 Campylium chrysophyllum 9(+.+)
159 Campylium stellatum 10(1.1)
160 Ptilidium ciliare 10(3.2)
161 Lophozia excisa 25(+.+)
162 Lophozia sp. 77(+.+)
163 Lescuraea patens 104(+.+)
164 Cephaloziella subdentata 104(+.+)
165 Dicranoweissia crispula 104(1.1)
166 Distichium inclinatum 104(+.+)
167 Gymnomitrium corallioides 104(1.1)
168 Lophozia quadriloba 104(+.+)
169 Pogonatum urnigerum 104(1.1)
170 Timmia austrica 104(+.+)
171 Tortula ruralis 137(5.2)
172 Lophozia alpestris 146(+.+)

(Lichenes)

173 Cetraria pinastri 7(+.+)
174 Cladonia coccifera 7(+.+)
175 Parmelia alpicola 7(1.1)
176 Xanthoria elegans 7(1.1)
177 Caloplaca festiva 25(+.+)
178 Lecanora atrosulphurea 25(1.1)
179 Umbilicaria cylindrica 25(1.1)
180 Peltigera spuria 61(1.1)
181 Parmelia stygia 73(2.1)
182 Parmeliopsis ambigua 73(+.+)
183 Stereocaulon tomentosum 73(1.1)
184 Cladonia fimbriata 77(+.+)
185 Cladonia mitis 77(1.1)
186 Peltigera scabrosa 77(1.1)
187 Cladonia pyxidata 104(+.+)
188 Pannaria leucostricta 137(1.1)
189 Peltigera malacea 146(1.1)

are brought to the surface by frost action.

Figure 11. Exposed ridge (1100 ft) south of Trout Lake, dominated by Dryas octopetala (light green) and Salix phlebophylla (dark green) Plot 62. (Photo by Lambert)

Dryas octopetala ssp. alaskensis is the most abundant species forming large prostrate mats. Scattered between the Dryas mats are other mat formers such as Arenaria arctica, Oxytropis nigrescens, Saxifraga tricuspidata, Salix phlebophylla and Arctostaphylos alpina. The most common non-mat forming species are Lupinus arcticus, Hierochloe alpina, Antennaria neoalaskana, Artemisia arctica and Luzula confusa. No species are restricted to the depauperatum and there are only five constants in the four plots representing this subassociation. The presence and moderately high coverage values of Salix phlebophylla indicate the close relationship between the depauperatum and the Salicetum phlebophyllae. Its subordinate position in this subassociation can be related to the less exposed position of the plots which result in greater development of mat forming vegetation, especially Dryas octopetala.

The constant occurrence of Rhytidium rugosum on the drier slopes is always closely associated with Dryas octopetala. The bryophyte flora is still sparse with only Polytrichum juniperinum, Ceratodon purpureus, and Dicranum elongatum being present in more than half of the sampled plots. Gymnomitrion corallioides, an indicator of exposed habitats, is absent. Due to a reduction in percentage of exposed rock there are fewer saxicolous lichens present and no constants. Foliose lichens, especially Cetraria cucullata, C. nivalis, C. chrysantha and Nephroma expallidum are present, but with low coverage values. Crustose lichens are conspicuous on both living and dead plant materials and include such species as Pertusaria panyrga, P. coricea, and Lecanora epibryon. Additional species are Hypogymnia subobscura, Physcia muscigena and Alectoria nitidula.

(b) dryadeto - salicetosum reticulatae - glaucae (Figure 12)

In contrast to the above subassociation this community develops on gentle to steep, convex to straight more southerly exposed slopes. Plots were analyzed that ranged in elevation from 1500-2390 ft at Canoe Lake and 450-1100 ft at Trout Lake. Their presence at higher elevations is related to the more southerly exposure. While snow duration is as long (8 months) as on the depauperatum, snow accumulation is generally greater because of the less exposed position. Increased snow accumulation gives more protection and reduces surface erosion by wind during the winter. Drainage in the spring is rapid, but because of the greater snow cover the habitats are generally moist for a longer period. By mid-summer, however, the sites are sub-xeric. The amount of exposed rock is less and in many plots completely absent. Where present, they are estimated to cover between 2-25 percent of the total surface area.

Figure 12. West facing slope (2350 ft) southwest of Canoe Lake, dominated by Dryas octopetala and Lupinus arcticus (scattered clumps). (Photo by Krajina)

Soil profiles indicate considerably more genetic development than any other unit in this low arctic subalpine zone. However, due to the difference in elevation some profiles are better developed than others. Frost heaving is common in the late spring and early summer and the vegetative mats tend to show some downslope movement, although features such as non-sorted stripes are not recognized. On steeper slopes solifluction is evident from the elongated step-like form of the vegetative mats that lie parallel to the direction of the slope.

Floristically, the dryadeto - salicetosum reticulatae - glaucae is the richest unit in the subalpine zone. This can be related to the more calcareous nature of the soils. Soil reaction is generally circum-neutral to slightly alkaline. Differential species that emphasize this fact include Salix reticulata, S. glauca, Rhododendron lapponicum, Papaver macounii, Silene acaulis, Saxifraga bronchialis, S. hieracifolia, S. hirculus, S. flagellaris, Cerastium beeringianum, Tofieldia coccinea, Campanula uniflora, Astragalus australis, A. umbellatus, Senecio resedifolius and Parrya nudicaulis. Constant species associated with Dryas octopetala are: Lupinus arcticus, Arenaria arctica, Oxytropis nigrescens, Polygonum viviparum and Hierochloe alpina.

Bryophytes are more important here than in the depauperatum. The more moist conditions of the habitats are reflected in the presence of such species as Aulacomnium turgidum, Dicranum fuscescens and Hylocomium splendens. Rhytidium rugosum, Abietinella abietina and Distichium capillaceum are common associates with Dryas octopetala and similarly stress the more calcareous nature of the substrate. These three species have their optimum development in this subassociation. Only one lichen calciphile was present - Cetraria tilesii. The lichen flora is again more abundant than the bryophytic, although coverage values are generally lower. Foliose species are common among the mat formers and include Cetraria nivalis, C. chrysantha, Hypogymnia subobscura, Nephroma expallidum and Peltigera canina. Cetraria cucullata, Cornicularia divergens and Thamnolia vermicularis are the major fruticose species among the mat vegetation. Crustose species present on dead plant matter include Pertusaria panyrga, P. coriacea, Ochrolechia upsaliensis and Lecanora epibryon.

Many species with wide amplitudes of tolerance are of importance in the Lupino - Dryadetum *alaskensis; they include Vaccinium uliginosum, Betula glandulose, Arctostaphylos alpina and Poa arctica. On the more exposed acid soils, species composition is sparse while on the more calcareous soils it is richer. Dryas octopetala and other associated species that have their optimum in this association exhibit remarkable adaptation against desiccating winds. This is clearly seen in the zonation of the vegetation. Climatic conditions, while harsh, are ameliorated by the more southerly exposure of the habitats and the deeper snow cover. Soil development is genetically well advanced in this association.

Two plots were analyzed in the Trout Lake area that are closely allied to the depauperatum, however, their total species composition would suggest a possible transition type community. Several species were recorded only in these two plots and are not found further to the east at Canoe Lake. They are Eritrichium splendens, Cardamine microphylla, Aster pygmaeus and Potentilla nivea. Both plots are present on exposed black shale, a substrate not outcropping at Canoe Lake in the Richardson Mountains. Exposure is southerly on moderate slopes (15-23°) at elevations between 485-675 ft. Because they would appear to be under represented, they have not been included in the averages for the Lupino Dryadetum *alaskensis, but have instead been added only to show their possible relationship to this association.

An additional plot dominated by Carex lugens at 2025 ft at Canoe Lake had a high correlation coefficient with the dryadeto - salicetosum reticulatae glaucae. This plot has similarly not been included in the averages as it is felt that further studies in this subalpine zone would show that it belongs to a separate association - Caricetum lugentis.

3. Betulo - Ledetum decumbentis Table 4 (a) & (b)

This association is characteristic of the more northerly exposed slopes between 1300-1900 ft. The slopes are well drained and are generally quite dry (subxeric) by mid-summer. Exposed felsenmeer is present in the majority of the plots studied. Soil profiles are predominantly shallow, however, the active layer is still thick because of the high percentage of rocks present in the C horizon. The Betulo - Ledetum decumbentis community is dominated by many low shrub species that because of their more exposed position rarely attained shrub height (over six inches).

Table No. **4 b**

	Betulo - Ledetum decumbentis																								
	betulo - ledetosum decumbentis									cassiopeetosum tetragonae															
Plot No.	89	24	31	30	121	16	6	20	14	70	67	23	36	35	12	114	131	166	33	163	3	19	5	179
Plot size (m^2)	......100......									......100......															
Date Analyzed	18/7 1965	18/6 1965	20/6 1965	20/6 1965	21/8 1965	15/6 1965	11/6 1965	16/6 1965	14/6 1965	14/7 1965	13/7 1965	18/6 1965	23/6 1965	23/6 1965	14/6 1965	14/8 1965	10/7 1966	27/7 1966	21/6 1965	27/7 1966	10/6 1965	16/6 1965	10/6 1965	12/8 1966
PLOT DATA																									
Locality	TL	CL	CL	CL	CL	CL	CL	CL	CL	TL	TL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL
Elevation (ft)	630	1310	1350	1350	1450	1475	1725	1850	1900	570	1100	1320	1350	1400	1425	1480	1700	1725	1725	1750	1800	1850	1850	1900
PHYSIOGRAPHY																									
Land form	Raised polygon	..Exposed.. slope		..Ridge lee side..			....Exposed slope.			Depre-ssion	.......Exposed slope.....				...Ridge... side		......Exposed slope......				Stone stripe	..Exposed.. slope		Ridge lee side
Relief: Profile	Flat	...Convex..		Cnv	Stg	Cnv	Stg	.Straight..		Cnv	Stg-Hum	Cnv	Cvx	Cnv	Stg	Cvx	Stg	Cnv-Hum	Cnv	Cnv	Cnv	Stg	Cnv	Cnv
Exposure (°)	Total	270	90	90	180	90	90	315	0	45	0	270	70	70	0	45	120	45	25	90	270	45	270	90
Slope gradient (°)	0	30	4	23	28	13	26	14	10	2	20	10	22	19	34	17	18	20	47	8	37	3	9	10
CLIMATE																									
Snow duration	........8½ months........									........9 months........											.......8½ months........			
STRATA COVERAGE (%)																									
B_2 layer					60							20						15	25			2		
C^2 layer	100	85	45	100	95	70	70	60	75	85	70	75	95	70	40	75	95	90	80	90	85	80	55	70
D layer Moss	65	15	10	10	5	15	15	25	10	60	30	55	20	50	30	25	25	90	40	55	20	20	10	20
Lichen	10	50	70	40	40	20	35	20	65	25	30	15	30	20	50	75	40	25	15	45	20	50	55	55
Dr		3	8				10	15	5	10	5		8		7	20			10		2		8	25
PLOT COVERAGE (%) by rock		5	10				15	20	10	15	15		10		10	25	3		15		5		15	35
SOIL																									
Drainage	......Well drained......									......Well-drained......															
Hygrotope	......Sub-xeric......									......Sub-xeric to mesic......															
Depth of soil profile (cm)	30	20	32	12	33	20	19	30	22	46	33	18	18	15	14	19	25	35	15	25	14	12	12	30
CHEMICAL ANALYSIS																									
No.of samples	4	1	1	1	1	NT	1	NT	NT	1	1	1	1	1	1	1	2	2	1	2	1	1		1
Organic layer OM	69.6	78.5	51.8	40.0	57.8		32.5			59.3	81.5	54.5	51.0	66.5	44.2	36.7	74.1	74.9	49.0	82.6	56.3	36.9		82.6
N%	1.65	1.19	.98	.98	1.19		.62			.56	1.05	1.26	.76	1.26	.93	.95	1.2	1.57	1.05	1.73	1.05	1.12		1.73
C/N	24.2	38.3	30.7	23.7	28.2		30.4			61.4	45.0	25.1	38.9	30.6	27.6	22.4	35.7	27.6	27.0	27.6	31.1	19.1		27.7
P ppm	12	22	26	16	29		43			13	29	27	35	22	19	12	34	31	24	22	27	17		34
Na	.57	.82	.75	.79	.53		.8			.5	.61	.74	.79	1.06	.8	.72	.88	.74	.79	.89	.8	.64		1.06
K	.47	1.04	.75	.38	1.11		.67			.78	1.25	1.18	.8	.93	.73	.9	.82	.98	.91	1.08	1.19	.85		.85
Ca	11.7	7.2	5.8	2.2	9.8		3.3			8.7	20.3	7.9	3.0	12.9	5.3	7.9	30.2	18.0	9.1	29.2	7.8	9.0		19.3
Mg	3.5	3.2	2.0	.4	1.3		.9			4.8	8.0	2.3	1.2	2.8	1.3	1.0	3.3	4.1	2.4	4.1	3.4	2.3		4.6
CEC	104.8	139.0	93.8	64.3	47.6		48.3			36.3	94.7	168.0	87.9	147.0	67.9	67.3	134.9	91.1	103.0	86.1	148.0	67.8		126.2
pH	4.3	4.0	4.1	3.7	3.8		4.3			4.4	4.4	4.2	3.8	4.2	4.2	3.8	3.5	4.9	4.6	4.9	4.5	3.8		4.2
No.of samples						1		1	1	1	1		1				1			1		1	1	
Organic - Mnieral layer OM						17.1		17.9	23.5	22.6	31.0		16.0				19.3			27.9		28.2	21.5	
N%						.41		.56	.01	.46	.87		.88				.48			.55		.98	.43	
C/N						24.2		18.5	13.6	28.5	20.7		10.5				23.3			29.4		16.8	29.0	
P ppm						11		8	16	3	11		26				16			16		19	24	
Na						.74		.52	.8	.46	.57		.74				.79			.89		.56	.79	
K						.24		.5	.35	.18	.36		.28				.69			.63		.69	.45	
Ca						.9		3.6	2.3	2.6	9.2		1.2				17.6			21.0		5.4	2.6	
Mg						.3		.9	.6	1.3	2.4		.3				1.6			4.1		1.1	.7	
CEC						43.7		26.4	49.0	41.1	54.2		61.0				81.3			58.4		43.6	67.3	
pH						3.7		4.1	3.9	4.9	4.4		3.8				3.5			5.3		3.6	4.1	
No.of samples		1	2		2	2	1	1	1	2	1	1	1	1		1	1	1	1	1	1		1	2
Mineral layer OM		4.1	9.4		2.3	3.3	1.1	2.0	3.3	2.1	9.9	4.6	1.1	2.0		1.6	2.9	4.9	4.4	5.5	6.3		1.7	2.4
N%		.15	.22		.23	.09	.04	.07	.08	.09	.28	.15	.06	.09		.14	.11	.25	.15	.15	.17		.07	.09
C/N		15.9	19.7		5.8	19.5	16.0	16.6	23.9	12.8	20.5	17.8	10.6	12.9		6.6	15.2	11.3	17.0	21.3	21.5		14.1	10.9
P ppm		21	12		14	4	16	4	3	5	6	13	14	8		7	8	6	3	18	10		6	12
Na		.73	.73		.59	.82	.77	.5	.8	.51	.41	.72	.81	.79		.72	.89	.62	.78	.89	.8		.74	.73
K		.24	.17		.19	.5	.08	.08	.12	.13	.17	.21	.1	.09		.19	.31	.31	.14	.26	.33		.09	.28
Ca		1.1	1.1		1.8	.9	.8	1.3	1.2	2.2	8.1	2.7	.9	1.2		2.5	14.4	7.9	2.2	8.9	1.7		.8	5.8
Mg		.4	.25		.46	.05	.0	.0	.1	1.4	2.3	.8	.0	.2		.1	.4	1.2	.5	.9	.8		.0	.8
CEC		32.3	46.3		18.0	27.6	19.5	18.3	48.3	15.2	43.6	36.9	39.1	19.9		17.5	43.0	13.0	43.7	22.3	28.1		13.7	25.9
pH		4.1	4.4		4.1	4.3	4.7	4.6	5.1	5.0	5.5	4.3	4.4	4.5		4.1	4.0	6.3	4.8	5.1	4.6		4.7	4.4

Table No. 4 a

	Betulo - Ledetum decumbentis																									
	betulo - ledetosum decumbentis									cassiopeetosum tetragonae																
Number of Plots	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
Plot No.	89	24	31	30	121	16	6	20	14	70	67	23	36	35	12	114	131	166	33	163	3	19	5	179		
Plot size (m^2)	100									100																
Elevation (ft)	630	1310	1350	1350	1450	1475	1725	1850	1900	570	1100	1320	1350	1400	1425	1480	1700	1725	1725	1750	1800	1850	1850	1900	Constancy	Avg. Cover
B_2 layer																										
1 Betula glandulosa	-	-	-	-	7.2	-	-	-	-	-	-	4.2	-	-	-	-	-	-	4.2	-	-	-	-	-		
2 Salix pulchra	-	-	-	-	-	-	-	-	-	-	-	3.1	-	-	-	-	-	4.1	3.1	-	-	1.1	-	-		
3 Salix glauca	-	-	-	-	-	-	-	-	-	-	-	2.1	-	-	-	-	-	-	-	-	-	-	-	-		
4 Spiraea beauverdiana	-	-	-	-	2.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
C layer																										
Betula glandulosa	7.3	4.2	1.1	6.2	?	4.1	3.1	6.2	6.2	4.2	3.1	?	6.2	2.1	1.1	6.2	5.2	5.2	?	4.2	5.2	1.1	6.2	2.1	V	4.6
Salix pulchra	-	-	-	-	-	-	-	-	-	-	-	?	1.1	-	-	-	-	?	?	4.1	1.1	?	-	-	II	.7
Salix glauca	-	+.+	-	-	-	-	-	-	-	-	-	?	1.1	-	-	1.1	-	-	-	-	-	-	-	-	I	.2
Spiraea beauverdiana	-	-	-	-	?	-	-	-	-	-	-	2.1	1.1	1.1	-	-	2.1	-	-	-	-	1.1	-	-	II	.4
5 Ledum decumbens	4.1	4.2	3.1	7.2	5.1	6.2	4.2	-	5.2	4.1	1.1	3.2	6.2	1.1	3.1	5.2	6.2	4.1	3.1	3.1	1.1	2.1	3.1	5.2	V	3.6
6 Vaccinium vitis-idaea	3.1	2.1	1.1	3.1	6.2	3.1	6.2	4.2	4.2	4.2	2.1	2.1	6.2	2.1	2.1	2.1	4.2	4.1	4.1	4.2	1.1	4.2	2.1	5.2	V	3.5
7 Arctostaphylos alpina	1.1	6.2	3.1	+.+	4.2	4.2	6.2	-	1.1	4.2	5.2	4.2	2.1	3.1	2.1	4.2	5.2	1.1	4.2	-	1.1	1.1	2.1	2.1	V	2.7
8 Vaccinium uliginosum	5.2	1.1	1.1	1.1	5.2	3.1	1.1	-	2.1	4.2	3.1	1.1	2.1	1.1	-	4.2	5.2	6.2	4.1	6.2	1.1	2.1	1.1	1.1	V	2.5
9 Hierochloe alpina	1.1	2.1	1.1	2.1	2.1	2.1	2.1	3.1	2.1	1.1	1.1	2.1	2.1	1.1	2.1	2.1	1.1	2.1	2.1	3.1	2.1	1.1	1.1	1.1	V	1.7
10 Cassiope tetragona	-	-	-	-	-	-	-	-	-	2.1	5.2	5.2	5.2	7.3	3.2	2.2	6.3	8.3	6.2	7.2	8.3	7.3	4.2	4.2	IV	3.2
11 Empetrum hermaphroditum	-	2.1	2.1	1.1	6.2	2.1	2.1	-	4.2	4.2	-	3.2	5.2	3.1	-	2.1	5.2	4.2	4.2	4.1	2.1	1.1	-	2.1	IV	2.3
12 Carex podocarpa	-	1.1	3.1	-	2.1	-	2.1	1.1	1.1	-	-	2.1	1.1	2.1	2.1	-	1.1	1.1	2.1	1.1	2.1	-	2.1	2.1	IV	1.2
13 Polygonum bistorta	-	-	-	-	2.1	-	+.+	-	1.1	1.1	3.1	2.1	1.1	2.1	-	2.1	-	4.1	2.1	3.1	1.1	1.1	1.1	-	IV	1.1
14 Salix phlebophylla	-	1.1	1.1	-	-	-	1.1	2.1	+.+	2.1	-	3.2	-	-	3.2	4.2	-	-	3.1	-	3.2	-	2.1	1.1	III	1.1
15 Loiseleuria procumbens	-	-	5.2	-	-	-	2.2	-	2.1	1.1	1.1	-	-	-	-	1.1	2.2	-	1.1	-	2.2	-	1.1	7.2	III	1.0
16 Luzula confusa	-	-	+.+	1.1	2.1	1.1	-	2.1	1.1	-	-	2.1	-	1.1	-	1.1	-	-	-	3.1	1.1	-	1.1	-	III	.7
17 Poa arctica	-	1.1	-	-	-	-	1.1	-	-	-	+.+	1.1	-	1.1	-	-	1.1	3.1	1.1	1.1	1.1	-	-	-	III	.5
18 Arctagrostis latifolia	-	1.1	-	-	-	-	2.1	-	-	-	-	3.1	1.1	3.1	-	-	-	+.+	1.1	-	2.1	-	-	-	II	.5
19 Carex lugens	-	-	-	-	-	1.1	+.+	-	-	2.1	-	1.1	1.1	-	-	-	-	4.1	-	2.1	-	-	-	+.+	II	.5
20 Diapensia lapponica	-	-	1.1	-	-	-	1.1	-	2.1	-	-	-	-	-	1.1	2.1	-	-	-	-	-	-	1.1	3.2	II	.5
21 Saussurea angustifolia	-	-	-	-	-	-	1.1	-	-	-	-	1.1	-	1.1	-	1.1	-	4.1	-	3.1	-	-	-	-	II	.4
22 Arenaria arctica	-	-	-	-	-	-	+.+	-	+.+	1.1	1.1	-	-	-	-	1.1	-	-	-	1.1	2.1	-	2.2	-	II	.4
23 Oxytropis nigrescens	-	-	-	-	-	-	1.1	-	-	-	2.1	-	-	-	-	2.1	-	-	-	-	-	-	2.1	2.1	II	.4
24 Pedicularis labradorica	-	-	1.1	1.1	-	+.+	-	-	-	-	-	+.+	-	-	-	1.1	-	1.1	1.1	1.1	-	-	-	-	II	.3
25 Polygonum viviparum	-	-	1.1	-	1.1	-	-	-	-	-	-	-	1.1	1.1	-	-	-	-	1.1	1.1	-	-	-	-	II	.3
26 Douglasia arctica	-	-	1.1	-	-	-	1.1	-	-	-	-	-	+.+	-	1.1	1.1	-	-	-	-	-	-	-	1.1	II	.3
27 Pedicularis lanata	-	-	-	-	-	-	+.+	-	-	1.1	1.1	-	-	-	-	-	-	+.+	-	1.1	-	-	-	1.1	II	.2
28 Anemone narcissiflora	-	+.+	-	-	-	-	1.1	-	-	-	-	-	-	1.1	-	-	-	1.1	-	1.1	-	-	-	-	II	.2
29 Petasites frigidus	-	-	-	-	-	-	-	-	-	-	-	-	1.1	-	-	-	-	3.1	+.+	2.1	-	-	-	-	I	.3
30 Dryas octopetala	-	2.1	-	-	-	-	1.1	-	-	-	-	-	-	-	-	-	-	1.1	-	3.1	-	-	-	-	I	.3
31 Artemisia arctica	-	-	-	-	-	-	-	2.1	-	-	-	-	-	1.1	-	1.1	-	-	-	-	1.1	-	-	-	I	.2
32 Lupinus arcticus	-	-	-	-	-	-	-	-	-	2.1	1.1	1.1	-	-	+.+	-	-	-	-	-	-	-	-	-	I	.2
33 Saxifraga bronchialis	-	-	-	-	-	-	-	-	-	-	1.1	-	-	-	-	-	-	-	-	3.2	2.1	-	-	-	I	.2
34 Saxifraga punctata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.1	1.1	-	-	-	-	-	I	.2
35 Arnica lessingii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.1	-	2.1	-	-	-	-	I	.2
36 Tofieldia coccinea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+.+	1.1	-	1.1	1.1	-	-	-	-	-	I	.2
37 Selaginella sibirica	-	-	-	-	-	-	+.+	+.+	-	-	-	-	1.1	-	-	+.+	-	-	-	-	-	-	-	-	I	.2
38 Pedicularis capitata	-	-	-	-	-	-	-	-	-	1.1	+.+	-	-	-	-	-	-	2.1	-	-	-	-	-	-	I	.2
39 Equisetum arvense	-	-	-	-	-	-	-	-	-	-	-	-	1.1	-	-	-	-	3.1	-	-	-	-	-	-	I	.2
40 Pyrola grandiflora	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.1	-	2.1	-	-	-	-	I	.2
41 Pedicularis arctica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.1	+.+	-	-	-	-	1.1	-	-	-	I	.1
42 Pedicularis lapponica	-	-	+.+	-	-	-	-	-	-	-	-	-	-	1.1	-	-	-	-	-	-	-	-	-	-	I	.1
43 Senecio atropurpureus	-	-	-	-	-	-	-	-	-	-	-	-	-	+.+	-	-	-	-	-	-	1.1	-	-	-	I	.1
44 Poa glauca	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.1	1.1	-	-	-	-	-	-	-	-	I	.1
45 Antennaria neoalaskana	-	-	-	-	-	-	-	-	-	+.+	-	-	-	-	-	-	-	-	-	-	1.1	-	-	-	I	.1
46 Polygonum alaskanum	-	1.1	-	-	-	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	I	.1
D layer (Bryophytes)																										
47 Dicranum elongatum	3.1	4.2	2.1	3.1	-	4.2	1.1	3.1	2.1	4.2	1.1	-	3.1	4.2	2.1	4.2	5.2	4.2	4.2	4.1	3.1	-	1.1	4.2	V	2.7
48 Polytrichum juniperinum	6.2	1.1	1.1	1.1	-	1.1	1.1	5.2	-	4.1	2.1	2.2	-	+.+	2.1	4.2	4.2	1.1	3.2	1.1	+.+	-	-	-	IV	2.1
49 Aulacomnium turgidum	4.2	1.1	1.1	-	1.1	-	-	1.1	-	5.2	2.1	1.1	-	3.1	1.1	2.1	-	3.1	2.1	5.2	1.1	4.1	-	-	IV	1.5
50 Sphenolobus minutus	1.1	+.+	1.1	1.1	-	+.+	1.1	-	-	1.1	1.1	5.2	1.1	1.1	1.1	2.1	2.1	-	1.1	+.+	-	+.+	+.+	1.1	IV	1.0
51 Hylocomium splendens	3.1	-	-	-	-	-	-	-	-	-	4.2	2.1	-	5.2	5.2	1.1	1.1	8.3	5.2	7.2	1.1	3.1	-	-	III	1.8
52 Dicranum fuscescens	3.1	-	-	-	2.1	2.2	-	1.1	1.1	-	1.1	2.1	3.1	-	3.1	+.+	-	-	2.2	-	1.1	1.1	-	-	III	.9
53 Ptilidium ciliare	1.1	-	-	3.1	+.+	1.1	-	-	2.1	-	-	5.2	-	-	-	-	-	3.2	2.1	-	-	-	-	-	II	.7
54 Rhytidium rugosum	4.2	-	-	-	-	+.+	-	2.1	-	5.2	1.1	-	-	-	4.2	1.1	-	-	-	-	-	-	-	-	II	.7
55 Rhacomitrium lanuginosum	-	-	1.1	-	-	-	-	-	-	2.1	2.1	-	1.1	-	-	-	-	-	+.+	-	-	-	2.1	3.1	II	.5
56 Sphagnum girgensohnii	-	-	-	-	-	-	-	-	-	-	3.1	-	1.1	2.2	-	-	-	3.2	1.1	2.1	-	-	-	-	II	.5
57 Dicranum scoparium	-	-	-	2.1	-	-	-	-	-	-	2.1	-	-	-	-	-	2.1	3.1	-	-	-	-	-	3.1	II	.5
58 Dicranum groenlandicum	-	-	-	-	-	-	2.1	-	-	-	-	-	1.1	-	2.1	4.2	-	-	-	-	-	-	-	-	I	.4
59 Aulacomnium palustre	-	-	-	-	-	-	2.1	-	-	-	-	3.1	-	-	-	-	-	4.2	-	-	-	-	-	-	I	.4
60 Dicranum angustum	1.1	-	-	2.1	-	-	-	-	-	-	-	-	-	3.1	-	-	-	-	-	-	-	-	-	-	I	.3
61 Polytrichum piliferum	-	-	-	-	-	-	-	-	-	-	-	-	2.1	-	-	2.1	-	-	-	-	-	-	2.1	-	I	.3
62 Gymnomitrion corallioides	-	-	-	-	-	-	+.+	-	-	-	-	-	-	-	-	+.+	-	-	-	-	-	-	1.1	2.1	I	.2
63 Sphagnum lenense	-	-	-	-	-	-	-	-	-	-	2.1	-	1.1	2.2	-	-	-	-	-	-	-	-	-	-	I	.2
64 Sphagnum rubellum	-	-	-	-	-	-	-	-	-	-	-	-	-	1.1	-	-	-	4.2	-	-	-	-	-	-	I	.2
65 Ceratodon purpureus	-	-	-	-	-	-	+.+	-	-	-	-	-	-	-	-	+.+	-	-	-	+.+	-	-	1.1	-	I	.2
66 Drepanocladus uncinatus	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+.+	-	+.+	-	+.+	-	-	-	-	I	.2
67 Hypnum callichroum	-	-	-	-	-	-	-	-	-	-	-	1.1	-	-	-	-	-	1.1	-	-	1.1	-	-	-	I	.1
68 Calypogeia trichomanis	-	-	-	-	-	-	-	-	-	-	-	+.+	-	-	-	-	-	1.1	+.+	-	-	-	-	-	I	.1
69 Lophozia ventricosa	-	-	-	-	-	-	-	-	-	-	-	1.1	-	1.1	-	-	+.+	-	-	-	-	-	-	-	I	.1
70 Pohlia sp.	-	+.+	+.+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+.+	-	I	.1
71 Eurhynchium pulchellum	-	1.1	-	-	-	-	-	-	-	-	-	-	-	-	1.1	-	-	-	-	-	-	-	-	-	I	.1
72 Lophozia sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+.+	1.1	-	-	-	-	-	-	-	I	.1
73 Lophozia alpestris	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+.+	-	-	-	-	-	I	.1
74 Pohlia nutans	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+.+	-	-	-	+.+	-	-	-	-	-	I	.1
75 Chandonanthus setiformis	-	-	-	-	-	-	-	-	-	-	+.+	+.+	-	-	-	-	-	-	-	-	-	-	-	-	I	.1
76 Tetraplodon paradoxus	-	-	-	-	-	-	-	-	-	-	+.+	-	-	-	-	-	-	-	+.+	-	-	-	-	-	I	.1
77 Lophozia obtusa	-	-	-	-	-	-	-	-	-	-	+.+	-	-	-	-	-	-	-	+.+	-	-	-	-	-	I	.1
(Lichenes)																										
78 Cetraria cucullata	1.1	6.2	4.1	4.2	+.+	4.2	1.1	3.1	6.2	1.1	2.1	1.1	1.1	1.1	3.1	4.1	.-	1.1	2.1	4.1	+.+	5.2	1.1	1.1	V	2.4
79 Cladonia mitis	-	+.+	2.1	2.2	4.2	2.2	1.1	2.1	1.1	1.1	-	1.1	1.1	2.1	1.1	4.2	4.2	1.1	2.1	2.1	-	6.2	2.1	4.2	V	2.0
80 Cetraria islandica	1.1	+.+	-	3.1	-	1.1	+.+	1.1	1.1	+.+	2.1	1.1	-	3.1	+.+	-	5.2	1.1	2.1	3.1	+.+	1.1	+.+	3.1	V	1.4
81 Cetraria nivalis	1.1	+.+	4.1	1.1	-	1.1	3.1	2.1	4.1	+.+	1.1	-	2.1	+.+	1.1	4.1	-	-	+.+	1.1	-	+.+	2.1	4.1	IV	1.5
82 Cladonia rangiferina	1.1	-	1.1	5.2	4.2	-	1.1	-	1.1	-	-	-	-	2.1	-	-	4.1	+.+	2.1	2.1	+.+	2.1	1.1	4.2	IV	1.3
83 Cetraria richardsonii	1.1	+.+	-	1.1	2.1	1.1	1.1	1.1	-	-	+.+	2.1	1.1	2.1	-	2.1	2.1	-	-	1.1	1.1	-	1.1	1.1	IV	.9
84 Thamnolia vermicularis	-	-	2.1	-	1.1	-	1.1	+.+	-	1.1	1.1	-	2.1	-	1.1	2.1	-	1.1	+.+	2.1	1.1	-	1.1	4.1	IV	.9
85 Dactylina arctica	1.1	+.+	-	-	-	1.1	1.1	+.+	+.+	1.1	-	-	-	1.1	+.+	1.1	2.1	1.1	1.1	2.1	1.1	1.1	1.1	-	IV	.8
86 Stereocaulon alpinum	-	-	-	-	5.2	-	4.2	-	-	2.1	+.+	-	5.2	-	-	3.1	-	1.1	+.+	3.1	-	-	7.3	4.2	III	1.5
87 Cornicularia divergens	1.1	+.+	5.2	-	-	1.1	2.1	3.1	-	1.1	2.1	-	-	-	-	5.2	-	-	+.+	-	2.1	-	2.1	1.1	III	1.1
88 Alectoria ochroleuca	-	-	-	-	-	-	1.1	2.1	6.2	1.1	-	-	-	-	-	5.2	-	-	+.+	1.1	2.1	-	1.1	1.1	III	1.0
89 Sphaerophorus globosus	-	1.1	1.1	-	-	-	1.1	+.+	-	1.1	1.1	-	-	-	1.1	3.1	-	1.1	1.1	5.1	+.+	-	1.1	1.1	III	.8
90 Ochrolechia frigida	-	-	3.1	-	-	-	3.1	1.1	1.1	+.+	-	-	-	-	1.1	3.1	-	-	-	3.1	-	-	2.1	3.1	III	.8
91 Rhizocarpon geographicum	-	-	2.1	-	-	-	1.1	1.1	1.1	2.1	2.1	-	-	-	+.+	3.2	-	-	-	-	1.1	-	1.1	-	III	.6
92 Cladonia gracilis	+.+	-	-	1.1	-	-	+.+	+.+	-	-	-	1.1	1.1	+.+	-	-	1.1	-	1.1	-	+.+	-	1.1	1.1	III	.5
93 Cetraria nigricascens	-	-	+.+	-	-	-	1.1	-	-	-	+.+	-	1.1	1.1	-	+.+	-	-	-	-	+.+	1.1	+.+	1.1	III	.4
94 Peltigera aphthosa	-	-	-	-	-	-	+.+	-	-	2.1	2.1	-	-	1.1	1.1	2.1	-	4.2	-	3.1	3.2	-	-	-	II	.8
95 Alectoria nigricans	-	1.1	5.2	-	-	1.1	1.1	-	-	2.1	-	-	1.1	-	6.3	1.1	-	-	-	-	-	1.1	-	-	II	.7
96 Umbilicaria hyperborea	-	-	+.+	-	-	-	3.+	1.+	-	1.+	-	-	-	-	1.+	-	-	-	1.+	-	1.+	-	-	3.+	II	.5
97 Nephroma expallidum	-	-	-	-	-	-	-	1.1	.-.	2.1	1.1	-	-	1.1	+.+	+.+	-	2.1	-	2.1	-	-	-	-	II	.5
98 Parmelia stygia	-	-	-	-	-	-	2.1	1.1	1.1	+.+	-	-	-	-	-	+.+	-	-	1.1	-	-	-	+.+	4.1	II	.5
99 Peltigera scabrosa	-	-	-	-	-	-	-	-	-	-	1.1	2.1	-	1.1	-	-	-	4.2	1.1	-	-	-	-	2.1	II	.5
100 Umbilicaria proboscidea	-	-	-	-	-	-	-	-	+.+	1.+	-	-	-	-	+.+	4.+	-	-	-	-	-	-	1.+	3.+	II	.5
101 Parmelia omphalodes	-	+.+	+.+	-	-	-	-	1.1	1.1	1.1	1.1	-	-	-	+.+	1.1	-	-	1.1	-	-	-	-	-	II	.4
102 Pertusaria dactylina	-	-	1.1	-	-	1.1	1.1	1.1	+.+	+.+	3.1	-	-	-	-	+.+	-	-	1.1	-	-	-	-	-	II	.4
103 Alectoria miniscula	-	-	1.1	-	-	-	1.1	1.1	-	-	-	-	-	-	1.1	4.1	-	-	-	-	-	-	-	1.1	II	.4
104 Cladonia uncialis	-	-	-	-	-	-	-	+.+	-	-	-	-	-	+.+	-	+.+	2.1	+.+	+.+	-	-	-	1.1	-	II	.4
105 Parmelia separata	-	-	1.1	-	-	-	-	+.+	1.1	-	-	-	1.1	-	1.1	1.1	-	-	2.1	-	-	-	-	-	II	.3
106 Pertusaria panyrga	-	3.1	1.1	-	-	-	1.1	-	-	-	-	-	-	-	-	+.+	-	-	+.+	-	-	-	+.+	-	II	.3
107 Cetraria chrysantha	-	-	1.1	-	-	-	1.1	-	-	1.1	1.1	-	-	-	-	1.1	-	+.+	-	-	-	-	-	-	II	.3
108 Lobaria linita	-	-	-	-	-	-	-	-	-	+.+	-	+.+	-	-	1.1	+.+	-	1.1	-	-	+.+	-	-	-	II	.3
109 Pertusaria coriacea	-	-	3.1	-	-	-	1.1	1.1	-	-	1.1	-	-	-	-	+.+	-	-	-	-	-	-	-	-	II	.3
110 Haematomma lapponicum	-	-	1.1	-	-	-	1.1	+.+	-	-	-	-	1.1	-	-	1.1	-	-	-	-	-	-	1.1	-	II	.2
111 Peltigera spuria	-	+.+	-	-	-	-	-	-	-	-	-	+.+	-	-	-	2.1	-	3.1	-	-	-	-	-	-	I	.7
112 Peltigera canina	-	-	-	-	-	1.1	+.+	+.+	-	-	-	-	-	-	1.1	-	-	-	-	-	-	-	-	-	I	.5
113 Stereocaulon tomentosum	-	-	4.2	-	-	-	-	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	I	.5
114 Psoroma hypnorum	-	-	1.1	-	-	-	-	-	-	1.1	1.1	-	-	-	-	-	-	-	-	-	-	-	+.+	-	I	.2
115 Cetraria hepatizon	-	-	-	-	-	-	1.1	-	-	-	-	-	-	-	1.1	-	-	-	1.1	-	-	-	1.1	-	I	.2
116 Cladonia chlorophaea	-	-	-	+.+	+.+	-	-	-	-	-	-	-	-	+.+	+.+	-	-	-	-	-	-	-	-	-	I	.2
117 Lecidea lapicida	-	-	2.1	-	-	-	-	1.1	-	+.+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	I	.2
118 Cetraria kamczatica	-	-	-	-	-	1.1	-	-	-	-	-	-	1.1	-	-	1.1	-	1.1	-	-	-	-	-	-	I	.2
119 Lecanora epibryon	-	1.1	-	-	-	-	+.+	-	-	-	-	-	-	-	-	-	-	-	+.+	-	-	-	-	-	I	.1
120 Solorina crocea	-	-	-	-	-	-	-	-	-	1.1	1.1	-	-	-	-	-	-	-	-	-	1.1	-	-	-	I	.1
121 Lecidea atromarginata	-	1.1	-	-	-	-	-	-	-	-	-	-	2.1	-	-	-	-	-	-	-	-	-	-	-	I	.1
122 Peltigera malacea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+.+	-	-	-	-	-	-	-	2.1	I	.1
123 Cladonia amaurocraea	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.1	-	-	-	-	-	-	-	-	I	.1
124 Nephroma arcticum	-	-	-	-	-	-	-	-	-	-	1.1	-	-	-	-	-	-	-	+.+	-	-	-	-	-	I	.1

130 Lecanora atrosulphurea	-	1.1	-	-	-	-	-	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	I	.1
131 Lecidea flavocaerulescens	-	-	-	-	-	-	+.+	-	-	-	-	-	-	-	1.1	-	-	-	-	-	-	-	-	-	I	.1
TOTAL SPECIES (incl. sporadics)	26	41	46	26	23	30	60	42	31	55	52	41	41	44	48	73	28	64	67	49	50	24	45	42		

Sporadic species

C layer

132 Lycopodium selago 3(1.1)
133 Saxifraga tricuspidata 6(1.1)
134 Salix richardsonii 12(1.1)
135 Calamagrostis lapponica 24(+.+)
136 Linnaea borealis 33(2.1)
137 Geum glaciale 67(1.1)
138 Luzula wahlenbergii 70(+.+)
139 Salix brachycarpa 70(1.1)
140 Smelowski calycina 70(1.1)
141 Lycopodium annotinum 131(2.1)
142 Senecio yukonensis 131(1.1)
143 Senecio fuscatus 163(1.1)
144 Stellaria longipes 163(1.1)
145 Anemone parviflora 166(1.1)
146 Salix chamissonis 166(5.2)
147 Stellaria ciliatosepala 166(2.1)

D layer (Bryophytes)

148 Cynodontium polycarpon 3(1.1)
149 Dicranum mühlenbeckii 3(1.1)
150 Lophozia badensis 3(+.+)
151 Encalypta vulgaris 6(2.1)
152 Hypnum plicatulum 12(1.1)
153 Nardia compressa 16(+.+)
154 Marsupella varians 24(1.1)
155 Oncophorus schistii 24(+.+)
156 Hypnum hamulosum 33(+.+)
157 Mnium rugicum 33(+.+)
158 Ptilium crista-castrensis 33(1.1)
159 Bryum sp. 70(2.1)
160 Cephaloziella subdentata 70(+.+)
161 Tomenthypnum nitens 89(1.1)
162 Pleurozium schreberi 163(1.1)
163 Blepharostoma trichophyllum 166(+.+)
164 Brachythecium sp. 166(1.1)
165 Cephalozia bicuspidata 166(+.+)
166 Lophozia kunzeana 166(+.+)
167 Lophozia quinquedentata 166(+.+)
168 Philonotis fontana 166(1.1)
169 Scapania irrigua 166(+.+)
170 Sphagnum teres 166(+.+)

(Lichenes)

171 Cetraria nigricans 3(1.1)
172 Parmelia almquistii 14(+.+)
173 Parmelia fraudans 24(1.1)
174 Pertusaria subobducens 24(+.+)
175 Cladonia gonecha 30(+.+)
176 Cladonia furcata 30(+.+)
177 Lecanora polytropa 30(+.+)
178 Cladonia pleurota 33(+.+)
179 Lecanora rupicola 33(+.+)
180 Ochrolechia inaequatula 33(+.+)
181 Parmelia alpicola 33(1.1)
182 Parmelia physodes 33(+.+)
183 Cladonia verticillata 70(+.+)
184 Hypogymnia subobscura 70(1.1)
185 Cetraria scholanderi 114(1.1)
186 Cladonia coniocraea 114(+.+)
187 Cetraria laevigata 121(2.1)

Two subassociations are described, the betulo - ledetosum decumbentis and the cassiopeetosum tetragonae, which is slightly chionophilous.

(a) betulo - ledetosum decumbentis (Figure 13)

The characteristic combination of species of this subassociation are present on more northeasterly and northwesterly exposed slopes at elevations between 1300-1900 ft. They vary in profile from straight to convex to concave and are usually on gently to moderately steep slopes (4-30°). Snow does not persist in the betulo - ledetosum decumbentis after late May or early June. There is probably little difference in duration of snow cover (approximately 8 1/2 months) between this subassociation and the Lupino - Dryadetum *alaskensis. Indications are that snow accumulation is greater in these sites thereby giving increased protection from abrasive winter winds as no wind eroded areas were observed. However, because of their position on the (mid to upper) slope there is less protection from the prevailing northwest winds once the snow has disappeared in the spring and before it is again covered in the autumn.

The undulating topography generally associated with the sampled plots would appear to closely resemble the soil terraces in Alaska described by Sigafoos and Hopkins (1952). Downslope movement caused by creep would seem to be very slow and is reflected in the lack of height in the mounds. Drainage on these slopes is rapid each spring with moisture conditions more mesic to sub-xeric throughout the summer. Exposed rocks are present in half of the sampled plots and are also abundant just below the vegetative mat. However, there appears to be no non-sorted stripe or polygon arrangement to them. The relatively thick vegetative mat probably inhibits frost heaving and plays a major role in retarding downslope movement of rock and rubble. Soil profiles are shallow in all communities, between 19-33 cm in depth, and overlie coarse ice shattered parent material. The profiles indicate greater stability relative to frost displacement by their continuity of profile morphologies. Soil reaction is moderately to strongly acid.

Figure 13. Betulo - Ledetum decumbentis betulo - ledetosum decumbentis at 1700 ft, Canoe Lake. Exposed rocks give evidence of frost heaving, mounds indicate downslope movement. (Photo by Krajina)

Constant vascular species associated with Betula glandulosa and Ledum decumbens but with reduced coverage values are: Vaccinium vitis-idaea, Arctostaphylos alpina, Hierochloe alpina and Vaccinium uliginosum. One or more of the associated woody species may be abundant in some plots than either Betula glandulosa or Ledum decumbens, but the latter are always prominent in the subassociation. Additional major species include Carex podocarpa and Luzula confusa. Where drainage might be impeded and more moist conditions prevail during the summer thick mats of Empetrum hermaphroditum are occasionally present. The few shrubs that are present are less than twelve inches in height and usually receive some protection from the mounds.

The constant occurrence of Dicranum elongatum indicates the well drained condition of the plots. Present in the D. elongatum cushions is Sphenolobus minutus. An additional indication of the sub-xeric conditions is the presence of Polytrichum juniperinum. In more moist microhabitats are Aulacomnium turgidum and Dicranum fuscescens. Lichens are numerous on the drier areas of the mounds and provide more surface coverage than the species present on the more mesic sides. Species present on the drier parts include Cetraria cucullata, C. nivalis, Thamnolia vermicularis, Alectoria ochroleuca, A. nigricans and Cornicularia divergens. Cladonia mitis, C. rangiferina, Cetraria islandica, C. richardsonii, Dactylina arctica and Stereocaulon alpinum are present on the more mesic sides of the mounds. Numerous crustose species are present on dead plant material and include such species as Ochrolechia frigida, Pertusaria dactylina, P. panyrga and P. coriacea.

(b) cassiopeetosum tetragonae (Figure 14)

Habitats dominated by Cassiope tetragona occur on predominantly north facing slopes where moderately late melting snow provides downslope seepage during the early summer. While this community might be considered as slightly chionophilous the inability of Betula glandulosa to tolerate prolonged periods of snow cover suggest that its duration is never so long-lasting as in the true chionophilous communities. All sampled plots are associated with either slope depressions, crevices or non-sorted stripes between 1320-1900 ft. Slope gradients range from 2-47°. Exposed rocks are present in every plot but one, and are estimated to cover between 2-35 percent of the surface area. Plots associated with non-sorted stripes are at higher elevations and on more exposed slopes. Snow cover in these sites is less than on those at lower elevations. Snow accumulation, however minimal, is sufficient to protect the underlying vegetation from desiccating winds and sudden changes in temperature during the early part of the annual thaw. Duration of snow is estimated to be 8 1/2 months.

Figure 14. Betulo - Ledetum decumbentis cassiopeetosum tetragonae on east facing slope (1400 ft), Canoe Lake. Scattered mats of Dryas octopetala are present on raised microhabitats also present individual stems of Lupinus arcticus. (Photo by Lambert)

Soil profiles are shallow with parent materials present directly beneath the vegetative mat in many areas. Drainage is rapid at higher elevations so that surface materials show little evidence of disturbance due to frost action. Cassiope tetragona dominated plots in the depressions at lower elevations are considerably larger in overall area than those associated with the non-sorted stripes. Snow duration is probably two to three weeks longer in these lower sites (9 months). Microrelief in the depressions is mainly low hummock or terrace form. Downslope movement is more evident and can probably be related to the greater accumulation of snow. Drainage is less rapid and the active layer remains moist well into the summer. Soils are shallow with many large rocks both exposed and just below the surface. Buried organic matter found under mineral soil is evidence of the disturbed nature of the substrate.

Relatively large pure patches of Cassiope tetragona are never present, although Cassiope did have the highest average cover value for this subassociation. Constant species include Betula glandulosa, Ledum decumbens, Vaccinium vitis-idaea V. uliginosum, Arctostaphylos alpina and Hierochloe alpina. Additional species present with lower constancy values are Empetrum hermaphroditum, Carex podocarpa, Polygonum bistorta, Salix phlebophylla, Loiseleuria procumbens, Poa arctica and Luzula confusa. Differential species that emphasize the more moist condition of the subassociation are Petasites frigidus and Saxifraga punctata. Several species attained shrub height such as Betula glandulosa, Salix pulchra, S. slauca and Spiraea beauverdiana. These species, however, are more abundant in the C layer as low prostrate forms. Species present on the hummock tops are indicative of the more sub-xeric condition include Salix phlebophylla, Carex podocarpa, Arenaria arctica, Lupinus arcticus, Carex lugens and Loiseleuria procumbens. Large mats of Arctostaphylos alpina are present on low hummocks which are moist in early summer and dry out appreciably later in the summer. In microhabitats that remain more moist, Empetrum hermaphroditum forms large mats.

Dicranum elongatum, Aulacomnium turgidum, Polytrichum juniperinum and Sphenolobus minutus are constant bryophytes. The occurrence of Hylocomium splendens, Sphagnum girgensohnii, S. lenense and Polytrichum piliferum differentiate this layer from the betulo - ledetosum decumbentis. Polytrichum piliferum is indicative of surface disturbance when present. Lichen species that differentiate this later from the previous subassociation are Peltigera scabrosa, P. malacea, Solorina crocea, Dactylina madreporiformis, Nephroma expallidum and Cladonia coccifera. Although these species are of low constancy, they do emphasize the prolonged snow cover and increased moisture.

Two plots (31 and 179) dominated by Loiseleuria procumbens and having a high coefficient of similarity with the Betulo - Ledetum decumbentis are included with this association and not placed into a separate association (Loiseleurietum). This is substantiated by the fact that plot 31 has a higher correlation with the betulo - ledetosum decumbentis while plot 179 is more closely aligned to the cassiopeetosum tetragonae.

Rates of drainage and snow duration would appear to disassociate these two subassociations. However, all the plots have high coefficients of similarity. Moisture conditions are generally considered to be more sub-mesic than mesic. The cassiopeetosum tetragonae although still moist in mid-summer has usually dried out considerably by the end of the summer. Many species in this subalpine zone have broad amplitudes of tolerance and all indications are that these two subassociations, dominated by Betula glandulosa and Ledum decumbens, comprise the major 'heath' type vegetation on the higher elevated more northerly exposed slopes. Deeper snow cover protects the community from desiccation and supplies it with additional moisture during the initial stages of vegetative growth each spring.

4. Vaccinio - Betuletum glandulosae   Table 5 (a) & (b)

The Vaccinio - Betuletum glandulosae is considered to represent the climatic 'climax' in the subalpine zone. Communities of this association occupy approximately 30 percent of the total area covered in this study. Habitats are present on the mid to upper slopes, but are also present on some lower slopes, exposed lake and creek banks. Low shrubs are present in these latter two sites and in sheltered depressions on the upper slopes. Analyzed plots varied in elevation from 1100-1900 ft at Canoe Lake and from 380-1270 ft at Trout Lake. All sites are moderately well drained, although varying slope gradients (2-36°) would suggest the rapidity of drainage varied between habitats. Where drainage is slow the saturated soils are prime sites for downslope movement. Freeze-thaw cycles are common in May and early June during the thaw. The areas delineated by this type are usually a mosaic of solifluction relief.

Table No. 5 b

		Vaccinio - Betuletum glandulosae																		
		vaccinio - betulosum glandulosae (fruticulosum)												vaccinio - betulosum glandulosae (fruticosum)						
Plot No.		74	99	60	66	41	139	55	113	134	135	28	118	78	76	86	161	101	17	26
Plot size (m^2)		........100........												100	100	50	100	100	50	50
Date Analyzed		15/7 1965	21/7 1965	12/7 1965	13/7 1965	2/7 1965	12/7 1966	6/7 1965	14/8 1965	11/7 1966	11/7 1966	19/6 1965	21/8 1965	16/7 1965	15/7 1965	18/7 1965	26/7 1966	9/8 1965	15/6 1965	19/6 1965
PLOT DATA																				
Locality		TL	TL	TL	TL	CL	CL	CL	CL	CL	CL	CL	CL	TL	TL	TL	DL	CL	CL	CL
Elevation (ft)		550	570	930	1270	1100	1100	1250	1325	1500	1525	1760	1900	380	400	660	1100	1250	1400	1650
PHYSIOGRAPHY																				
Land form		Depression	Lake edge	.........Exposed slope.........					Old slide	...Exposed slope..			Drainage way	.Old river. bank		Exposed slope	Raised polygon.	Exposed slope	Depression	
Relief: Profile		Flat-Hum	Flat	Cvx-Hum	Cvx	Cvx	Cvx-Hum	Cvx-Hum	Stg-Hum	......Cvx-Hum.....			Stg-Hum	Stg	Stg-Hum	Cnv	Cvx	Stg-Hum	Cnv	Cnv
Exposure (°)		45	315	0	0	45	90	90	90	90	90	0	120	135	90	200	Total	135	270	315
Slope gradient (°)		0	1	22	15	20	6	11	8	4	3	21	14	36	10	16	2	10	29	5
CLIMATE																				
Snow duration		........9 months........												........9 months........						
STRATA COVERAGE (%)																				
B_2 layer						15						25	40	15	45	25	85	30	60	75
C layer		85	65	95	85	95	95	90	90	95	90	40	85	85	60	85	60	70	40	25
D layer	Moss	40	80	50	55	30	60	35	55	60	65	75	90	55	20	20	80	75	40	65
	Lichen	10	40	15	10	30	35	20	35	20	25	25	30	10	10	10	45	50	15	15
	Dr	1																	2	
PLOT COVERAGE (%) by rock		3													3				2	
SOIL																				
Drainage		........Moderate to well-drained........												........Moderate to well-drained........						
Hygrotope		........Mesic........												........Mesic........						
Depth of active layer (cm)		30	55	25	53	20	54	40	75	35	55	25	50	30	50	62	20	72	20	20
CHEMICAL ANALYSIS																				
No.of samples			1	1	1	2	1	1		1		1	1	1		1	1		1	1
Organic layer	OM		47.6	22.1	72.5	77.0	64.5	53.2		56.3		48.3	52.2	65.5		40.0	87.4		60.8	65.6
	N%		.92	.63	1.26	1.4	1.4	.88		.94		1.4	1.4	1.4		1.12	1.63		1.12	1.47
	C/N		30.0	20.3	33.4	35.1	33.8	35.1		34.7		20.0	21.6	27.1		20.7	31.1		31.5	25.9
	P ppm		18	10	29	48	33	32		25		3	13	16		38	17		54	26
	Na		.54	.42	.44	.97	.72	.8		.73		.81	.73	.71		.57	.98		.79	.81
	K		.65	.64	1.57	1.45	1.5	1.95		.8		.55	2.14	.86		.98	.74		1.86	1.4
	Ca		14.8	13.8	17.2	21.6	20.0	13.5		17.9		23.3	10.5	33.5		17.4	23.6		10.2	5.2
	Mg		4.4	3.8	5.4	8.3	6.3	5.0		4.3		10.0	4.7	10.1		5.6	4.6		5.2	2.8
	CEC		36.1	39.6	184.0	202.5	107.6	74.0		69.7		147.0	43.6	174.0		39.4	104.5		157.0	193.0
	pH		4.6	5.3	4.6	4.8	4.7	5.0		4.3		5.6	4.3	5.2		5.0	4.3		4.5	4.1
No.of samples		1	1	1			1		1				1	1		1				
Organic - Mineral layer	OM	20.7	35.9	8.3			21.4		13.3				11.4	18.8		17.2				
	N%	.36	.31	.56			.51		.59				.25	.7		.48				
	C/N	33.4	67.2	8.6			28.0		13.1				26.4	15.6		20.7				
	P ppm	5	8	3			8		13				14	5		6				
	Na	.53	.39	.42			.56		.56				.62	.58		.42				
	K	.38	.21	.13			.55		1.63				.48	.17		.24				
	Ca	7.0	9.7	5.4			11.6		13.1				9.4	18.5		5.8				
	Mg	1.3	2.1	1.7			3.6		4.5				1.6	5.2		2.0				
	CEC	46.1	43.0	28.4			54.1		26.6				29.0	82.3		28.0				
	pH	4.3	5.4	4.8			5.0		5.1				4.5	5.9		4.6				
No.of samples		2	1		2	1	1	2	1	2	3		2		2	2	3			1
Mineral layer	OM	5.8	3.0		7.6	10.0	3.0	3.6	1.2	1.2	1.7		1.4		8.2	2.7	3.6			6.2
	N%	.36	.16		.26	.39	.17	.1	.18	.03	.07		.22		.19	.13	.18			.09
	C/N	12.5	10.9		16.9	14.9	12.8	23.0	4.4	19.5	8.6		4.1		25.7	11.9	10.6			40.0
	P ppm	2	14		5	5	6	5	4	7	8		6		7	4	6			8
	Na	.48	.37		.43	.38	.59	.44	.6	.7	.83		.61		.44	.43	.72			.74
	K	.13	.1		.15	.19	.25	.3	.41	.4	.25		.29		.3	.12	.44			.25
	Ca	3.1	5.1		3.8	4.5	5.6	3.9	8.4	6.0	5.8		6.8		7.1	5.4	6.8			1.1
	Mg	.5	1.3		1.0	1.3	1.6	1.7	2.0	3.0	1.5		1.7		1.6	2.1	2.5			.3
	CEC	27.9	32.1		33.4	38.2	24.0	27.8	10.2	19.5	25.1		17.5		26.1	21.2	23.3			67.3
	pH	4.4	5.1		4.7	4.7	4.7	5.0	5.0	4.5	4.5		4.8		4.8	5.3	4.4			3.9

Table No. 5 a

	Vaccinio - Betuletum glandulosae																				
	vaccinio - betulosum glandulosae (fruticulosum)												vaccinio - betulosum glandulosae (fruticosum)								
Number of Plots	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7		
Plot No.	74	99	60	66	41	139	55	113	134	135	28	118	78	76	86	161	101	17	25		
Plot size (m^2)	100												100	100	50	100	100	50	50		
Elevation (ft)	550	570	930	1270	1100	1100	1250	1325	1500	1525	1760	1900	380	400	660	1100	1250	1400	1650	Constancy	Avg. Cover
B_2 layer																					
1 Betula glandulosa	-	-	-	-	-	-	-	-	-	-	-	-	2.1	7.2	5.2	9.4	5.2	8.3	8.3		
2 Salix glauca	-	-	-	-	4.2	-	-	-	-	-	5.2	-	4.1	3.2	1.1	2.1	1.1	1.1	-	III	1.1
3 Salix pulchra	-	-	-	-	3.1	-	-	-	-	-	2.1	7.2	-	-	-	-	-	-	1.1		
C layer																					
Betula glandulosa	5.2	4.2	4.2	3.1	6.2	6.2	6.2	7.3	5.2	5.2	2.1	7.2	?	?	?	?	?	?	?	V	5.5
4 Vaccinium uliginosum	4.2	5.2	5.2	6.2	4.1	4.2	3.1	4.2	4.2	2.1	1.1	5.2	7.2	6.3	4.2	4.2	6.2	-	2.1	V	4.0
5 Carex lugens	6.2	1.1	5.2	1.1	2.1	2.1	6.2	3.1	6.2	6.2	1.1	6.2	-	1.1	-	3.1	7.3	-	2.1	V	3.0
6 Ledum decumbens	1.1	-	1.1	2.1	4.1	1.1	4.2	1.1	4.1	3.1	-	2.1	2.1	1.1	4.1	5.2	6.2	1.1	2.1	V	2.3
7 Vaccinium vitis-idaea	1.1	-	1.1	-	4.1	2.1	2.1	1.1	5.2	2.1	-	4.1	2.1	1.1	6.2	5.2	2.1	4.2	2.1	V	2.3
Salix pulchra	-	2.1	3.1	5.2	?	5.2	4.2	1.1	4.2	5.2	?	?	-	-	-	-	-	-	?	IV	2.5
8 Arctostaphylos alpina	4.2	2.1	3.1	4.2	-	2.1	-	2.1	2.2	5.2	-	3.1	3.1	5.2	5.2	-	4.2	2.1	-	IV	2.4
9 Polygonum bistorta	1.1	-	1.1	+.+	-	3.1	1.1	3.1	2.1	2.1	-	4.1	1.1	2.1	1.1	-	2.1	-	1.1	IV	1.3
10 Hierochloe alpina	1.1	-	-	2.1	-	4.1	+.+	2.1	1.1	1.1	-	1.1	-	-	1.1	2.1	-	2.1	2.1	IV	1.1
11 Empetrum hermaphroditum	-	1.1	1.1	-	6.2	-	-	-	1.1	2.2	2.1	1.1	3.1	-	3.1	-	3.1	-	2.1	III	1.3
12 Arctagrostis latifolia	-	-	-	-	3.1	3.1	3.1	3.1	1.1	1.1	3.1	2.1	-	-	-	1.1	+.+	-	2.1	III	1.2
13 Salix phlebophylla	3.1	-	1.1	2.1	-	4.2	1.1	4.2	-	3.1	-	-	-	-	2.1	-	-	2.1	-	III	1.2
14 Poa arctica	-	1.1	1.1	-	-	3.1	-	3.1	-	1.1	1.1	3.1	-	+.+	-	+.+	+.+	-	1.1	III	.9
15 Anemone narcissiflora	-	-	-	-	1.1	2.1	1.1	2.1	2.1	2.1	+.+	2.1	-	-	-	1.1	1.1	1.1	-	III	.8
16 Lupinus arcticus	-	4.1	1.1	-	1.1	1.1	1.1	1.1	-	1.1	1.1	-	-	-	2.1	-	1.1	2.1	-	III	.8
17 Petasites frigidus	-	-	-	-	+.+	1.1	1.1	3.1	1.1	-	1.1	2.1	2.1	-	-	-	-	-	-	III	.6
18 Luzula confusa	1.1	-	2.1	-	-	2.1	1.1	1.1	-	1.1	-	1.1	-	-	-	-	3.1	-	-	III	.6
19 Stellaria ciliatosepala	-	+.+	-	-	-	2.1	-	+.+	1.1	-	+.+	-	1.1	+.+	1.1	1.1	-	1.1	-	III	.6
20 Dryas octopetala	-	-	3.1	2.1	-	-	-	2.1	-	-	1.1	-	-	-	1.1	-	-	2.1	-	II	.6
21 Pedicularis lanata	-	-	1.1	-	1.1	2.1	1.1	-	1.1	1.1	-	-	-	-	-	-	-	-	1.1	II	.4
22 Senecio atropurpureus	-	-	-	-	-	1.1	-	-	1.1	1.1	-	1.1	1.1	-	-	2.1	-	-	1.1	II	.4
23 Pedicularis arctica	-	1.1	-	2.1	-	-	-	2.1	-	-	-	2.1	-	-	-	-	1.1	-	-	II	.4
24 Polygonum viviparum	-	1.1	-	-	2.1	3.1	+.+	1.1	-	-	-	-	-	-	-	-	-	-	-	II	.4
25 Pedicularis labradorica	-	-	-	-	+.+	-	1.1	1.1	1.1	-	-	+.+	-	-	1.1	-	-	1.1	-	II	.4
26 Tofieldia coccinea	1.1	-	2.1	1.1	-	-	-	-	-	-	1.1	-	-	-	+.+	-	-	1.1	-	II	.4
27 Saussurea angustifolia	-	-	-	-	+.+	2.1	+.+	1.1	-	-	-	-	1.1	-	-	-	-	-	-	II	.3
28 Pedicularis capitata	1.1	-	1.1	1.1	-	-	-	-	-	-	-	+.+	-	-	1.1	-	-	-	-	II	.3
29 Eriophorum vaginatum	-	-	-	-	-	-	-	-	6.2	3.1	-	6.2	-	-	-	-	4.1	-	-	I	1.0
30 Salix brachycarpa	-	5.1	-	-	-	-	2.1	5.2	-	-	-	-	-	-	-	-	-	-	-	I	.6
31 Pyrola grandiflora	-	-	1.1	-	1.1	-	-	-	-	-	4.1	-	1.1	-	-	-	-	-	-	I	.4
32 Cassiope tetragona	-	1.1	3.1	1.1	-	-	-	-	-	-	-	1.1	-	-	-	-	-	-	-	I	.3
33 Oxytropis maydelliana	2.1	1.1	1.1	-	-	-	-	-	-	-	-	-	-	2.1	-	-	-	-	-	I	.3
34 Equisetum arvense	-	1.1	-	-	-	-	-	-	-	-	-	-	5.1	-	-	-	-	-	-	I	.3
35 Senecio fuscatus	-	-	-	-	-	2.1	+.+	1.1	-	-	-	-	-	-	-	-	-	-	1.1	I	.3
36 Antennaria neoalaskana	-	-	-	-	1.1	-	2.1	-	-	-	-	-	-	-	1.1	-	-	1.1	-	I	.3
37 Pedicularis lapponica	-	1.1	-	-	-	-	1.1	+.+	+.+	-	-	-	-	-	-	-	-	-	-	I	.2
38 Saxifraga punctata	-	-	1.1	1.1	-	-	-	-	-	-	1.1	1.1	-	-	-	-	-	-	-	I	.2
39 Artemisia arctica	-	-	-	-	-	-	-	1.1	-	-	-	-	-	-	1.1	-	-	1.1	1.1	I	.2
40 Stellaria longipes	1.1	-	+.+	-	-	-	+.+	-	-	-	-	+.+	-	-	-	-	-	-	-	I	.2
41 Saxifraga tricuspidata	-	-	-	-	-	-	-	-	-	-	-	-	-	1.1	-	-	-	1.1	2.1	I	.2
42 Kobresia myosuroides	-	-	1.1	-	-	1.1	-	+.+	-	-	-	-	-	-	-	-	-	-	-	I	.2
43 Cardamine digitata	-	-	+.+	-	+.+	-	-	-	-	-	-	-	+.+	-	-	-	-	-	-	I	.2
44 Salix reticulata	-	1.1	-	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	I	.1
45 Pyrola secunda	-	-	-	-	-	-	-	-	-	-	-	1.1	1.1	-	-	-	-	-	-	I	.1
46 Calamagrostis canadensis	-	-	-	-	-	-	-	+.+	-	-	-	-	-	+.+	-	-	-	-	-	I	.1
47 Luzula nivalis	-	-	-	-	-	1.1	-	-	1.1	-	-	-	-	-	-	-	-	-	-	I	.1
48 Arenaria arctica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.1	-	-	1.1	-	I	.1
49 Castilleja raupii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.1	1.1	I	.1
D layer (Bryophytes)																					
50 Aulacomnium turgidum	4.2	7.3	1.1	6.3	3.1	6.2	-	5.2	4.1	5.2	5.2	5.2	3.1	-	+.+	6.3	3.1	1.1	5.3	V	3.7
51 Polytrichum juniperinum	5.2	3.1	2.1	2.1	1.1	3.2	1.1	3.1	1.1	4.2	1.1	3.1	1.1	-	1.1	3.2	1.1	1.1	1.1	V	2.0
52 Hylocomium splendens	+.+	4.2	3.1	1.1	3.2	4.2	-	2.1	-	2.1	5.2	7.3	6.2	-	2.1	6.3	1.1	-	7.3	IV	2.8
53 Dicranum elongatum	3.1	-	2.1	-	3.1	3.1	-	5.2	4.2	1.1	5.2	3.2	-	1.1	1.1	5.2	3.1	2.1	-	IV	2.2
54 Rhytidium rugosum	2.1	-	4.2	-	1.1	3.2	2.1	2.1	-	-	-	-	4.2	4.2	3.1	-	-	6.3	2.2	III	1.7
55 Sphagnum girgensohnii	-	-	2.1	1.1	1.1	-	-	-	5.2	5.2	-	3.2	2.1	-	-	2.2	7.3	-	-	III	1.5
56 Aulacomnium palustre	-	-	2.1	1.1	-	-	4.1	-	5.2	2.1	-	+.+	-	1.1	4.2	-	-	-	-	III	1.0
57 Sphenolobus minutus	-	-	1.1	-	1.1	1.1	-	2.1	2.1	-	2.1	-	-	-	-	1.1	2.1	-	1.1	III	.7
58 Dicranum angustum	-	1.1	-	-	-	3.2	-	1.1	-	5.3	-	3.2	-	-	-	2.1	1.1	-	-	II	.8
59 Dicranum groenlandicum	-	-	-	-	2.1	-	5.2	3.2	-	4.2	-	-	-	-	1.1	-	4.2	-	-	II	.8
60 Dicranum fuscescens	-	-	-	-	-	5.2	-	-	4.2	-	-	-	3.1	2.1	-	-	-	-	2.1	II	.8
61 Lophozia sp.	-	-	+.+	-	-	1.1	1.1	-	-	-	3.1	-	1.1	-	+.+	-	-	-	-	II	.4
62 Bryum sp.	-	1.1	1.1	+.+	-	1.1	-	-	-	-	-	-	-	-	-	-	-	+.+	-	II	.3
63 Pleurozium schreberi	-	-	-	-	1.1	-	1.1	-	1.1	-	-	-	-	-	-	-	+.+	-	1.1	II	.3
64 Dicranum scoparium	-	-	2.1	-	-	-	1.1	-	-	2.1	-	4.2	-	-	-	-	-	-	-	I	.5
65 Ptilidium ciliare	-	-	-	-	3.1	-	-	-	-	-	6.2	-	-	-	-	-	-	-	-	I	.5
66 Dicranum mühlenbeckii	1.1	-	1.1	2.1	-	-	-	-	-	-	-	-	-	-	-	-	-	3.2	-	I	.4
67 Hypnum callichroum	-	-	1.1	4.2	-	-	-	-	-	-	-	-	1.1	+.+	-	-	-	-	-	I	.4
68 Sphagnum rubellum	-	1.1	-	-	-	-	-	-	-	-	-	-	1.1	-	-	3.2	-	-	-	I	.3
69 Lophozia quinquedentata	-	4.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.1	-	-	I	.3
70 Distichium capillaceum	-	2.1	+.+	-	-	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	I	.2
71 Drepanocladus uncinatus	-	-	-	-	-	-	-	-	-	-	-	-	-	1.1	-	-	1.1	+.+	-	I	.2
72 Tomenthypnum nitens	-	1.1	+.+	-	-	-	-	-	-	-	-	+.+	-	-	-	-	-	-	-	I	.2
73 Calypogeia trichomanis	-	-	-	-	-	-	-	-	+.+	-	-	1.1	-	-	-	-	1.1	-	-	I	.2
74 Eurhynchium pulchellum	-	-	-	-	-	-	+.+	-	-	-	-	-	-	-	-	-	-	+.+	-	I	.1
75 Lophozia kunzeana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.1	+.+	-	-	I	.1
76 Blepharostoma trichophyllum	-	-	-	+.+	-	-	-	-	-	-	-	-	-	+.+	-	-	-	-	-	I	.1
77 Lophozia alpestris	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.1	+.+	-	-	I	.1
78 Tetraplodon paradoxus	-	-	-	-	1.1	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	I	.1
(Lichenes)																					
79 Cetraria cucullata	1.1	1.1	1.1	+.+	3.1	4.1	3.1	3.1	4.1	4.1	1.1	2.1	1.1	1.1	1.1	6.2	5.2	-	1.1	V	2.5
80 Cetraria islandica	-	1.1	1.1	-	3.1	2.1	1.1	1.1	4.2	3.2	1.1	2.1	1.1	1.1	1.1	4.2	3.1	2.1	1.1	V	1.6
81 Peltigera aphthosa	+.+	1.1	1.1	-	2.1	2.1	2.1	2.1	2.1	1.1	3.1	2.1	1.1	2.1	1.1	2.1	1.1	-	1.1	V	1.3
82 Cladonia mitis	-	+.+	-	-	2.1	2.1	3.2	2.2	1.1	-	2.1	3.2	1.1	1.1	-	2.1	4.2	2.2	1.1	IV	1.4
83 Thamnolia vermicularis	1.1	1.1	1.1	1.1	1.1	3.1	1.1	2.1	-	1.1	-	1.1	-	1.1	1.1	2.1	3.1	-	-	IV	1.0
84 Stereocaulon alpinum	-	2.1	1.1	-	+.+	2.1	1.1	1.1	-	2.2	2.1	1.1	1.1	-	1.1	3.1	1.1	-	-	IV	.9
85 Cetraria nivalis	-	1.1	2.1	+.+	1.1	2.1	-	1.1	-	+.+	-	+.+	-	-	1.1	1.1	1.1	1.1	-	IV	.7
86 Cladonia rangiferina	+.+	-	-	-	2.1	2.1	2.2	2.1	1.1	1.1	-	3.2	-	-	-	2.1	4.2	-	2.2	III	1.2
87 Cladonia amaurocraea	-	4.2	-	-	+.+	2.1	+.+	1.1	-	-	1.1	1.1	+.+	-	-	3.1	1.1	-	-	III	.8
88 Nephroma expallidum	-	2.1	-	-	+.+	2.1	+.+	-	1.1	+.+	1.1	-	-	-	2.1	-	-	1.1	+.+	III	.6
89 Dactylina arctica	1.1	-	1.1	-	1.1	-	-	-	1.1	-	3.1	2.1	-	-	-	-	1.1	1.1	1.1	III	.6
90 Peltigera canina	-	-	1.1	-	2.1	-	-	-	-	-	2.1	2.1	-	+.+	1.1	-	2.1	-	1.1	III	.6
91 Cladonia gracilis	-	1.1	-	-	1.1	1.1	1.1	2.1	1.1	1.1	1.1	1.1	-	-	-	-	-	1.1	-	III	.6
92 Peltigera scabrosa	-	1.1	1.1	2.1	1.1	1.1	-	-	1.1	1.1	1.1	2.1	-	-	-	-	-	-	-	III	.6
93 Sphaerophorus globosus	+.+	-	-	+.+	-	2.1	-	1.1	-	1.1	-	+.+	-	-	-	-	2.1	-	-	II	.5
94 Cetraria richardsonii	-	+.+	-	-	-	-	-	-	-	-	1.1	1.1	1.1	-	1.1	-	-	1.1	1.1	II	.4
95 Cladonia uncialis	+.+	-	-	-	+.+	-	-	2.1	1.1	-	-	1.1	-	-	-	2.1	-	-	-	II	.4
96 Lobaria linita	-	2.1	1.1	1.1	-	-	-	-	-	1.1	1.1	-	-	-	-	-	-	-	-	II	.3
97 Alectoria ochroleuca	-	-	-	-	-	2.1	-	-	1.1	1.1	-	1.1	-	-	-	-	-	-	-	I	.3
98 Cornicularia divergens	2.1	-	-	-	-	-	-	1.1	1.1	-	-	-	-	-	-	-	-	1.1	-	I	.3
99 Peltigera polydactyla	-	1.1	-	-	-	-	-	-	-	-	-	-	-	+.+	1.1	2.1	-	-	-	I	.3
100 Psoroma hypnorum	-	+.+	+.+	+.+	-	-	-	-	-	-	-	-	-	-	-	-	-	+.+	-	I	.2
101 Alectoria nigricans	-	-	1.1	-	1.1	-	-	-	-	-	-	-	-	-	-	-	-	1.1	-	I	.2
102 Hypogymnia subobscura	+.+	-	1.1	-	-	-	-	-	-	+.+	-	-	-	-	-	-	-	-	-	I	.2
103 Peltigera spuria	-	+.+	-	-	-	-	-	2.1	-	-	-	-	-	-	-	-	-	-	-	I	.2
104 Cetraria chrysantha	-	-	-	-	-	-	1.1	1.1	-	-	-	-	-	-	-	-	-	-	-	I	.1
105 Ochrolechia frigida	-	-	+.+	+.+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	I	.1
106 Parmelia omphalodes	-	-	-	-	-	-	-	1.1	-	-	-	-	-	-	-	-	-	1.1	-	I	.1
107 Alectoria nitidula	+.+	-	-	-	-	-	-	-	-	1.1	-	-	-	-	-	-	-	-	-	I	.1
108 Stereocaulon tomentosum	1.1	-	-	-	-	-	-	-	-	-	-	-	-	1.1	-	-	-	-	-	I	.1
109 Cladonia gonecha	-	1.1	-	-	+.+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	I	.1
110 Cladonia chlorophaea	-	-	-	-	+.+	-	-	1.1	-	-	-	-	-	-	-	-	-	-	-	I	.1
TOTAL SPECIES (incl. sporadics)	32	47	58	35	48	52	43	58	42	43	41	53	33	28	39	35	45	46	38		

Sporadic species

C layer
111 Senecio yukonensis 17(2.1)
112 Carex podocarpa 26(2.1)
113 Equisetum arvense 28(1.1)
114 Polygonum alaskanum 28(+.+)
115 Astragalus umbellatus 60(1.1)
116 Castilleja pallida 60(1.1)
117 Saxifraga bronchialis 60(1.1)
118 Alnus crispa 78(1.1)
119 Poa glauca 86(2.1)
120 Selaginella sibirica 86(1.1)
121 Rubus chamaemorus 101(+.+)
122 Valeriana capitata 113(+.+)
123 Agoseris aurantiaca 118(2.1)

D layer (Bryophytes)
124 Abietinella abietina 17(1.1)
125 Ceratodon purpureus 17(+.+)
126 Cynodontium strumiferum 17(1.1)
127 Tetraplodon mnioides 17(1.1)
128 Tortula ruralis 17(+.+)
129 Bartramia ithyphylla 26(2.2)
130 Campylium polygamum 26(+.+)
131 Cynodontium polycarpon 28(1.1)
132 Hypnum revolutum 28(1.1)
133 Amblystegium juratzkanum 55(+.+)
134 Sphagnum recurvum 60(4.2)
135 Conostomum tetragonum 66(1.1)
136 Dicranoweisia crispula 66(3.1)
137 Lophozia porphyroleuca 101(1.1)
138 Sphagnum teres 101(3.1)
139 Scapania irrigua 99(3.1)
140 Pohlia nutans 113(+.+)
141 Lophozia obtusa 118(1.1)
142 Ptilium crista-castrensis 118(6.2)
143 Sphagnum balticum 134(2.1)
144 Nardia sp. 139(2.2)
145 Oncophorus tenellus 139(1.1)
146 Lophozia attenuata 161(1.1)
147 Lophozia excisa 161(3.1)
148 Lophozia quadriloba 161(1.1)

(Lichenes)
149 Peltigera malacea 17(2.2)
150 Rhizocarpon geographicum 17(+.+)
151 Solorina crocea 17(+.+)
152 Cetraria pinastri 26(+.+)
153 Cetraria sepincola 26(+.+)
154 Cetraria nigricascens 60(1.1)
155 Parmelia stygia 74(1.1)
156 Cladonia furcata 99(+.+)
157 Ochrolechia inaequatula 99(4.2)
158 Solorina saccata 99(+.+)
159 Ochrolechia upsaliensis 113(1.1)
160 Pertusaria panyrga 113(1.1)
161 Umbilicaria cylindrica 113(1.+)

Hanson (1953), Churchill (1955) and Spetzman (1959) have described a similar vegetation type in the foothill/subalpine region in northern Alaska.

Two variations are recognized and are discussed below.

(a) vaccinio - betulosum glandulosae (fruticulosum) (Figure 15)

Plots sampled in this variation are present on east facing slopes in the Canoe Lake vicinity between 1100-1900 ft. At Trout Lake they have more northerly exposures and are between 550-1270 ft. Physiographically these site profiles are hummocky and either convex or straight. The hummocks are mostly elongated and lying parallel with the direction of the slope. They are between 1-6 ft long and 1-2 ft high and are indicative of soil movement. Exposed rocks are not present in any of the analyzed plots. Snow duration is approximately 9 months, however, this varies due to the microrelief within each plot. During the autumn and winter the depressions between the hummocks are filled with snow. This snow protects the vegetation from desiccating winter winds. The hummock tops are free of snow before the depressions, and occasionally show signs of winter exposure, which is indicated by sparse vegetation cover and small patches of bare soil. Snow remains longer on the east facing slopes at Canoe Lake because they are protected by the higher ridges from the prevailing northwest winds. The west facing slopes are usually free of snow at least a week before those opposite.

Drainage is more rapid on the hummocks, giving rise to a much thicker active layer, than the depressions. Subsurface meltwater channels are present at the lowest points under the hummocks. It is not unusual for ice to be present directly under the depression vegetation in mid-summer. Although the Vaccinio - Betuletum glandulosae is considered to be the climatic 'climax' the soil profiles do not always indicate a great degree of genetic development. Downslope movement of materials causes a burying of organic matter within the mineral horizons. Profiles show greater development within the hummocks than in the depressions.

Figure 15. Vaccinio - Betuletum glandulosae (fruticulosum) on gentle east facing dip slope (1400 ft) east of Canoe Lake. Carex lugens present on the mounds. (Photo by Krajina)

The major vascular species of this variation are present on the more mesic sides of the hummocks. Constant species associated with Betula glandulosa and Vaccinium uliginosum are Carex lugens, Ledum decumbens and Vaccinium vitis-idaea. Additional important species include Arctostaphylos alpina, Polygonum bistorta, Arctagrostis latifolia, Anemone narcissiflora and Empetrum hermaphroditum. An indication of the degree of drainage on the hummock tops and their more exposed position is the presence of Hierochloe alpina, Salix phlebophylla, Dryas octopetala, Lupinus arcticus and Antennaria neoalaskana. In the moister depressions Salix pulchra is the major vascular species and because of its more sheltered position sometimes attains shrub height (over 6 inches). The tussock forming Eriophorum vaginatum is present in only three plots and is not treated separately in the synthesis tables because of its high correlation with the fruticulosum.

Lichens are less abundant due to the more compact habit of the vascular flora. On the dry hummock tops Cetraria cucullata, C. nivalis and Thamnolia vermicularis are generally present. Mosses are rare on the more exposed microhabitats. They are, however, abundant on the more mesic sides and include such species as Aulacomnium turgidum, Hylocomium splendens, Polytrichum juniperinum, Dicranum elongatum D. scoparium, D. groenlandicum and Sphagnum girgensohnii. Scattered throughout these mosses are several lichens such as Cetraria islandica, Cladonia mitis, C. rangiferina, C. amaurocraea, Stereocaulon alpinum, Dactylina arctica and Nephroma expallidum. Bryophytes dominate the depression microhabitats and certain species characteristic of moister habitats are present. They include Sphagnum girgensohnii, Ptilidium ciliare, Aulacomnium palustre and Dicranum angustum.

(b) vaccinio - betulosum glandulosae (fruticosum) (Figure 16)

This variation is present in depressions on westerly and northerly exposed upper slopes and on sheltered slopes at lower elevations. Shrub size (1/2-2 ft) Betula glandulosa are characteristic of this type. In the Canoe Lake region plots were analyzed at between 1100-1900 ft elevation and at Trout Lake between 380-660 ft. Site profiles on the lower slopes are either straight or straight-hummocky. The upland depressions correspond to the snow-patch habitats described by Porsild (1951), where owing to the prevailing winds, a snowdrift forms regularly each winter giving protection to the underlying plant cover. Plots of this type are generally small (100 sq. m. or less). At both Trout Lake and Canoe Lake these sites are easily recognized in the spring by their persistent snow cover, and the lack of snow on surrounding communities. These depressions are a result of mass downslope movement of rocks, soil and vegetation (generally in the spring) due to excessive drainage water and frost heaving. The sampled plots on the lower slopes show signs of mass movement that appear related to either solifluction or thermokarst activity. The latter relating to the exposure of perennially frozen ground by spring flood waters along raised creek banks. Due to the more sheltered position of these plots a protective snow cover does not appear to be necessary to guarantee the survival of shrub species. Drainage is more rapid in this variation than in the fruticulosum and can be related to the reduction in hummock type microrelief. Soil profiles are shallower in the depressions because of past disturbance. On the lower slopes and creek banks profiles are generally deeper, however, depth to permafrost seldom exceeds 65 cm.

Figure 16. Vaccinio - Betuletum glandulosae (fruticosum) depression on lower slope (1200 ft) northwest corner of Canoe Lake. Bordered by fruticulosum hummocks elongated and lying parallel with the direction of the slope. (Photo by Krajina)

Vascular plants associated with the shrub Betula glandulose and Vaccinium uliginosum in the fruticosum as constants are Ledum decumbens, Vaccinium vitis-idaea, Arctostaphylos alpina and Salix glauca. Due to the reduction in size or lack of hummock microrelief several species of major importance in the fruticulosum, although present in the fruticosum, are of minor importance. They include Carex lugens, Anemone narcissiflora, Polygonum bistorta and Arctagrostis latifolia. Shading by shrubs might be an additional factor in their reduced presence and low coverage values. In the depressions habitats Sphagnum species are absent, probably due to the drier conditions. They are present on the lower slopes where drainage is less rapid due to shallow slope gradients. The presence of Rhytidium rugosum suggests that drainage, once the thaw has commenced, is more rapid than on surrounding sites. Other major bryophytes present are Aulacomnium turgidum, Hylocomium splendens, Dicranum elongatum and Polytrichum juniperinum. The occurrence and abundance of lichen species is reduced partially on account of shading and possibly because of the disturbed condition of the sites. Cetraria cucullata is abundant in only two plots (101 and 161), both of which are at lower elevation.

The range in elevation between the highest and lowest elevated plots indicates that a good winter snow cover is provided. On more northerly exposed slopes the community is present in depressions while on more southerly exposed slopes the fruticosum is seldom exposed to desiccating winds. Species diversity is greater in the Vaccinio - Betuletum glandulosae than in any other community where Betula glandulose is a major constituent. These sites never experience as rapid a drainage as do those habitats on the upper slopes, nor as restricted a drainage as those on the lower slopes, soil moisture conditions are more mesic than sub-mesic. Permafrost lies close to the surface (within 60 cm). Diurnal changes in temperature and relative humidity are never so great as on the upper slopes and ridge tops or in the wetland sites. The highest temperature recorded at Canoe Lake in 1965 was 85°F in plot 17. Soil temperatures are generally warmer and probably allow a great degree of microbial activity because of their more mesic condition. However, slow downslope movement of materials probably restricts increased soil development.

5. Betulo - Chamaemoretum Table 6 (a) & (b)

The Betulo - Chamaemoretum is characteristic of poorly drained lower slopes with seepage occurring throughout the vegetative season. These sites are not waterlogged, although, a low hummocky microrelief is always present. The plots generally have a more southerly exposure and range in elevation from 1075-1475 ft. Slope gradients are gentle or moderate (0-20°). Many of the sites are old drainage pathways with the remainder restricted to more easterly exposed slopes. Snow cover is moderately deep due to the sheltered low elevated position and the presence of shrubs. Duration is approximately 9-9 1/2 months. The physiography and floristic composition of this association is similar to the _Alnus crispa_ type along the Colville River, Alaska and described by Churchill (1955).

Two subassociations are recognized, the betulo - chamaemoretosum with _Alnus crispa_ absent, and the alnetosum crispae.

(a) betulo - chamaemoretosum

This subassociation is found on a variety of habitats all of which are regarded as hygric. Site types range from old drainage pathways to lake edges. Sampled plots were on southerly exposed slopes between 1075-1190 ft. Microrelief is generally straight to concave hummocky with a gently sloping gradient (0-10°). Snow duration is estimated to be 9 months and is considered moderately deep (no actual measurements are available). Soils are shallow with little profile development. Permafrost is present within 25 cm of the surface and as deep as 42 cm (measured August 11th, 1966). While drainage is not restricted, the hygric condition that prevails especially in the mineral soil leaves these sites susceptible to frost heaving during the spring and autumn. This condition gives rise to the hummocky microrelief present in all plots.

Constant species in this subassociation are _Betula glandulosa_, _Rubus chamaemorus_, _Vaccinium uliginosum_, _V. vitis-idaea_, _Ledum decumbens_, _Empetrum_

Table No. 6 b

		Betulo - Chamaemoretum									
		betulo - chamaemoretosum						alnetosum crispae			
Plot No.		106	51	47	46	152	123	167	112	181	176
Plot size (m^2)		....................100..................						.............50.............			
Date Analyzed		12/8 1965	5/7 1965	4/7 1965	4/7 1965	23/7 1966	22/8 1965	28/7 1966	17/8 1965	13/8 1966	11/8 1966
PLOT DATA											
Locality		CL	CL	CL	CL	CL	CL	CL	CL	CL	CL
Elevation (ft)		1075	1100	1125	1125	1150	1190	1175	1250	1350	1475
PHYSIOGRAPHY											
Land form		River bank	Old creek	Depre-ssion	Drain-age way	Lake edge	Old creek	Drain-age way	Exposed slope	Exposed slope	Exposed slope
Relief: Profile		...Straight...		Cnv	Stg	Flat	Stg	Cnv	Stg-Hum	Stg-Hum	Cnv-Hum
Exposure (°)		120	180	135	135	315	90	200	90	90	70
Slope gradient (°)		5	3	4	4	0	10	20	19	10	20
CLIMATE											
Snow duration		................9½ months.................						..........9½ months.........			
STRATA COVERAGE (%)											
B_1 layer								30	30	40	70
B_2 layer		70			90	30	50	75	70	20	30
C layer		70	65	90	40	85	90	100	85	90	60
D layer	Moss	100	95	90	80	95	95	100	85	90	45
	Lichen	5	2		3	15	10		3	3	2
SOIL											
Drainage		............Poor to Moderate.............						.........Moderate..........			
Hygrotope		.................Hygric..................						..........Hygric...........			
Depth of active layer (cm)		42	35	30	30	40	26	28	30	20	43
CHEMICAL ANALYSIS											
No.of samples		2	3	3	2	2	2	3	2	1	2
Organic layer	OM	86.0	70.5	72.5	50.3	71.8	79.7	68.0	94.9	82.0	74.4
	N%	1.12	1.19	1.38	1.05	1.21	.84	1.48	1.01	1.39	1.29
	C/N	45.1	36.3	30.1	27.9	34.3	66.2	26.2	56.0	34.2	33.5
	P ppm	32	5	5	4	18	16	15	26	16	38
	Na	.9	.88	1.09	.94	.96	.68	.93	.64	.98	.93
	K	.88	.6	.87	.36	1.08	.72	.67	1.23	.93	.94
	Ca	13.6	29.5	7.9	8.6	25.2	18.6	20.6	15.5	26.4	23.8
	Mg	5.1	7.2	3.1	3.5	5.1	2.4	5.8	6.8	3.9	3.4
	CEC	116.5	148.0	134.3	138.0	72.4	120.5	65.6	140.5	132.3	92.9
	pH	4.2	5.0	4.2	4.8	4.1	4.2	4.7	3.8	4.7	4.5
No.of samples					2	1			1		
Organic - Mineral layer	OM				31.2	34.5			17.5		
	N%				1.08	1.09			.62		
	C/N				18.7	18.4			16.4		
	P ppm				3	18			16		
	Na				.89	1.12			.55		
	K				.17	.51			.25		
	Ca				3.5	18.7			10.9		
	Mg				.9	2.8			2.5		
	CEC				58.6	53.4			29.3		
	pH				4.5	4.2			4.4		
No.of samples		2	2			1	1			2	2
Mineral layer	OM	8.2	3.7			0.0	7.0			5.4	9.8
	N%	.32	.13			.06	.26			.21	.31
	C/N	14.1	15.7			0.0	15.6			13.7	18.2
	P ppm	7	12			4	4			5	22
	Na	.58	.55			.47	.56			.82	.81
	K	.15	.1			.3	.24			.38	.6
	Ca	3.3	4.4			3.6	10.3			7.4	10.1
	Mg	1.1	.6			.3	.6			25.2	24.3
	CEC	28.8	41.8			3.6	34.7			4.9	4.4
	pH	4.7	5.5			4.9	4.8				

Table No. 6 a

		Betulo - Chamaemoretum											
		betulo - chamaemoretosum						alnetosum crispae					
Number of Plots		1	2	3	4	5	6	1	2	3	4		
Plot No.		106	51	47	46	152	123	167	112	181	176		
Plot size (m^2)		100						50					
Elevation (ft)		1075	1100	1125	1125	1150	1190	1175	1250	1350	1475		
B layer	sub layer											Constancy	Avg. Cover
1 Alnus crispa	1	-	-	-	-	-	-	7.3	7.3	7.3	7.3	II	2.8
2 Salix pulchra	2	-	-	-	6.2	6.2	-	6.2	-	4.2	5.2		
3 Salix glauca	2	5.2	-	-	-	-	1.1	-	2.1	-	-	II	.8
4 Spiraea beauverdiana	2	4.2	-	-	3.1	-	-	-	1.1	-	5.3		
5 Betula glandulosa	2	8.3	-	-	7.3	-	7.3	7.3	7.3	5.2	4.2		
C layer													
Betula glandulosa		?	3.1	6.2	?	4.1	?	?	?	?	?	V	5.8
6 Rubus chamaemorus		8.2	2.1	8.2	4.1	5.1	7.2	5.1	6.2	2.1	5.1	V	5.2
7 Empetrum hermaphroditum		-	3.1	8.3	2.1	6.2	7.2	7.2	6.2	3.1	3.2	V	4.5
8 Vaccinium uliginosum		3.1	3.1	5.2	2.1	5.2	4.2	6.2	5.2	6.2	5.2	V	4.4
9 Ledum decumbens		2.2	2.1	3.1	3.1	4.2	6.2	6.2	6.2	4.2	4.2	V	4.0
10 Vaccinium vitis-idaea		1.1	2.1	2.1	3.1	5.2	6.3	5.2	4.1	4.2	1.1	V	3.3
11 Pedicularis lapponica		1.1	1.1	1.1	1.1	2.1	1.1	4.1	1.1	+.+	-	V	1.3
Salix pulchra		-	4.1	3.1	?	?	-	?	-	?	?	IV	3.4
12 Arctagrostis latifolia		1.1	1.1	-	1.1	-	2.1	1.1	3.1	1.1	3.1	IV	1.3
13 Petasites frigidus		+.+	+.+	-	1.1	1.1	2.1	-	2.1	-	5.1	IV	1.3
14 Polygonum bistorta		1.1	-	1.1	-	3.1	-	3.1	2.1	1.1	1.1	IV	1.2
Spiraea beauverdiana		?	-	1.1	?	-	-	4.2	?	-	?	III	1.8
15 Lycopodium annotinum		-	-	4.2	-	1.1	-	4.2	-	6.2	3.2	III	1.8
16 Carex lugens		-	5.1	-	+.+	-	-	3.1	+.+	4.2	-	III	1.4
17 Andromeda polifolia		-	-	2.1	-	1.1	-	3.1	+.+	2.1	-	III	.9
18 Eriophorum vaginatum		-	1.1	1.1	-	2.1	-	1.1	2.1	-	-	III	.7
19 Pedicularis labradorica		+.+	1.1	+.+	1.1	1.1	-	-	-	-	-	III	.5
20 Poa arctica		1.1	-	-	-	-	+.+	3.1	-	-	2.1	II	.8
21 Arctostaphylos alpina		-	-	-	-	-	-	1.1	+.+	1.1	-	II	.3
22 Luzula wahlenbergii		2.1	-	-	-	-	-	-	-	-	3.1	I	.5
23 Linnaea borealis		-	-	-	-	-	-	3.1	-	2.1	-	I	.5
24 Stellaria ciliatosepala		-	-	-	2.1	-	-	-	-	-	2.1	I	.4
25 Calamagrostis canadensis		3.1	-	-	-	-	-	-	+.+	-	-	I	.4
26 Pinguicula villosa		-	-	1.1	-	+.+	-	-	-	-	-	I	.2
27 Equisetum arvense		-	1.1	-	+.+	-	-	-	-	-	-	I	.2
28 Carex aquatilis		-	+.+	-	-	+.+	-	-	-	-	-	I	.2
D layer (Bryophytes)													
29 Sphagnum girgensohnii		7.3	-	6.3	8.3	-	8.4	9.4	8.3	6.2	4.2	IV	5.6
30 Sphagnum recurvum		7.2	7.3	+.+	-	7.3	+.+	-	2.1	7.3	3.1	IV	3.5
31 Polytrichum juniperinum		1.1	3.1	1.1	4.2	4.2	4.2	5.2	1.1	-	-	IV	2.3
32 Sphagnum rubellum		1.1	4.2	1.1	-	5.3	1.1	-	1.1	3.2	-	IV	1.6
33 Aulacomnium turgidum		-	5.2	-	-	1.1	2.1	1.1	+.+	1.1	1.1	IV	1.2
34 Aulacomnium palustre		2.1	2.1	2.1	4.2	5.2	-	-	-	-	-	III	1.5
35 Hylocomium splendens		-	-	-	1.1	3.2	2.1	-	2.2	6.2	-	III	1.4
36 Dicranum scoparium		-	-	3.1	1.1	-	-	3.2	1.1	2.1	1.1	III	1.1
37 Lophozia kunzeana		1.1	-	1.1	1.1	1.1	-	+.+	1.1	-	-	III	.6
38 Polytrichum commune		3.2	-	2.1	-	-	-	2.1	-	-	4.2	II	1.1
39 Calliergon stramineum		-	-	-	+.+	+.+	-	-	-	+.+	2.1	II	.5
40 Calypogeia trichomanis		-	-	-	-	1.1	3.2	-	1.1	-	-	II	.5
41 Dicranum angustum		-	-	-	-	3.2	-	-	1.1	+.+	-	II	.5
42 Drepanocladus uncinatus		-	-	-	2.1	-	-	-	-	1.1	1.1	II	.4
43 Tomenthypnum nitens		2.1	-	-	1.1	-	1.1	-	-	-	-	II	.4
44 Sphagnum lenense		4.2	-	-	-	-	-	-	1.1	-	-	I	.5
45 Sphenolobus minutus		-	-	-	-	-	2.1	-	1.1	-	-	I	.3
(Lichenes)													
46 Cetraria cucullata		-	1.1	-	-	2.1	+.+	-	+.+	-	-	II	.5
47 Peltigera scabrosa		2.1	-	-	-	2.1	-	-	+.+	-	-	II	.5
48 Cladonia amaurocraea		-	-	-	-	3.2	+.+	-	+.+	-	-	II	.5
49 Cetraria pinastri		2.1	-	-	-	-	-	-	1.1	-	1.1	II	.4
50 Cladonia rangiferina		-	-	-	-	2.1	1.1	-	-	+.+	-	II	.4
51 Stereocaulon alpinum		-	-	-	-	2.1	+.+	-	-	-	1.1	II	.4
52 Cetraria islandica		-	-	-	-	-	3.1	-	+.+	-	-	I	.4
TOTAL SPECIES (incl. sporadics)		30	24	25	31	41	30	25	37	31	27		

Sporadic species

C layer

53 Luzula rufescens 46(2.1)
54 Selaginella sibirica 47(3.1)
55 Carex rotundata 51(5.1)
56 Eriophorum angustifolium 51(2.1
57 Senecio yukonensis 106(2.1)
58 Viola epipsila 123(+.+)
59 Oxycoccus microcarpus 152(3.1)
60 Pyrola secunda 176(2.1)
61 Hierochloe alpina 181(1.1)
62 Cassiope tetragona 181(1.1)
63 Carex vaginata 181(2.1)

D layer (Bryophytes)

64 Lophozia excisa 46(1.1)
65 Pohlia nutans 46(1.1)
66 Tetraplodon paradoxus 46(+.+)
67 Sphagnum balticum 47(8.3)
68 Sphagnum lindbergii 106(3.2)
69 Sphagnum riparium 106(4.2)
70 Dicranum elongatum 112(1.1)
71 Dicranum fuscescens 123(4.2)
72 Gymnocolea inflata 123(1.1)
73 Cephalozia bicuspidata 152(1.1)
74 Dicranum mühlenbeckii 152(1.1)
75 Lophozia ventricosa 152(+.+)
76 Mylia anomala 152(+.+)
77 Nardia scalaris 152(1.1)
78 Sphagnum aongstroemii 152(3.2)
79 Ceratodon purpureus 176(+.+)
80 Calliergon cordifolium 181(1.1)
81 Cephalozia leucantha 181(+.+)

(Lichenes)

82 Parmeliopsis ambigua 46(1.1)
83 Peltigera aphthosa 46(+.+)
84 Cetraria sepincola 46(1.1)
85 Lecidea sp. 106(1.1)
86 Peligera canina 51(+.+)
87 Peltigera malacea 112(+.+)
88 Cladonia mitis 123(1.1)
89 Peltigera polydactyla 123(1.1)
90 Cetraria richardsonii 152(2.1)
91 Thamnolia vermicularis 152(1.1)
92 Cladonia fimbriata 152(1.1)

hermaphroditum and Pedicularis lapponica. The woody species (B. glandulosa V. uliginosum, V. vitis-idaea and L. decumbens) present in the betulo-chamaemoretosum have broad amplitudes of tolerance. Their presence in these poorly drained habitats is related to their ability to root only in the organic horizon thereby avoiding the excess moisture present in the mineral horizons. Associated species with high constancy and coverage values include Salix pulchra, Pedicularis labradorica, Petasites frigidus and Arctagrostis latifolia. Two differential species are present, they are Pedicularis labradorica and Pinguicula villosa. The high constancy and coverage of Rubus chamaemorus suggests an available supply of calcium in the organic layer, and that considerable drying out occurs in the hummocks. Lichen presence and coverage is very low with no species present in more than half of the sampled plots. Sphagnum girgensohnii, S. recurvum, S. rubellum, Aulacomnium palustre and Polytrichum juniperinum are the dominant bryophytes. The presence of Sphagnum species and Aulacomnium palustre in the depressions is an indication of the hygric condition of the habitats.

(b) alnetosum crispae

Floristically this subassociation is similar to the betulo - chamaemoretosum except for the presence of Alnus crispa. The tall Alnus crispa plots are distinguished by their dark bluish green colour. They occur at low elevations, between 1175-1475 ft, on steeper slopes (10-20° gradients) and are usually present below exposed felsenmeer. During the early part of the summer the sampled plots were very wet. Seepage is generally continuous throughout most of the summer. The permafrost table is high, never less than 43 cm from the surface, so that seepage would appear to have little affect on its position. Surface microrelief is generally hummocky with moisture conditions similar to those of the previous subassociation. Snow accumulation is greater in these habitats and its build up during the winter is no doubt aided by the shrubs themselves.

As the majority of these plots are on east facing slopes with their sides exposed, snow cover protects the Alnus crispa from desiccating winter winds.

The tall well-developed Alnus crispa shrubs protect the other woody species present in the community and produce a favourable environment for their additional growth. Betula glandulose, Salix pulchra, S. glauca and Spiraea beauverdiana all attain shrub height (under 2 ft) in this association. Species composition in the C layer is similar to that of the betulo - chamaemoretosum with Rubus chamaemorus having high coverage values in every plot. Shading by the shrubs appears to affect the distribution of several species, restricting the establishment of Pinguicula villosa and Pedicularis labradorica. Several species present in the association have higher constancy values and coverage values in this subassociation, they are Lycopodium annotinum, Arctostaphylos alpina, Andromeda polifolia Carex lugens and Linnaea borealis. The D layer is again dominated by Sphagna. However, Dicranum scoparium and Aulacomnium turgidum are present on the drier hummock surfaces. The absence of Aulacomnium palustre probably reflects the better drainage on these steeper more elevated slopes. Lichen cover is very meagre.

6. Betulo - Eriophoretum vaginati Table 7 (a) (b)

Hanson (1953) has termed this a 'complex' in recognition of the close association of microcommunities, however, they were not separated in his synthesis tables. In the present study only one association is recognized. This community type may occur in both upland and lowland areas of the subalpine zone where drainage is poor and moisture conditions remain semi-hydric throughout the summer. They are not restricted to any particular slope, but are exposed to all the cardinal points. Snow duration is estimated to be 9 months. Accumulation is never deep due to the generally low microrelief and exposed position of the plots. This is reflected in the low growth of species present in this association. Drainage is poor and at times restricted.

Table No **7b**

		Betulo - Eriophoretum vaginati														
		eriophoretosum vaginati											salicetosum reticulatae			
Plot No.		93	69	59	52	138	54	130	40	48	180	34	87	27	21	71
Plot size (m^2)		..............................100..................................											......100.......			100
Date Analyzed		20/7 1965	14/7 1965	12/7 1965	5/7 1965	12/7 1966	6/7 1965	24/8 1965	2/7 1965	5/7 1965	13/8 1966	21/6 1965	18/7 1965	19/6 1965	16/6 1954	14/7 1965
PLOT DATA																
Locality		TL	TL	TL	CL	CL	CL	CL	CL	CL	CL	CL	TL	CL	CL	TL
Elevation (ft)		500	575	625	1080	1100	1100	1130	1130	1150	1500	1850	650	1750	1850	500
PHYSIOGRAPHY																
Land form		Raised polyon	..Exposed.. slope		Raised polygon	..Exposed.. slope		Old creek	Exposed slope	Raised polyon	Exposed slopes	Drain-age way	Exposed slope	Dried up lake	Exposed slope	Slope depression
Relief: Profile		....Cvx-Hum........			Hum	Stg-Hum	..Hummocky..		Cvx-Hum	Hum	Stg-Hum	Cvx-Hum	....Cnv-Hum...		Stg-Hum	Cvx-Hum
Exposure (°)		45	45	90	25	270	90	0	70	0	90	70	200	0	270	45
Slope gradient (°)		2	2	5	0	4	10	1	10	0	5	15	8	2	10	8
CLIMATE																
Snow duration		..............................9 months...................................											.......9 months......			9 months
STRATA COVERAGE (%)																
B_2 layer																25
C layer		100	85	80	95	95	40	95	70	95	90	60	100	95	95	100
D layer	Moss	50	65	55	50	65	90	75	85	40	85	70	70	60	50	50
	Lichen	20	10	5	5	20	5	55	10	15	5	15	15	10	10	10
SOIL																
Drainage		..............................Impeded..											......Moderate.......			Impeded
Hygrotope		.... Hydric to semi-hydric..............................											Hygric to semi-hygric			Hygric
Depth of active layer (cm)		25	20	28	35	30	27	28	30	30	30	33	28	30	30	35
CHEMICAL ANALYSIS																
No.of samples		2	1	1	3	1	3	2	1	3	2	1	2	2	2	1
Organic layer	OM	74.9	55.8	59.3	82.8	72.6	62.1	76.3	84.5	85.6	88.4	77.2	34.2	62.8	57.9	69.5
	N%	1.26	.77	1.05	1.39	1.09	.88	.84	1.89	1.28	1.76	1.12	1.16	1.01	1.86	1.05
	C/N	30.6	42.0	32.8	36.6	38.6	51.8	55.5	25.9	39.4	29.5	40.0	17.4	37.2	18.2	38.4
	P ppm	10	10	19	11	28	5	17	5	32	32	0	8	15	10	21
	Na	.67	.79	.8	.91	.74	.81	.66	1.34	1.02	1.12	1.0	.63	.96	.81	.74
	K	.68	.73	1.01	.55	.74	.62	.76	.99	1.43	.87	.3	.3	.9	.48	.98
	Ca	8.1	7.9	21.0	7.9	16.3	11.7	13.5	13.9	8.13	32.9	4.5	29.5	27.0	26.6	11.3
	Mg	2.0	4.3	9.2	3.7	.9	3.4	4.1	4.4	1.6	3.3	1.0	10.8	15.3	6.6	4.3
	CEC	124.0	82.3	98.3	160.0	84.3	107.9	80.8	193.0	129.7	138.0	139.0	74.3	134.5	138.0	84.1
	pH	4.1	4.3	4.8	4.4	5.9	4.8	3.7	4.3	3.7	4.2	4.5	6.3	6.1	5.8	4.2
No.of samples						2			1							
Organic - Mineral layer	OM					39.4			33.1							
	N%					.56			.42							
	C/N					42.1			45.7							
	P ppm					20			2							
	Na					.9			.93							
	K					.82			.2							
	Ca					15.6			4.7							
	Mg					4.7			.9							
	CEC					50.8			76.3							
	pH					4.0			4.5							
No.of samples			1	1		1	1	1		1	1	1				
Mineral layer	OM		19.8	21.4		4.3	16.4	.6		18.3	2.7	1.9				
	N%		.22	.63		.13	.52	.1		1.32	.09	.07				
	C/N		52.2	19.7		19.1	18.7	3.5		8.0	17.4	12.2				
	P ppm		3	11		9	2	3		2	7	5				
	Na		.57	.56		.76	.42	.54		.88	.92	.89				
	K		.21	.35		.09	.08	.07		.13	.34	.14				
	Ca		3.3	12.7		11.3	3.2	5.4		1.7	7.4	1.2				
	Mg		1.5	3.9		2.3	.7	.6		.2	1.0	.1				
	CEC		38.1	57.4		30.5	49.5	13.0		76.3	12.2	23.9				
	pH		4.9	5.3		4.4	4.9	5.2		3.8	4.5	4.8				

Table No. **7 a**

	Betulo - Eriophoretum vaginati																
	eriophoretosum vaginati											salicetosum reticulatae					
Number of Plots	1	2	3	4	5	6	7	8	9	10	11	1	2	3	1		
Plot No.	93	69	59	52	138	54	130	40	48	180	34	87	27	21	71		
Plot size (m^2)	......................100......................											....100.....			100		
Elevation (ft)	500	575	625	1080	1100	1100	1130	1130	1150	1500	1850	650	1750	1850	500		
B layer																Constancy	Avg. Cover
1 Alnus crispa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.1		
C layer																	
2 Eriophorum vaginatum	7.2	6.2	6.2	8.3	8.3	5.2	8.3	6.2	7.2	8.2	6.2	6.2	8.2	7.2	7.2	V	7.0
3 Betula glandulosa	5.2	3.1	3.1	2.1	3.1	1.1	3.1	3.1	5.2	5.2	4.1	-	4.2	3.1	3.1	V	3.1
4 Ledum decumbens	4.1	3.1	1.1	2.1	4.1	3.1	5.2	4.1	5.2	5.2	3.1	-	+.+	1.1	4.1	V	3.0
5 Vaccinium vitis-idaea	5.2	2.1	2.1	1.1	5.2	1.1	5.2	3.1	4.2	5.2	3.1	-	1.1	3.1	4.1	V	2.9
6 Empetrum hermaphroditum	3.1	2.1	1.1	1.1	4.2	1.1	-	2.1	-	3.1	1.1	-	2.1	2.1	4.2	V	1.8
7 Vaccinium uliginosum	2.1	2.1	2.1	2.1	1.1	1.1	1.1	1.1	2.1	3.1	3.1	2.1	2.1	-	2.1	V	1.7
8 Carex lugens	-	4.1	4.1	-	5.2	1.1	2.1	1.1	-	4.1	2.1	1.1	4.1	5.2	-	IV	2.2
9 Rubus chamaemorus	-	1.1	2.1	1.1	3.1	3.1	4.1	3.1	2.1	2.1	2.1	-	-	-	-	IV	1.6
10 Pedicularis lapponica	-	2.1	1.1	1.1	1.1	1.1	2.1	1.1	-	2.1	3.1	-	-	-	+.+	IV	1.0
11 Salix pulchra	-	1.1	5.2	-	-	2.1	-	-	-	3.1	1.1	1.1	4.2	4.2	2.1	III	1.6
12 Polygonum bistorta	-	1.1	-	-	2.1	-	-	2.1	-	2.1	-	2.1	2.1	1.1	-	III	.8
13 Arctostaphylos alpina	-	3.1	-	-	4.2	-	-	2.1	-	-	-	-	-	2.1	3.1	II	.9
14 Salix reticulata	-	-	2.1	-	-	-	-	-	-	-	-	1.1	4.2	4.1	-	II	.7
15 Andromeda polifolia	1.1	-	-	2.1	-	-	-	-	-	-	2.1	-	-	-	+.+	II	.4
16 Pinguicula villosa	-	-	-	2.1	1.1	-	-	-	-	1.1	2.1	-	-	-	-	II	.4
17 Luzula nivalis	1.1	-	-	-	1.1	-	-	-	-	-	-	+.+	1.1	-	-	II	.3
18 Arctagrostis latifolia	-	-	-	-	-	-	-	2.1	-	-	-	+.+	3.1	-	-	I	.4
19 Petasites frigidus	-	-	-	-	-	-	-	2.1	-	-	-	2.1	2.1	-	-	I	.4
20 Carex rotundata	-	-	-	1.1	-	-	-	-	-	-	3.1	1.1	-	-	-	I	.3
21 Cassiope tetragona	-	-	-	-	-	-	-	-	-	-	-	-	+.+	-	4.2	I	.3
22 Dryas octopetala	-	-	-	-	-	-	-	-	-	-	-	2.1	1.1	1.1	-	I	.3
23 Salix glauca	-	-	-	-	-	-	-	-	-	-	-	2.1	2.1	1.1	-	I	.3
24 Lagotis glauca	-	-	-	-	-	-	-	-	-	-	-	2.1	2.1	-	-	I	.3
25 Poa arctica	-	-	-	-	-	-	-	-	-	-	-	+.+	1.1	+.+	-	I	.2
26 Stellaria ciliatosepala	-	-	-	-	-	-	-	-	-	-	-	1.1	+.+	1.1	-	I	.2
27 Pyrola grandiflora	-	-	-	-	-	-	-	-	-	-	-	-	2.1	1.1	-	I	.2
28 Hierochloe alpina	1.1	-	-	-	-	-	-	1.1	-	-	-	1.1	-	-	-	I	.2
29 Pedicularis lanata	-	-	-	-	-	-	-	1.1	-	-	-	+.+	+.+	-	-	I	.2
30 Salix phlebophylla	-	-	-	-	-	-	-	2.1	-	-	-	1.1	-	-	-	I	.2
31 Oxytropis maydelliana	-	-	1.1	-	-	-	-	-	-	-	-	+.+	-	1.1	-	I	.2
32 Saxifraga punctata	-	-	-	-	-	-	-	-	-	-	-	1.1	1.1	-	-	I	.1
33 Luzula confusa	-	-	-	-	-	-	-	1.1	-	-	-	1.1	-	-	-	I	.1
34 Pedicularis labradorica	-	-	+.+	-	-	-	-	-	-	-	-	-	-	+.+	-	I	.1
35 Juncus biglumis	-	-	-	-	-	-	-	-	-	-	-	+.+	-	-	+.+	I	.1
36 Senecio atropurpureus	-	-	-	-	-	-	-	-	-	-	-	1.1	-	1.1	-	I	.1
37 Saxifraga hieracifolia	-	-	-	-	-	-	-	-	-	-	-	1.1	+.+	-	-	I	.1
38 Polygonum viviparum	-	-	-	-	-	-	-	-	-	-	-	1.1	1.1	-	-	I	.1
39 Draba nivalis	-	-	-	-	-	-	-	-	-	-	-	+.+	+.+	-	-	I	.1
40 Eutrema edwardsii	-	-	-	-	-	-	-	-	-	-	-	1.1	1.1	-	-	I	.1
D layer (Bryophytes)																	
41 Aulacomnium turgidum	1.1	3.1	2.1	1.1	2.1	1.1	2.1	3.1	3.1	2.1	2.1	4.2	5.2	5.2	2.1	V	2.5
42 Sphagnum lenense	5.2	4.2	5.2	5.2	7.3	7.3	7.3	8.3	1.1	9.4	6.3	-	-	-	1.1	IV	4.3
43 Sphagnum rubellum	2.1	4.2	2.1	3.2	6.2	-	-	-	-	3.1	3.2	-	1.1	2.2	2.2	IV	1.9
44 Dicranum angustum	-	2.1	-	3.2	-	-	5.3	1.1	4.2	1.1	4.2	-	+.+	2.1	2.1	IV	1.7
45 Sphenolobus minutus	1.1	-	1.1	-	1.1	+.+	2.1	-	-	+.+	4.2	1.1	+.+	1.1	+.+	IV	1.0
46 Polytrichum juniperinum	3.1	1.1	2.1	-	2.1	+.+	1.1	-	1.1	-	-	+.+	-	+.+	1.1	IV	.9
47 Sphagnum recurvum	-	4.2	5.2	-	-	6.2	+.+	5.2	-	-	2.1	-	-	3.1	1.1	III	1.8
48 Hylocomium splendens	1.1	2.1	-	-	-	1.1	-	-	-	-	-	5.2	5.2	4.2	5.2	III	1.6
49 Dicranum elongatum	3.2	-	1.1	-	-	1.1	-	-	-	2.1	2.1	1.1	1.1	2.1	1.1	III	.9
50 Sphagnum girgensohnii	-	4.2	-	-	-	-	-	-	2.1	-	4.2	-	-	-	5.2	II	1.0
51 Dicranum scoparium	3.1	2.1	+.+	-	-	1.1	-	-	5.2	-	-	-	-	-	-	II	.8
52 Sphagnum balticum	2.1	-	-	+.+	-	3.2	-	2.1	-	1.1	1.1	-	-	-	-	II	.6
53 Dicranum fuscescens	3.1	-	-	-	-	-	1.2	-	-	-	-	-	3.1	-	3.2	II	.6
54 Ptilidium ciliare	-	-	-	-	2.1	-	-	-	-	-	-	2.1	3.2	1.1	-	II	.5
55 Calypogeia trichomanis	-	-	-	-	1.1	-	3.1	-	-	1.1	+.+	-	-	-	-	II	.4
56 Rhacomitrium lanuginosum	1.1	2.1	-	-	-	-	-	-	-	-	-	-	-	1.1	1.1	II	.3
57 Dicranum groenlandicum	-	-	-	3.2	4.2	-	-	-	-	1.1	-	-	-	-	-	I	.5
58 Tomenthypnum nitens	-	-	-	-	-	-	-	-	-	-	-	5.2	3.2	4.2	-	I	.8
59 Aulacomnium palustre	-	-	5.2	-	-	-	-	-	-	-	-	-	-	+.+	-	I	.4
60 Rhytidium rugosum	-	2.1	-	-	-	+.+	-	-	-	-	-	-	-	-	1.1	I	.3
61 Polytrichum commune	-	-	-	-	-	-	2.1	-	1.1	-	-	-	-	-	-	I	.2
62 Lophozia sp.	-	-	+.+	-	-	-	-	-	2.1	-	-	-	-	-	-	I	.2
63 Lophozia quadriloba	1.1	-	-	-	-	-	-	1.1	-	-	-	-	-	-	-	I	.1
64 Dicranum mühlenbeckii	-	+.+	-	-	-	-	-	-	-	-	-	-	-	-	1.1	I	.1
65 Drepanocladus uncinatus	-	1.1	-	-	-	-	-	-	-	-	-	-	-	-	+.+	I	.1
66 Hypnum callichroum	-	-	1.1	-	-	-	-	-	-	-	-	-	-	+.+	-	I	.1
67 Lophozia ventricosa	-	-	-	-	-	-	-	-	-	-	-	-	+.+	1.1	-	I	.1
(Lichenes)																	
68 Cetraria cucullata	2.1	+.+	+.+	2.1	3.1	-	6.3	1.1	3.1	1.1	2.1	+.+	+.+	1.1	1.1	V	1.8
69 Cladonia mitis	+.+	+.+	-	1.1	1.1	-	4.2	-	2.1	1.1	1.1	+.+	+.+	-	-	IV	.9
70 Cetraria islandica	-	+.+	+.+	1.1	+.+	-	-	1.1	+.+	1.1	1.1	+.+	+.+	1.1	1.1	IV	.8
71 Cladonia rangiferina	3.2	-	-	1.1	3.2	-	4.2	+.+	2.1	-	-	-	-	-	1.1	III	1.0
72 Peltigera aphthosa	1.1	2.1	1.1	-	-	-	1.1	1.1	-	-	-	2.1	1.1	3.1	1.1	III	.9
73 Cladonia amaurocraea	-	+.+	+.+	-	2.1	-	4.2	-	-	1.1	1.1	1.1	1.1	1.1	-	III	.9
74 Dactylina arctica	2.1	1.1	-	+.+	2.1	-	1.1	1.1	+.+	-	1.1	-	+.+	-	-	III	.7
75 Peltigera scabrosa	1.1	1.1	1.1	-	+.+	-	1.1	1.1	-	-	-	-	1.1	-	+.+	III	.5
76 Thamnolia vermicularis	2.1	-	-	-	+.+	1.1	1.1	-	-	1.1	-	-	-	1.1	-	II	.5
77 Cetraria nivalis	1.1	-	-	-	1.1	-	-	-	1.1	+.+	1.1	-	-	-	-	II	.3
78 Peltigera polydactyla	-	-	-	-	-	1.1	1.1	-	+.+	-	+.+	-	+.+	-	-	II	.3
79 Peltigera canina	-	-	1.1	-	-	-	-	1.1	-	-	-	1.1	1.1	1.1	-	II	.3
80 Stereocaulon alpinum	-	-	-	-	-	1.1	-	-	-	-	1.1	-	-	1.1	1.1	II	.3
81 Cladonia gracilis	-	-	-	-	1.1	-	-	-	-	-	1.1	1.1	-	+.+	-	II	.3
82 Alectoria ochroleuca	-	+.+	-	-	1.1	-	-	-	-	1.1	-	-	-	-	-	I	.2
83 Stereocaulon rivulorum	-	+.+	-	-	-	-	+.+	-	+.+	-	-	-	-	-	-	I	.2
84 Cladonia furcata	-	-	+.+	-	-	-	-	-	+.+	-	+.+	-	-	-	-	I	.2
85 Cetraria richardsonii	-	-	-	-	-	-	-	-	-	1.1	-	+.+	+.+	-	-	I	.2
86 Cladonia chlorophaea	+.+	-	-	-	-	-	-	-	-	-	1.1	-	-	+.+	-	I	.2
87 Nephroma expallidum	-	-	-	-	-	-	-	-	-	-	-	+.+	-	-	2.1	I	.2
88 Alectoria nitidula	-	+.+	-	-	1.1	-	-	-	-	-	-	-	+.+	-	-	I	.2
89 Alectoria nigricans	1.1	-	-	-	-	-	-	-	+.+	-	-	-	-	-	-	I	.1
90 Cladonia gonecha	-	-	-	-	-	-	-	-	-	-	+.+	+.+	-	-	-	I	.1
TOTAL SPECIES (incl sporadics)	35	36	32	26	36	24	30	32	26	31	41	46	56	45	37		

Sporadic species

C layer

91 Anemone narcissiflora 21(1.1)
92 Arenaria arctica 21(1.1)
93 Lupinus arcticus 21(+.+)
94 Arnica alpina 27(1.1)
95 Equisetum arvense 27(+.+)
96 Pyrola secunda 27(1.1)
97 Ranunculus nivalis 27(+.+)
98 Valeriana capitata 27(1.1)
99 Salix arbutifolia 34(1.1)
100 Anemone parviflora 40(1.1)
101 Saussurea angustifolia 40(1.1)
102 Carex montanensis 52(1.1)
103 Carex rariflora 52(1.1)
104 Viola epipsila 52(+.+)
105 Pedicularis arctica 59(1.1)
106 Spiraea beauverdiana 71(1.1)
107 Pedicularis capitata 87(1.1)

D layer (Bryophytes)

108 Philonotis fontana 21(+.+)
109 Brachythecium sp. 27(+.+)
110 Lophozia quinquedentata 27(+.+)
111 Polytrichum piliferum 34(+.+)
112 Gymnocolea inflata 52(2.1)
113 Lophozia obtusa 69(1.1)
114 Pogonatum alpinum 93(1.1)
115 Lophozia alpestris 93(1.1)
116 Pohlia nutans 93(1.1)
117 Ceratodon purpureus 130(5.2)
118 Tetraplodon paradoxus 130(1.1)
119 Dicranella subulata 138(1.1)
120 Harpanthus scutatus 138(+.+)
121 Sphagnum obtusum 138(2.1)
122 Lophozia attenuata 180(1.1)
123 Sphagnum aongstroemii 180(1.1)

(Lichenes)

124 Cladonia coccifera 21(+.+)
125 Ochrolechia inaequetula 27(+.+)
126 Icmadophila ericetorum 34(+.+)
127 Ochrolechia frigida 34(+.+)
128 Pertusaria dactylina 34(3.2)
129 Pertusaria panyrga 34(+.+)
130 Cetraria sepincola 48(+.+)
131 Cornicularia divergens 48(+.+)
132 Cetraria chrysantha 54(2.1)
133 Cetraria pinastri 71(+.+)
134 Cladonia uncialis 87(1.1)
135 Sphaerophorus globosus 93(2.1)
136 Cetraria laevigata 130(+.+)

The localized instability of the soil where Betulo - Eriophoretum vaginati dominates gives rise to two major microhabitats. These habitats are a direct result of frost action (congeliturbation) in the mineral soil which produce a hummock-depression microrelief. No attempt has been made to date in arctic North America to analyze these microcommunities separately and to distinguish microenvironmental differences. The depth to the upper surface of permafrost varies with surface microrelief. The active layer is deeper under the hummocks than the depressions. This is related to increased drainage in the hummocks and the insulating properties of the moss layer in the depression. Ice or frozen ground are invariably present within 10-15 cm of the surface under the moss layer in the depression, whereas in the hummocks perennially frozen ground is from 20-35 cm below the surface.

Two subassociations are distinguished in this subalpine zone, the eriophoretosum vaginati and the salicetosum reticulatae.

(a) eriophoretosum vaginati (Figure 17)

The eriophoretosum vaginati covers large areas on the lower slopes of the subalpine zone. It occurs on a variety of habitats, including old drainage pathways, old creek beds, raised polygons and exposed slopes. Sampled plots in the Canoe Lake area are generally between 1100-1500 ft elevation and between 500-625 ft at Trout Lake. Slope gradients vary from 2-23° with the majority of the plots having an easterly exposure. All areas where the eriophoretosum vaginati is present have a very broken topography due to excessive frost action. Detailed studies by Hopkins and Sigafoos (1951) and Sigafoos (1951) have described in detail the tussock forming Eriophorum vaginatum and its role in differential frost heaving in wet mineral soil.

Moisture conditions vary from hygric to semi-hydric. Drainage waters pass quickly over the upper slopes, but due to a reduced slope gradient at the lower levels water movement is less rapid. While the free water is not completely impeded as in the wetland areas it is slowed down considerably by the hummock (tussock) microrelief that prevails and the undulating surface of the permafrost table. Where the slope gradients are steeper the hummocks tend to be more elongated and lie parallel with the slope indicating downslope movement. On very shallow slopes and flat surfaces the hummocks appear at random, tending to be taller and occasionally with bare soil among them. The bare mineral soil plays a major role in the development of these tall hummocks in areas of restricted drainage. The raised polygon sites occur in areas that are better drained than those on which other tussock groups are formed.

Figure 17. Betulo - Eriophoretum vaginati betulo - eriophoretosum vaginati tussocks surrounded at the base by dead leaves and culms. Dark brown areas are Sphagnum lenense with scattered Rubus chamaemorus. (Photo by Lambert)

Snow cover and duration differs in the eriophoretosum vaginati because of the hummock-depression microrelief. Snow is packed into the depressions during the winter and is usually a week behind the hummock snow in thawing. Total duration of snow cover in the Canoe Lake area for this subassociation is estimated at 9 months.

Eriophorum vaginatum is by far the most important species with very high cover values in all sampled plots. Tussock density was calculated to be between 5-8 per square meter. The fact is, however, the tussocks consist of more dead than living leaves and culms. The older tussocks are nearly spherical with the old dead leaves and culms crowded to the outer surface. The tussocks are substrate for several species of vascular plant that are common on turf hummocks: constants include Betula glandulosa, Vaccinium uliginosum and V. vitis-idaea. Additional species with high constancy are Rubus chamaemorus, Empetrum hermaphroditum, Pedicularis lapponica and Carex lugens. All these species are rooted in the organic-mineral layer. Small clumps of Salix pulchra are occasionally present in the moist depressions along with Andromeda polifolia and Pinguicula villosa. Sphagnum appears to be the preferred substrate for these two species. It should be pointed out that no Eriophorum vaginatum dominated plots were analyzed where the tall development of tussocks and the exposed unstable mineral soil restricted establishment of many additional vascular plants. In plots where small amounts of bare soil are present Juncus biglumis is always present.

Sphagnum lenense, S. girgensohnii, S. rubellum, Calypogeia trichomanis and Dicranum angustum are common bryophytes on the moist tussock bases and in the depressions. An indication of the slow movement of free drainage water in isolated areas of several plots is the presence of Sphagnum balticum and Aulacomnium palustre. On the drier more open tussocks are such mesophytic species as Dicranum elongatum, D. groenlandicum and Sphenolobus minutus. Lichen coverage is very sparse with only Cetraria cucullata present on the larger more open tussocks. Scattered among the Sphagna are Dactylina arctica, Cetraria islandica, Cladonia mitis, C. rangiferina, C. amaurocraea, Peltigera aphthosa and P. scabrosa, all with high constancy but low cover values.

Closely aligned with this subassociation is a community in which Alnus crispa forms a shrub (under 2 ft) layer. This community appears transitional between the Betula - Chamaemoretum and the Betulo - Eriophoretum vaginatum. It is included in the synthesis tables of the latter association.

(b) salicetosum reticulatae (Figure 18)

The salicetosum reticulatae occurs only on the upper slopes where drainage though poor never appears completely restricted. Compared with the lower slope eriophoretosum vaginati, moisture conditions in these habitats are considered to be more hygric and never semi-hydric. This subassociation is poorly represented in this area of the subalpine zone, communities being analyzed from only three localities. Their microrelief is always hummocky with either straight or concave profiles. Slope gradients are shallow (2-10°) with either north or northwest exposures. The analyzed plots are present at elevations between 1750-1850 ft at Canoe Lake and at 650 ft at Trout Lake. All sites appear to receive some protection from the surrounding slopes. Vegetation on these bordering slopes belongs to either the Dryadion or the Betulo - Ledetum decumbentis types. Melt water from these rapidly drained slopes is channelled into the salicetosum reticulatae.

Snow cover is as long (9 months) as on the lower elevated Eriophorum vaginatum dominated slopes. However, compared to the surrounding slopes, snow persists as much as three weeks longer. Consequently, while vegetative growth gives a characteristic green colour to the bordering slope communities, this community appears light brown in mid-June, being noticeable from a considerable distance. The thickness of the active layer in these upland sites is probably the same as on the lower slopes. Measurements in this subassociation were made in early July whereas in the eriophoretosum vaginati they were made in late July and mid-August. Height and density of tussocks are similar to those on the lower slopes, 15-20 cm high and between 5-8 tussocks per square meter.

Figure 18. Betulo - Eriophoretum vaginati salicetosum reticulatae, northwest facing slope (1850 ft), bordering sparsely vegetated slope dominated by Dryas octopetala. (Photograph taken June 16/65 by Lambert)

Dwarf heath species that are constant in the eriophoretosum vaginati are present here but with reduced constancy and coverage values. Rubus chamaemorus, Pedicularis lapponica, Andromeda polifolia and Pinguicula villosa are absent at these higher elevations. Several species in this subassociation that are generally associated with the sub-xeric upper slopes are present as characteristic constants. They include Salix reticulata, Dryas octopetala and Poa arctica. Additional species associated with higher elevations of the subalpine zone and present as sporadics are: Salix phlebophylla, Lupinus arcticus, Arenaria arctica and Oxytropis maydelliana. The occurrence of such species as Salix reticulata, Saxifraga hieracifolia and Lagotis glauca are indicative of increased quantities of available calcium and the more calcareous nature of the soils in these sites.

An indication of the reduction in available moisture and the drier condition of these plots was the absence of Sphagnum lenense and S. girgensohnii and the low presence of S. rubellum and S. recurvum. Species such as Tomenthypnum nitens and Ptilidium ciliare have replaced the Sphagnum species. The associated lichens are similar to those of the eriophoretosum vaginati.

Soil instability is characteristic of this subassociation, however, downslope movement is less obvious because of the shallow slope gradients. No microrelief patterns such as rings, nets, garlands, stripes and ridges were found associated with the Betulo - Eriophoretum vaginati. This association would appear unique and, as suggested by Porsild (1951), seems restricted to those unglaciated regions of western arctic North America. Hanson (1953) could find no close resemblance with his Alaskan cottongrass - sedge - dwarf heath type to communities in Scandinavia.

Aquatic plant communities

The aquatic vegetation in the subalpine/foothill zone occur only in, or around, lakes. Porsild (1951) has distinguished two types of fresh water vegetation: ponds and lakes, and brooks and rivers. Plant communities around lakes are usually arranged in concentric bands roughly corresponding to water depth. Because of the scarcity of lakes in this unglaciated region of western arctic Canada, few sites were found for analysis. Of the two recognized aquatic life forms, rooted submerged and rooted emergent, only the latter were found in the two study areas. In the Alaskan foothills, Spetzman (1959) found that water depth seldom exceeded two feet for the emergent aquatics. This emergent type plays an important role in the obliteration of lakes through the accumulation of peat which results in rising permafrost levels and restricted drainage.

1. Arctophiletum fulvae Table 8 (a) & (b) (Figure 19)

The Arctophiletum fulvae is poorly represented in the two study areas, only four plots were analyzed in the Canoe Lake area. All four sites were

Table No. 8 b

		Arctophiletum fulvae			
Plot No.		116	171	160	159
Plot size(m^2)		16	16	16	16
Date Analyzed		20/8 1965	10/8 1966	26/7 1966	25/7 1966
PLOT DATA					
Locality		CL	CL	DL	DL
Elevation		1045	1050	1100	1100
PHYSIOGRAPHY					
Land form		............Lake edge...........			
Relief: Profile		...............Flat......			
Exposure (°)		0	0	250	0
Slope gradient		0	0	1	0
CLIMATE					
Snow duration		............8½ months...........			
STRATA COVERAGE (%)					
C layer		100	85	80	90
D layer Moss		20	5	95	25
PLOT COVERAGE (%)					
by water		20	10	95	25
SOIL					
Drainage		.............Impeded............			
Hygrotope		..............Hydric............			
Depth of active layer		...........Undetermined.........			
CHEMICAL ANALYSIS					
No.of samples		1	1		
Organic - Mineral layer	OM	2.8	4.6		
	N%	.06	.21		
	C/N	27.0	12.7		
	P ppm	16	7		
	Na	.68	.78		
	K	.11	.22		
	Ca	2.3	7.3		
	Mg	.3	.9		
	CEC	19.5	11.0		
	pH	4.9	5.2		
No.of samples		3	1	1	1
Mineral layer	OM	1.7	1.3	-	.9
	N%	.16	.13	.04	.05
	C/N	6.9	5.8	-	10.4
	P ppm	7	6	2	5
	Na	.85	.82	.83	.9
	K	.29	.25	.23	.22
	Ca	4.2	1.6	1.7	1.9
	Mg	.7	.6	-	-
	CEC	17.1	17.3	33.0	32.6
	pH	4.7	4.6	4.3	4.4

Table No. 8 a

	Arctophiletum fulvae					
Number of Plots	1	2	3	4		
Plot No.	116	171	160	159		
Plot size (m^2)	16	16	16	16		
Elevation	1045	1050	1100	1100		
<u>C layer</u>					Constancy	Avg. Cover
1 Arctophila fulva	10.5	9.4	6.2	9.4	V	8.5
2 Hippuris vulgaris	1.1	1.1	7.1	4.1	V	3.2
3 Senecio congestus	-	1.1	1.1	1.1	IV	.8
4 Epilobium palustre	-	-	6.1	5.1	III	2.8
5 Ranunculus gmelinii	-	2.1	1.1	-	III	.8
6 Cardamine pratensis	1.1	2.1	-	-	III	.8
<u>D layer</u> (Bryophytes)						
7 Drepanocladus aduncus	-	-	9.3	5.2	III	3.5
8 Bryum sp.	2.1	-	-	3.1	III	1.2
9 Calliergon cordifolium	-	2.1	1.1	-	III	.8
10 Epilobium palustre	-	-	6.1	6.1	III	3.0
TOTAL SPECIES (incl. sporadics)	7	6	10	8		

Sporadic species

<u>C layer</u>

11 Carex aquatilis 160(1.1)
12 Ranunculus pallasii 159(3.1)

<u>D layer</u> (Bryophytes)

13 Mnium punctatum 116(5.2)
14 Marchantia polymorpha 116(+.1)
15 Polytrichum commune 116(2.1)
16 Sphagnum dusenii 160(3.2)

between 1050-1100 ft elevation. Two are from the shore of Canoe Lake, the other two are from Divided Lake six miles east of Canoe Lake. An example of the role of this association in lake obliteration is well illustrated at Divided Lake where accumulated organic material has divided the lake and cut off the major drainage outlet from the largest body of water. In lakes that are drying up a super-saturated condition prevails throughout the growing season. Generally, the extensive fibrous root mat and peaty layer is insufficient to support the weight of a man.

Snow accumulation is considerable around the lake shore due to the deep cut banks and its duration is estimated to be 8 1/2 months. Drainage waters from the surrounding slopes and the melting lake ice result in a rise in water level, approximately 1-1 1/2 ft, during the thaw period. Consequently, during the early part of the summer the Arctophiletum fulvae is submerged. By the end of the summer, with a drop in water level, only the outer limits of the community remains in standing water around the lake edge.

Figure 19. Lake shore vegetation, Canoe Lake. In the foreground Arctophiletum fulvae, bordered by bands of Eriophorum scheuchzeri. Cut bank supports Salix pulchra. (Photo by Krajina)

The Arctophiletum fulvae is floristically poor with only eight species present. Arctophila fulva and Hippuris vulgaris are the only constant species. Other species associated with these emergent aquatics are Senecio congestus, Epilobium palustre Ranunculus gmelinii and Cardamine pratensis. In the D layer there are no lichens present. Bryophytes are sparse in the lake shore communities. This can probably be related to the scouring affect of loose lake ice along the shore during break-up. The prevailing north west winds jam the loose ice into the south end of Canoe Lake. Plot 171, located at the south end,had an estimated bryophyte coverage of only five percent, while plot 116 at the northeast end, had twenty percent. Major mosses include Drepanocladus aduncus, Calliergon cordifolium and Mnium punctatum var. elatum, the last taxon is able to withstand more prolonged flooding. In two plots (159 and 160) at Divided Lake, Epilobium palustre seedlings covered as much as thirty percent of the fibrous mat surface.

Semi-terrestrial plant communities

Semi-terrestrial habitats, composed of wet sedge meadows, cover approximately fifteen percent of the ground surface in the two study areas. Wet sedge meadow species grow up to the edge of open water on one extreme and are mixed with the tussock type of the lower slopes at the other extreme. These habitats, where the water table is at, near or above the ground surface are considered as hydric to semi-hydric. The associations described for these habitats, along with their characteristic combination of species, must be considered only tentative. Several types are insufficiently represented with a few communities appearing to be transitional between association and subassociations. The vegetation is relatively poor in species with few differential and/or constant species present. Lichens are absent in all but one plot. Present, however, are a number of woody species with broad amplitudes of tolerance. These are found wherever small hummocks and ridges are formed as a result of frost heaving.

The wet sedge meadows are characteristic of poorly drained wetlands and depressions, such as old lake sites and drainage pathways. Free surface water is usually present, but only in small pools, in these sites during the latter part of the summer. Major vegetation units may be distinguished between sites where there is free flowing drainage water during the spring and summer, and where there is no drainage outlet and water loss is primarily through evaporation.

1. Eriophoretum angustifolii Table 9 (a) & (b)

The Eriophoretum angustifolii dominated plots are not restricted to the wetlands of lower elevations but are also present on the upper slopes in narrow exposed drainage pathways. In more protected sites on the slopes shrub species force out the Eriophorum angustifolium. In the flat wetlands E. angustifolium dominates exposed sites where there is little winter snow accumulation. Water runoff is quickly lost. Snow, however, is generally present on the surrounding communities for several more weeks. Perennially frozen ground is closer to the surface on the upper slopes than on the lower and is related to the amount of free flowing drainage water passing over the sites.

Two subassociations have been distinguished and are related to elevation and amount of free flowing drainage water. They are the eriophoretosum angustifolii and the salicetosum pulchrae.

(a) eriophoretosum angustifolii (Figure 20)

This subassociation develops in drainage pathways on the lower slopes or on lake edges where slope gradients are minimal. Water movement, while not rapid, is continuous throughout most of the summer. Supplementary seepage occurs during the latter part of the vegetative season. Snow cover during the winter is seldom more than a foot deep and free flowing drainage water removes it while snow remains on the neighbouring areas. Permafrost levels are lower because of the surface and seepage water present during the summer.

Table No. 9 b

	Eriophoretum angustifolii								
	eriophorosum angustifolii					salicosum pulchra			
Plot No.	72	107	42	154	49	63	57	38	120
Plot size (m^2)	25	25	25	25	25	25	25	25	25
Date Analyzed	14/7 1965	12/8 1965	2/7 1965	23/7 1966	5/7 1965	13/7 1965	6/7 1965	2/7 1965	21/8 1965
PLOT DATA									
Locality	TL	CL	CL	DL	CL	TL	CL	CL	CL
Elevation (ft)	485	1050	1075	1140	1145	730	1060	1175	1750
PHYSIOGRAPHY									
Land form	Depression	.Drainage.. pathway		Lake edge	Drainage pathway	Old creek	Depression	..Drainage.. pathway	
Relief: Profile	Cnv.	..........Flat...........				Flat	Cvx.	...Straight.	
Exposure (°)	0	90	135	0	0	90	70	45	90
Slope gradient (°)	0	2	0	0	0	2	5	13	10
CLIMATE									
Snow duration	..............8 months..........					.........8½ months.........			
STRATA COVERAGE (%)									
B_2 layer									70
C layer	100	97	98	90	95	90	70	45	90
D layer	0	2	5	35	45	80	50	60	96
PLOT COVERAGE (%)									
by water		3		10					
SOIL									
Drainage	...............Poor.............					.........Moderate..........			
Hygrotope	..............Hydric............					....Hydric to semi-hygric..			
Depth of active layer (cm)	31	60	23	44	36	28	24	30	32
CHEMICAL ANALYSIS									
No of samples	1	1			1	1	2	2	1
Organic layer OM	43.5	71.7			52.3	42.1	73.9	71.4	64.9
N%	.98	1.05			1.75	.98	1.54	1.01	.92
C/N	25.7	39.6			17.3	25.7	30.0	43.4	40.9
P ppm	5	31			29	5	4	3	32
Na	.43	.88			.95	.43	.9	1.4	.66
K	.19	.55			3.28	.19	.78	.66	.44
Ca	4.6	8.3			34.5	4.6	7.9	10.6	11.2
Mg	1.6	1.6			19.6	1.6	3.0	2.1	1.2
CEC	39.4	64.3			83.7	39.4	138.0	122.0	80.9
pH	4.6	4.6			7.2	4.6	4.9	4.4	4.8
No.of samples	2		1			1	1	1	
Organic - Mineral layer OM	16.5		23.3			18.8	21.3	11.2	
N%	.31		.28			.56	.16	.3	
C/N	32.7		4.8			19.5	77.2	21.7	
P ppm	16		8			8	2	11	
Na	.51		.8			.43	.68	.86	
K	.09		.11			.24	.14	.9	
Ca	3.8		2.4			7.3	2.7	2.0	
Mg	1.35		.5			2.6	.9	.6	
CEC	31.8		67.3			41.6	76.5	67.0	
pH	4.8		4.4			4.9	4.9	4.5	
No.of samples		1		2	2				
Mineral layer OM		3.1		2.3	4.2				
N%		.15		.13	1.19				
C/N		13.5		9.4	3.3				
P ppm		10		5	8				
Na		.55		.69	.68				
K		.14		.17	.23				
Ca		3.5		4.9	6.1				
Mg		.6		.6	1.8				
CEC		26.7		19.1	14.8				
pH		4.5		4.5	4.7				

Table No. 9 a

	Eriophoretum angustifolii										
	eriophorosum angustifolii					salicosum pulchrae					
Number of plots	1	2	3	4	5	6	7	8	9		
Plot No.	72	107	42	154	49	63	57	38	120		
Plot size (m^2)	25	25	25	25	25	25	25	25	25		
Elevation	485	1050	1075	1140	1145	730	1060	1175	1750	Constancy	Avg. Cover
C layer											
1 Eriophorum angustifolium	10.5	9.4	9.4	9.4	9.4	7.3	8.3	7.3	9.4	V	7.7
2 Salix pulchra	-	-	-	-	-	5.2	2.1	5.2	?	III	2.0
3 Betula glandulosa	-	-	-	-	1.1	2.1	3.1	2.1	1.1	III	.9
4 Salix arbutifolia	1.1	-	-	-	-	3.1	-	-	5.2	III	.9
5 Vaccinium uliginosum	-	-	-	-	+.+	3.1	2.1	-	1.1	III	.7
6 Ledum decumbens	-	-	-	-	1.1	1.1	1.1	1.1	1.1	III	.5
7 Rubus chamaemorus	-	-	-	-	1.1	-	1.1	1.1	2.1	III	.5
8 Carex lugens	-	1.1	-	-	-	2.1	+.+	-	-	II	.4
9 Vaccinium vitis-idaea	-	-	-	-	1.1	-	1.1	+.+	-	II	.3
10 Carex aquatilis	-	-	1.1	2.1	-	-	-	-	-	II	.3
11 Eriophorum vaginatum	-	-	-	-	-	1.1	-	1.1	-	II	.2
D layer (Bryophytes)											
12 Sphagnum girgensohnii	-	-	-	-	-	4.2	7.3	7.3	8.3	III	2.6
13 Sphagnum balticum	-	-	-	1.1	5.2	-	5.2	1.1	-	III	1.2
14 Drepanocladus aduncus	-	-	2.1	2.1	3.1	-	-	-	1.1	III	.7
15 Sphagnum lenense	-	-	-	-	-	5.2	1.1	5.2	-	II	1.1
16 Aulacomnium palustre	-	-	-	-	+.+	5.2	-	-	5.3	II	1.1
17 Polytrichum commune	-	-	-	-	4.2	-	4.2	2.1	-	II	1.0
18 Calliergon stramineum	-	1.1	-	5.2	-	-	-	-	1.1	II	.7
19 Polytrichum juniperinum	-	-	-	-	-	1.1	4.2	-	-	I	.5
20 Sphagnum platyphyllum	-	-	-	-	-	3.1	-	1.1	-	I	.4
21 Sphagnum rubellum	-	-	-	-	-	2.1	-	-	1.1	I	.3
22 Bryum pseudotriquetrum	-	-	-	1.1	+.+	-	-	-	-	I	.2
TOTAL SPECIES (incl. sporadics)	2	5	4	12	14	25	16	14	16		

B2 layer
- Salix pulchra 120(8.3)

C layer
- 23 Carex chordorrhiza 49(2.1)
- 24 Carex rotundata 49(2.1)
- 25 Eriophorum scheuchzeri 49(2.1)
- 26 Andromeda polifolia 57(1.1)
- 27 Empetrum hermaphroditum 57(+.+)
- 28 Pedicularis lapponica 57(1.1)
- 29 Pedicularis sudetica 63(1.1)
- 30 Salix reticulata 63(2.1)
- 31 Arctagrostis latifolia 107(1.1)
- 32 Calamagrostis canadensis 107(1.1)
- 33 Polygonum viviparum 120(+.+)
- 34 Arctophila fulva 154(1.1)

D layer (Bryophytes)
- 35 Sphagnum compactum 38(1.1)
- 36 Aulacomnium turgidum 38(1.1)
- 37 Dicranum angustum 63(1.1)
- 38 Dicranum elongatum 63(1.1)
- 39 Drepanocladus uncinatus 63(1.1)
- 40 Sphenolobus minutus 63(1.1)
- 41 Pohlia nutans 63(+.+)
- 42 Campylium polygamum 63(+.+)
- 43 Philonotis fontana 63(1.1)
- 44 Sphagnum aongstroemii 120(2.1)
- 45 Mnium punctatum 154(3.1)
- 46 Drepanocladus vernicosus 154(+.+)
- 47 Drepanocladus exannulatus 120(2.1)
- 48 Calliergon cordifolium 154(4.1)
- 49 Cinclidium subrotundum 154(1.1)
- 50 Polytrichum swartzii 154(6.3)
- 51 Atrichum sp. 42(+.+)
- 52 Drepanocladus revolvens 63(+.+)
- 53 Calliergon trifarium 63(1.1)

D layer (Lichenes)
- 54 Peltigera scabrosa 120(+.+)

Figure 20. Eriophoretum angustifolii in drainage pathway on lower slope (1100 ft), Canoe Lake. Habitat flooded in early summer and with continuous water movement throughout the vegetative season. (Photo by Krajina)

Eriophorum angustifolium dominates all communities and is the only constant species. In the initial stages associated species are rare. Later stages, related to a decrease in free water movement, see the establishment of several woody species and additional bryophytes. Mosses are absent or very sparse in three of the five plots representing this subassociation. The dense coverage of E. angustifolium and the rapid movement of water restrict bryophytes to the leesides of the sedge clumps. The only species present in two or more plots are Drepanocladus aduncus, Calliergon stramineum and Bryum pseudotriquetrum. These species are all within the flood zone of the drainage pathway. The only Sphagnum species present and able to withstand a degree of flooding is S. balticum.

(b) salicetosum pulchrae

The salicetosum pulchra is present on both upper (1750 ft level) and lower (between 1060-1175 ft) slopes. The major difference between this subassociation and the eriophoretosum angustifolii is the reduction in amount of free flowing drainage water. On the upper slopes surface water is less because of the total area involved. However, on the lower slopes reduction appears related to mass movement of surface materials above the drainage pathways, resulting in changes of direction of flow. Drainage is then mainly in the form of seepage. Reduction in water content leads to increased frost action in the mineral soil, giving rise to a hummock-depression type of microrelief. Snow duration is approximately two weeks longer than the eriophoretosum angustifolii and the accumulation is greater because of the presence of small shrubs. All four plots representing this subassociation have easterly exposures. Average depth to permafrost (28 cm) is less than in the eriophoretosum angustifolii (35 cm).

Constant species associated with Eriophorum angustifolium include Salix pulchra, Betula glandulosa and Ledum decumbens. Additional species indicative of the semi-hydric hummocky conditions are Vaccinium uliginosum, Rubus chamaemorus, Carex lugens Vaccinium vitis-idaea and Eriophorum vaginatum. Salix arbutifolia is present in the wetter areas of plots 63 and 120 between small hummocks. The reduction in excessive amounts of free flowing drainage water is reflected in the presence and high coverage of Sphagnum girgensohnii and S. lenense. Sphagnum balticum is present where drainage and seepage waters collect. Additional bryophytes include Polytrichum commune, P. swartzii, P. juniperinum, Aulacomnium palustre, Sphagnum platyphyllum and S. rubellum. Only one lichen, Peltigera scabrosa, is present in this subassociation, in plot 120.

It is felt that both subassociations are under-represented and that the eriophoretosum angustifolii is probably only a phase of the more advanced salicetosum pulchrae. Additional analyses of this Eriophoretum angustifolii are needed.

2. Caricetum aquatilis Table 10 (a) & (b) (Figure 21)

The Caricetum aquatilis community dominates areas where drainage restriction is recent. These areas are generally small depressions and lakes in the process of drying up. Moisture conditions are considered hydric throughout the vegetative season. Surface topography is flat with little evidence of the development of patterned ground. Exposure is considered to be total in all plots except three, which receive some protection from higher ground on at least one side. Permafrost is close to the surface (average depth 34 cm) and appears consistent in every plot. In many cases the organic layer constitutes part of the perennially frozen ground. Snow cover is never deep and duration is estimated to be 8 1/2 months.

The association is represented by two variants the caricosum aquatilis and the salicosum arbutifoliae.

(a) caricosum aquatilis

The majority of the plots studied in this variant are present in old lake beds. The water table is high and in some cases bodies of free water with a very open type of vegetation are present. The major source of water in these habitats is from melting snow and seepage from surrounding higher ground. The initial causes for these lakes drying up appears to be due to the encroachment of vegetation into the generally small drainage outlet channels over a prolonged period of time.

The only constant species is Carex aquatilis. In the plots with open water a common species is Potentilla palustris. Where the water table is at, or near, the surface scattered culms of Eriophorum scheuchzeri are present. Although C. aquatilis tends to dominate large areas other Carex species (C. chordorrhiza and C. rotundata) may be present with high cover values in a given part of a wet sedge meadow. This is possible due to the vegetative means of colonization of these Carex species. Also present with low cover values is Salix arbutifolia. Bryophyte coverage is generally low with small clumps of

to follow page 75

Figure 21. Originally part of Trout Lake this aquatic habitat has been virtually obliterated. Carex aquatilis dominates the site with Carex chordorrhiza, C. rotundat and Potentilla palustris. Bordering the areas of open water is Arctophila fulva. On the left raised polygons are dominated by Betula glandulosa. (Photo by Lambert)

Table No. 10 b

		Caricetum aquatilis													
		caricosum aquatilis											salicosum arbutifoliae		
Plot No.		95	84	79	82	81	100	91	90	58	108	50	80	153	155
Plot size (m^2)		25	25	25	25	25	25	25	25	25	25	25	25	25	25
Date Analyzed		20/7 1965	17/7 1965	17/7 1965	17/7 1965	17/7 1965	21/7 1965	18/7 1965	18/7 1965	6/7 1965	12/8 1965	5/7 1965	17/7 1965	23/7 1966	24/7 1966
PLOT DATA															
Locality		TL	TL	TL	TL	TL	TL	TL	TL	CL	CL	CL	TL	CL	CL
Elevation (ft)		490	490	510	510	510	570	620	620	1050	1050	1100	520	1050	1150
PHYSIOGRAPHY															
Land form		Drainage pathway		.............Old lake...........						Old creek	Lake edge	Old creek	Lake edge	Old lake	Drainage pathway
Relief: Profile		.............Flat...........					Humm.	.............Flat...........					Stg.	Flat	Stg.
Exposure (°)		......................Total.................								45	Total	180	0	Total	135
Slope gradient (°)		......................0.....................								1	0	1	2	0	2
CLIMATE															
Snow duration		.....................8½ months.................................											.....8½ months....		
STRATA COVERAGE (%)															
C layer		50	75	80	85	95	55	50	35	95	90	70	60	98	100
D layer		15	35	30	20	35	60	20	90	15	50	35	80	80	80
PLOT COVERAGE (%)															
by water		40	2	20	20	5	15	40	2		5			2	
SOIL															
Drainage		..........................Impeded.............................											......Poor........		
Hygrotope		..........................Hydric.............................											.....Hydric.......		
Depth of active layer (cm)		30	30	35	30	37	48	35	34	20	40	38	35	21	30
CHEMICAL ANALYSIS															
No.of samples		2	1	1	1	1	1	1	1	1	1	1	1	2	3
Organic layer	OM	42.0	75.2	93.5	89.0	87.6	43.7	56.5	84.2		46.7	84.2	92.5	81.7	87.2
	N%	1.01	1.47	2.24	1.83	1.05	.77	1.4	1.47		.73	1.68	.92	1.46	1.47
	C/N	24.3	29.7	24.2	28.4	48.4	32.9	23.4	33.2		37.1	29.1	58.3	35.1	31.6
	P ppm	24	3	5	3	33	31	3	6		21	5	5	17	18
	Na	.68	.95	1.47	.79	2.23	.58	.59	1.19		.8	.83	2.26	.76	1.04
	K	.14	.47	.33	.26	1.11	.59	.13	.61		.42	.63	.56	.61	.87
	Ca	6.8	7.2	5.6	16.0	9.7	6.1	14.9	16.4		5.8	16.2	18.6	16.2	24.2
	Mg	1.3	2.5	1.0	2.0	3.0	1.8	6.6	9.8		1.5	2.7	3.0	4.3	3.5
	CEC	44.1	69.8	91.7	87.5	63.4	46.8	49.3	69.7		73.9	128.0	141.8	130.8	106.5
	pH	4.0	4.5	4.5	4.4	3.8	4.6	4.4	4.7		4.5	4.6	4.4	4.4	4.4
No.of samples						1			1		1				
Organic - Mineral layer	OM					12.7			30.4		38.9				
	N%					.84			1.26		.59				
	C/N					8.8			14.0		38.2				
	P ppm					12			5		24				
	Na					.63			.87		.68				
	K					.09			.18		.29				
	Ca					9.0			8.4		4.1				
	Mg					1.1			2.6		.7				
	CEC					29.8			47.1		51.1				
	pH					4.4			4.5		4.3				
No.of samples							1			1		1			1
Mineral layer	OM						11.3			7.0		5.5			1.3
	N%						.17			.29		.18			.07
	C/N						38.6			14.6		17.7			10.8
	P ppm						16			13		13			7
	Na						.56			.53		.44			.71
	K						.13			.26		.13			.3
	Ca						3.3			7.3		5.1			6.1
	Mg						.6			2.0		.6			1.0
	CEC						23.6			34.6		55.3			32.4
	pH						4.6			5.7		4.7			4.4

Table No. **10 a**

	Caricetum aquatilis															
	caricosum aquatilis											salicosum arbutifoliae				
Number of Plots	1	2	3	4	5	6	7	8	9	10	11	1	2	3		
Plot No.	95	84	79	82	81	100	91	90	58	108	50	80	153	155		
Plot size (m^2)	25	25	25	25	25	25	25	25	25	25	25	25	25	25		
Elevation (ft)	490	490	510	510	510	570	620	620	1050	1050	1100	520	1050	1150		
C layer															Constancy	Avg. Cover
1 Carex aquatilis	7.1	7.2	8.3	3.1	7.2	5.1	6.1	5.1	7.1	8.3	8.2	6.2	8.4	9.4	V	6.7
2 Salix arbutifolia	1.1	-	1.1	1.1	4.1	4.1	-	3.1	-	-	-	5.1	8.2	5.1	IV	2.3
3 Potentilla palustris	4.2	-	-	5.1	5.1	3.1	4.1	-	-	3.1	3.1	-	-	-	III	2.0
4 Eriophorum angustifolium	-	-	-	-	2.1	1.1	-	-	6.1	6.2	2.1	-	-	-	II	1.2
5 Carex chordorrhiza	-	6.1	-	7.1	-	4.1	-	-	-	-	-	-	-	-	II	1.2
6 Eriophorum scheuchzeri	-	1.1	1.1	1.1	5.1	-	-	1.1	-	-	-	-	-	-	II	.6
7 Carex rariflora	-	-	-	-	1.1	-	-	-	-	-	-	-	5.2	3.1	II	.6
8 Pedicularis sudetica	-	-	-	-	1.1	1.1	-	2.1	-	-	-	+.+	-	-	II	.3
9 Betula glandulosa	-	-	-	-	-	-	-	-	-	-	-	2.1	2.1	3.1	II	.5
10 Salix pulchra	-	-	-	-	-	-	-	-	-	-	-	1.1	2.1	4.1	II	.5
11 Andromeda polifolia	-	-	-	-	-	-	-	-	-	-	-	1.1	1.1	4.1	II	.4
12 Vaccinium uliginosum	-	-	-	-	-	-	-	-	-	-	-	-	1.1	4.2	I	.3
13 Ranunculus pallasii	-	-	-	-	1.1	+.+	1.1	-	-	-	-	-	-	-	I	.2
14 Calamagrostis canadensis	-	-	-	-	-	-	-	-	1.+	1.2	-	-	-	-	I	.1
15 Pedicularis lapponica	-	-	-	-	-	-	-	-	-	-	-	+.+	1.1	-	I	.1
16 Ledum decumbens	-	-	-	-	-	-	-	-	-	-	-	+.+	-	1.1	I	.1
D layer (Bryophytes)																
17 Sphagnum squarrosum	-	-	-	4.2	5.2	6.2	-	8.4	-	-	1.1	-	6.3	-	III	2.1
18 Polytrichum commune	4.2	-	-	-	-	-	-	1.1	-	1.1	1.1	1.1	3.2	3.2	III	1.0
19 Sphagnum recurvum	-	-	-	-	-	-	-	-	-	-	-	6.3	8.4	7.3	II	1.5
20 Sphagnum platyphyllum	-	-	-	3.2	4.2	2.1	4.2	-	-	-	-	-	-	-	II	.9
21 Aulacomnium palustre	-	-	-	-	1.1	2.1	-	-	-	-	-	2.1	4.2	-	II	.6
22 Aulacomnium turgidum	-	-	-	-	-	-	-	-	-	-	-	1.1	4.2	3.2	II	.5
23 Sphagnum rubellum	-	-	-	1.1	-	-	-	1.1	-	-	-	3.1	-	-	II	.3
24 Sphagnum teres	-	-	-	-	-	5.2	-	5.2	-	-	-	-	-	-	I	.9
25 Sphagnum contortum	-	2.2	6.2	-	-	-	-	-	-	-	-	-	-	-	I	.6
26 Drepanocladus aduncus	-	-	-	-	-	-	-	-	-	2.1	6.2	-	-	-	I	.6
27 Sphagnum lenense	-	-	-	-	-	-	-	-	-	-	-	3.2	-	5.2	I	.6
28 Calliergon cordifolium	-	-	-	-	-	-	-	-	4.1	-	2.1	-	-	-	I	.4
29 Mnium punctatum	-	-	-	-	-	-	-	-	2.1	-	1.1	-	-	-	I	.2
30 Cinclidium subrotundum	-	-	-	1.1	1.1	-	-	-	-	-	-	-	-	-	I	.1
TOTAL SPECIES (incl.sporadics)	6	5	4	10	13	11	5	8	6	6	11	14	15	15		

Sporadic species

C layer
31 Cardamine pratensis 50(1.1)
32 Hippuris vulgaris 50(1.1)
33 Salix glauca 50(1.1)
34 Carex rotundata 82(4.1)
35 Eriophorum vaginatum 155(1.1)
36 Vaccinium vitis-idaea 153(1.1)

D layer
37 Pogonatum alpinum 58(1.1)
38 Drepanocladus exannulatus 81(1.1)
39 Lophozia excisa 83(+.+)
40 Lophozia kunzeana 83(+.+)
41 Sphagnum girgensohnii 83(7.3)
42 Sphagnum lindbergii 84(6.2)
43 Sphagnum obtusum 91(1.1)
44 Bryum pseudotriquetrum 95(1.1)
45 Mnium cinclidioides 95(1.1)
46 Calliergon stramineum 153(1.1)
47 Calypogeia trichomanis 155(2.1)
48 Sphagnum balticum 155(4.2)

Sphagnum squarrosum, S. platyphyllum. S. contortum, S. lindbergii and S. teres constituting the major cover in the D layer. All species can withstand submergence and waterlogging over prolonged periods.

The caricosum aquatilis appears to have a close relationship to the oligotrophic Alpine Carex - Sphagnum community in Scotland described by Ratcliffe (1964) and to the Sedge - Sphagnum - moss bog of northern Alaska described by Hanson (1953) and Churchill (1955).

(b) salicosum arbutifoliae

Three plots were analyzed in which Carex aquatilis and Salix arbutifolia were present as co-dominants. Although the habitats are extremely wet, hummocky conditions prevail throughout the plots. Whereas these sites might have been under water in the past there is no indication that there is at present any movement of water over them. The kinds of sites are all different and include a lake edge, old lake site and an old drainage pathway. After the initial loss of snow the Sphagnum hummock tops dry out relatively rapidly. No ice wedges or patterned ground were observed in these plots, but the ground topography appeared transitional between low-centered and high-centered polygons. Snow duration is estimated to be 8 1/2 months with no appreciable difference in rate of thaw between hummock-depression microrelief. There is no open water present by mid-summer. Exposure is total; two plots (83 and 155) were on very shallow slopes (2°).

Species present on the hummocks include Betula glandulosa Vaccinium uliginosum, Andromeda polifolia, Ledum decumbens and Pedicularis lapponica, while the wetter depressions are dominated by Carex aquatilis and Salix arbutifolia. In plots 153 and 155 Carex rariflora is present with high coverage values in the wet depressions. Salix pulchra, with low coverage values, is scattered throughout the plots on the sides of the hummocks. Clumps of Sphagnum fill the wetter depressions and include such species as S. squarrosum and S. balticum. An indication of the semi-hydric condition and possible successional nature of the variation is the preponderance of Sphagnum recurvum that covers a large percentage of the hummocks. On the upper drier parts of the hummocks are scattered clumps of Sphagnum lenense, S. rubellum, S. girgensohnii, Aulacomnium turgidum and Polytrichum commune.

Two analyzed plots dominated by Carex aquatilis and Eriophorum angustifolium appear related to the order Caricetalia fuscae described in Europe and reviewed by Brooke (1966). The major difference between the European and North American types is the lack of Sphagnum species in the latter type. In this study, two plots are considered as part of the Caricetum aquatilis because of the presence of Potentilla palustris. However, it is felt that they are a possible transition toward the Eriophoretum angustifolii.

3. Eriophoretum scheuchzerii Table 11 (a) & (b)

Low-centered polygons are considered to be indicative of flat areas. They are usually numerous in poorly drained areas particularly in wet sedge meadows. Their distribution and development in the Mackenzie Delta region of western arctic Canada has been described in detail by Mackay (1963). Ice wedges that form in poorly drained areas produce ridges that enclose the flat ground between them to give a saucer shape to the low-centered polygons. Initially, these sites are covered by surface water throughout the growing season and support marsh and aquatic vegetation. Tundra polygons are rare in the Canoe Lake region except for one small area at the south end of the lake. At Trout Lake they are more numerous. This can probably be related to the more regular topagraphy in the latter region. In both regions low-centered polygons are present only at lower elevations in areas of restricted drainage where snow cover is light and duration is similar to surrounding wet sedge meadow habitats (8 1/2 months). Exposure is always total because of their flat to concave profile. The active layer is narrow with the permafrost restricting any drainage. The waterlogged condition of the soil restricts decomposition which accounts for the accumulation of peat.

Table No. 11 b

	Eriophoretum scheuchzeri			
Plot No.	94	53	128	127
Plot size (m^2)	25	25	25	25
Date Analyzed	20/7 1965	5/7 1965	23/8 1965	23/8 1965
PLOT DATA				
Locality	TL	CL	CL	CL
Elevation (ft)	500	1050	1130	1130
PHYSIOGRAPHY				
Land form	....Low-centered polygon..			
Relief: Profile	..........Flat...........			
Exposure (°)	..........Total..........			
Slope gradient (°)	............0............			
CLIMATE				
Snow duration	.......8½ months.........			
STRATA COVERAGE (%)				
C layer	60	55	80	90
D layer	80	90	97	97
SOIL				
Drainage	.......Impeded...........			
Hygrotope	........Hydric...........			
Depth to active layer (cm)	20	26	40	37
CHEMICAL ANALYSIS				
No.of samples	4	3	3	3
Organic layer OM	70.0	92.7	76.6	86.0
N%	1.61	1.8	1.28	1.5
C/N	25.9	32.7	47.9	34.8
P ppm	4	8	14	24
Na	.91	.82	.78	.64
K	.28	.32	.28	.36
Ca	8.7	6.5	15.0	11.8
Mg	1.8	1.0	2.3	.8
CEC	62.4	160.6	109.8	160.3
pH	4.4	4.6	4.2	4.3
No.of samples		1	1	1
Organic - Mineral layer OM		25.0	17.4	23.9
N%		.13	.51	.5
C/N		112.0	19.8	27.7
P ppm		3	10	10
Na		.46	.62	.53
K		.05	.06	.04
Ca		2.8	8.6	7.5
Mg		.6	.8	.4
CEC		67.3	47.3	67.8
pH		4.9	4.1	4.7

Table No. II a

Eriophoretum scheuchzeri

Number of Plots	1	2	3	4
Plot No.	94	53	128	127
Plot size (m^2)	25	25	25	25
Elevation (ft)	500	1050	1130	1130

	1	2	3	4	Constancy	Avg. Cover
C layer						
1 Eriophorum scheuchzeri	7.3	6.3	8.3	9.4	V	7.5
2 Carex rotundata	4.1	2.1	2.1	2.1	V	2.5
3 Betula glandulosa	3.1	-	7.2	-	II	2.5
4 Andromeda polifolia					II	1.0
D layer (Bryophytes)						
5 Sphagnum balticum	8.3	8.3	9.4	2.1	V	6.5
6 Polytrichum commune	1.1	1.1	2.2	-	IV	1.0
7 Drepanocladus exannulatus	-	-	+.+	9.4	II	2.5
8 Aulacomnium turgidum	1.1	-	2.2	-	II	.8
TOTAL SPECIES (INCL.SPORADICS)	11	11	13	5		

Sporadic species

C layer

9 Arenaria humifusa	53(+.+)
10 Cardamine pratensis	53(+.+)
11 Chrysosplenium tetrandrum	53(1.1)
12 Equisetum arvense	53(1.1)
13 Ranunculus gmelinii	53(1.1)
14 Saxifraga cernua	53(1.1)
15 Salix arbutifolia	94(2.1)
16 Carex chordorrhiza	127(4.1)
17 Ledum decumbens	128(2.1)
18 Oxycoccus microcarpus	128(1.1)
19 Pedicularis lapponica	128(2.1)
20 Rubus chamaemorus	128(2.1)
21 Vaccinium vitis-idaea	128(1.1)

D layer (Bryophytes)

22 Drepanocladus aduncus	53(5.2)
23 Lophozia kunzeana	94(1.1)
24 Polytrichum juniperinum	94(3.1)
25 Scapania irrigua	94(+.+)
26 Sphagnum lindbergii	94(5.2)
27 Gymnocolea inflata	128(+.+)

The Eriophoretum scheuchzerii is considered to be under-represented with only four plots analyzed. Eriophorum scheuchzeri is also present along lake shores where it usually forms one of the concentric bands associated with lake shore vegetation. However, the E. scheuchzeri bands are usually so narrow that none were analyzed.

Initial development of the community is in open water. Two constant species E. scheuchzeri and Carex rotundata characterize the primary stage of development. Additional species, present with low coverage values, include Ranunculus gmelinii, Cardamine pratensis and Saxifraga cernua. Bryophyte composition is variable with either Drepanocladus exannulatus or Sphagnum balticum dominating. No two neighbouring low-centered polygons ever appear to have the same dominant bryophyte. In later stages of development as the habitats become semi-hydric woody and herbaceous species with broad ranges of amplitude become established. They include such species as Betula glandulosa, Andromeda polifolia, Ledum decumbens, Pedicularis lapponica, Rubus chamaemorus and Oxycoccus microcarpus. Two plots representing this stage were analyzed and in both Sphagnum balticum and S. lindbergii were dominant in the wetter areas. Associated species on the less saturated microhabitats include Polytrichum commune and Aulacomnium turgidum.

4. Caricetum rariflorae Table 12 (a) & (b)

The initial transition from low to high-centered polygons is a result of an increase in size and number of ice-wedges. As the ridges widen and are divided again, peaty hummocks appear as unsorted features throughout what was originally a depression. Moisture conditions within these plots are still hydric to semi-hydric with the water table at, or near, the surface during the summer months. Exposure is total with no protective slopes or low ridges surrounding them. Snow cover and duration are estimated to be the same as for the Eriophoretum scheuchzeri. Drainage in the hummocks and ridges is improved because of their raised position and they support a number of woody species.

Table No. 12 b

	Caricetum rariflorae		
Plot No.	80	156	151
Plot size (m^2)	25	25	25
Date Analyzed	17/7 1965	24/7 1966	15/7 1966
PLOT DATA			
Locality	TL	CL	CL
Elevation (ft)	510	1100	1350
PHYSIOGRAPHY			
Land form	Low-centered polygon		
Relief: Profile	...Flat-Hummocky....		
Exposure (°)	........Total.......		
Slope gradient (°)	..........0.........		
CLIMATE			
Snow duration	.....8½ months......		
STRATA COVERAGE (%)			
C layer	85	95	90
D layer	20	95	90
PLOT COVERAGE (%)			
by water	2		
SOIL			
Drainage	......Impeded.......		
Hygrotope	.......Hydric.......		
Depth of active layer (cm)	35	32	31
CHEMICAL ANALYSIS			
No.of samples	1	2	2
Organic layer OM	92.5	92.5	88.8
N%	.92	1.58	1.6
C/N	58.3	30.8	30.8
P ppm	19	5	35
Na	2.26	.93	1.27
K	.56	.73	1.22
Ca	18.5	23.1	22.6
Mg	3.0	6.1	7.4
CEC	141.8	102.5	108.7
pH	4.4	4.3	4.4
No.of samples		1	
Mineral layer OM		2.8	
N%		.17	
C/N		9.6	
P ppm		12	
Na		.74	
K		.18	
Ca		3.6	
Mg		1.3	
CEC		36.1	
pH		4.0	

Table No. 12 a

	Caricetum rariflorae		
Number of Plots	1	2	3
Plot No.	80	156	151
Plot size (m^2)	25	25	25
Elevation (ft)	510	1100	1350

C layer				Constancy	Avg. Cover
1 Carex rariflora	8.4	7.3	7.3	V	7.3
2 Carex rotundata	2.1	7.3	6.2	V	3.0
3 Salix arbutifolia	+.+	3.1	3.1	V	2.3
4 Betula glandulosa	-	3.1	5.2	IV	2.7
5 Andromeda polifolia	-	4.1	4.1	IV	2.7
6 Oxycoccus microcarpus	-	3.1	4.1	IV	2.3
7 Ledum decumbens	-	3.1	2.1	IV	1.7
8 Eriophorum scheuchzeri	2.1	-	2.1	IV	1.3
9 Pedicularis lapponica	-	1.1	2.1	IV	1.0
10 Vaccinium uliginosum	-	2.1	+.+	IV	1.0
D layer (Bryophytes)					
11 Polytrichum commune	1.1	4.2	4.2	V	3.0
12 Sphagnum balticum	-	7.3	6.3	IV	4.3
13 Sphagnum lenense	-	+.+	7.3	IV	2.7
14 Aulacomnium turgidum	-	+.+	3.1	IV	1.3
15 Sphagnum compactum	-	1.1	1.1	IV	.7
TOTAL SPECIES (incl.sporadics)	10	16	21		

Sporadic species

C layer

16 Carex aquatilis 80(1.1)
17 Pinguicula villosa 151(2.1)
18 Eriophorum angustifolium 151(+.+)
19 Pedicularis labradorica 151(+.+)
20 Rubus chamaemorus 151(1.1)

D layer

21 Drepanocladus aduncus 80(1.1)
22 Sphagnum contortum 80(1.1)
23 Sphagnum obtusum 80(5.2)
24 Sphagnum platyphyllum 80(1.1)
25 Sphagnum imbricatum 151(+.+)
26 Sphagnum rubellum 151(+.+)
27 Sphagnum aongstroemii 156(2.2)
28 Sphagnum recurvum 156(7.3)

Depth to permafrost varies, being greater under the peaty hummocks and ridges than the wet depression.

Constant dominants in the wetter areas are Carex rariflora and C. rotundata. Also constant, but with low coverage values, is Salix arbutifolia. Eriophorum scheuchzeri is present in two plots (83 and 151) with low coverage. Woody species present on the hummocks are Betula glandulosa, Andomeda polifolia, Ledum decumbens, Oxycoccus microcarpus and Vaccinium uliginosum plus several herbaceous species including Pedicularis lapponica and Rubus chamaemorus. Polytrichum commune is the only constant bryophyte. Sphagnum balticum and S. compactum between the hummocks and S. recurvum, S. lenense and Aulacomnium turgidum on hummock sides are present in plots 151 and 156. While in plot 80 where there are fewer hummocks, S. obtusum, S. platyphyllum and S. contortum, all species able to withstand submergence, are the major bryophytes.

B. Chionophilous plant communities with snow duration averaging ten months or more.

Plant communities in the two study areas subjected to at least ten months snow cover do not display a great variation. They may be divided into two major associations. The first, a very late snow bed in which plant cover is usually less than 50 percent and second, the late snow bed or subalpine meadow in which prostrate willow, sedges and grasses predominate. There is a third association which could be termed slightly chionophilous, dominated by Salix shrubs, because of several chionophilous herbaceous species present in the C layer. While generally found on the upper side of late snow beds where their height acts as a wind break, they are also found below these beds where seepage is prevalent. Additionally, they occur along eroded drainage pathways where snow accumulates to great depths. No communities were found where snow melt was so late that phanerogams were completely absent.

The lack of variation in these chionophilous plant communities can probably be related to the quality of the soil. Every soil profile studied in these late snow bed associations proved to be moderately acid. Conditions differ in the chionophilous communities of the European Alps (Braun-Blanquet, 1932), Tatra Mountains, Czechoslovakia (Krajina, 1933) and Sweden (Gjaerevoll, 1950, 1956, 1965), where parallel series of plant communities are found on calcareous and non-calcareous soils. No detailed information has been found to date in the literature regarding chionophilous communities in the subalpine region of arctic Canada.

Within the two study areas a total of three associations and nine variations are recognized and discussed below.

1. Salicetum pseudopolasis   Table 13 (a) & (b) (Figure 22)

Salix pseudopolaris attains its greatest abundance and dominates communities in the very late snow bed sites. This community is generally present on moderately steep concave or straight slopes (15-28°) where snow melt is very late and in some years never completed. Snow duration is estimated to be between 10 1/2 and 11 1/2 months. In 1965, one very late snow bed site in an amphitheatre on the west cuesta at Canoe Lake (Figure 23) did not completely disappear. However, in 1966 the snow bed had completely melted by mid-August.

All sample plots had southeast to south exposures. Soil moisture conditions during the prolonged melting period are considered to be hydric or semi-terrestrial. After snow melt they exhibit some drying out, however, seepage from above keeps them moist or hygric regardless of the length of time exposed. While precipitation in the area would generally have little affect on these sites because of the very late snow cover soil surface materials are constantly moving downslope due to snow creep and erosion by the many rivulets crossing the exposed soil surface. During snow melt the soils are temporarily waterlogged. Percent plot coverage by rock and exposed mineral soil is closely aligned to duration of snow cover. In plot 102 with the longest snow cover, coverage was estimated at seventy percent.

Salix pseudopolaris may form compact mats and is associated with other mat

Figure 22. Salicetum pseudopolaris dominates the light brown areas bordering the upper edge and sides of the snow patch. Note the dull colour of the snow, a result of the deposition by wind of organic and inorganic materials. (Photo by Krajina)

Figure 23. Amphitheatre (1400 ft.), Canoe Lake, bordered below by shrub (B_1) Salix pulchra and above by Lupino - Dryadetum *alaskensis. (Photo by Krajina early August 1965).

Table No. 13 b

		Salicetum pseudopolaris				
Plot No.		110	109	102	103	150
Plot size (m^2)		16	16	16	16	16
Date Analyzed		13/8 1965	13/8 1965	10/8 1965	10/8 1965	15/7 1966
PLOT DATA						
Locality		CL	CL	CL	CL	CL
Elevation (ft)		1295	1300	1475	1475	1480
PHYSIOGRAPHY						
Land form		..Creek.... bank		Amphitheatre		Creek bank
Relief: Profile		..Concave..		...Straight..		Cvx-Stg
Exposure (°)		135	135	180	180	180
Slope gradient (°)		20	15	28	25	2
CLIMATE						
Snow duration		.........11 months........				$10\frac{1}{2}$ months
STRATA COVERAGE (%)						
C layer		90	92	25	55	80
D layer Moss		8	1	25	25	30
Lichen		3	5	3	10	
Dr				10	3	
PLOT COVERAGE (%)						
by rock			4	70	50	
SOIL						
Drainage		............Moderate.............				
Hygrotope		.............Hygric................				
Depth of active layer (cm)		..........Undetermined...........				
CHEMICAL ANALYSIS						
No.of samples		1			1	
Organic - Mineral layer	OM	27.8			25.3	
	N%	.84			.67	
	C/N	19.2			21.9	
	P ppm	23			28	
	Na	.49			.42	
	K	.7			.63	
	Ca	13.2			8.7	
	Mg	4.1			2.3	
	CEC	41.3			43.9	
	pH	5.8			4.8	
No.of samples		4	4	4	4	2
Mineral layer	OM	2.1	3.5	2.7	2.5	5.0
	N%	.15	.22	.2	.19	.31
	C/N	8.2	8.7	8.3	6.2	9.4
	P ppm	7	11	11	8	6
	Na	.55	.73	.47	.43	.72
	K	.17	.22	.23	.13	.28
	Ca	7.5	10.0	3.8	3.2	13.1
	Mg	1.8	3.1	.8	.6	1.3
	CEC	13.1	17.6	17.4	28.6	29.0
	pH	5.4	5.4	4.9	4.9	5.9

Table No. 13 a

	Salicetum pseudopolaris						
Number of Plots	1	2	3	4	5		
Plot No.	110	109	102	103	150		
Plot size (m^2)	16	16	16	16	16		
Elevation (ft)	1295	1300	1475	1475	1480		
C layer						Constancy	Avg. Cover
1 Salix pseudopolaris	8.2	2.1	3.2	6.3	6.3	V	5.0
2 Carex lachenalii	2.1	+.+	5.2	2.1	6.2	V	3.2
3 Arenaria sajanensis	1.1	1.1	1.1	2.1	5.2	V	2.0
4 Oxyria digyna	3.1	2.1	2.1	-	5.1	IV	2.4
5 Sibbaldia procumbens	4.1	2.1	1.1	2.1	-	IV	1.8
6 Artemisia tilesii	+.+	1.1	-	6.3	1.1	IV	1.8
7 Dodecatheon frigidum	2.1	3.1	-	1.1	1.1	IV	1.4
8 Anemone narcissiflora	+.+	2.1	-	3.1	1.1	IV	1.4
9 Poa arctica	1.1	1.1	2.1	2.1	-	IV	1.2
10 Ranunculus pygmaeus	4.1	-	5.2	-	7.3	III	3.2
11 Arnica lessingii	-	4.2	1.1	4.2	-	III	1.8
12 Artemisia arctica	1.1	5.2	2.2	-	-	III	1.6
13 Ranunculus nivalis	2.1	2.1	2.1	-	-	III	1.2
14 Saxifraga punctata	2.1	2.1	-	1.1	-	III	1.0
15 Polygonum bistorta	2.1	2.1	-	+.+	-	III	1.0
16 Carex podocarpa	-	6.2	-	3.1	-	II	1.8
17 Salix chamissonis	+.+	8.3	-	-	-	II	1.8
18 Equisetum arvense	3.2	2.1	-	-	-	II	1.0
19 Myosotis alpestris	1.1	4.2	-	-	-	II	1.0
20 Luzula confusa	-	-	2.1	3.1	-	II	1.0
21 Arctagrostis latifolia	1.1	3.1	-	-	-	II	.8
22 Trisetum spicatum	-	2.1	-	2.1	-	II	.8
23 Saxifraga rivularis	1.1	-	3.1	-	-	II	.8
24 Epilobium anagallidifolium	3.1	+.+	-	-	-	II	.8
25 Petasites frigidus	1.+	2.1	-	-	-	II	.6
D layer (Bryophytes)							
26 Polytrichum norvegicum	-	1.1	6.2	2.1	5.2	IV	2.8
27 Pohlia drummondii	4.1	2.1	3.1	5.2	-	IV	2.8
28 Drepanocladus fluitans	1.1	-	1.1	1.1	1.1	IV	.8
29 Polytrichum juniperinum	2.1	1.1	-	4.1	-	III	1.4
30 Drepanocladus uncinatus	1.1	+.+	-	1.1	-	III	.6
31 Pogonatum alpinum	7.2	1.1	-	-	-	II	1.6
32 Brachythecium albicans	3.1	3.1	-	-	-	II	1.2
33 Bryum pseudotriquetrum	-	-	-	+.+	1.1	II	.4
34 Lophozia latifolia	-	-	+.+	-	1.1	II	.4
35 Bryum sp.	+.+	-	+.+	-	-	II	.4
36 Bartramia ithyphylla	+.+	-	-	1.1	-	II	.4
(Lichenes)							
37 Peltigera canina	2.1	1.1	-	1.1	-	III	.8
38 Cladonia chlorophaea	-	+.+	1.1	1.1	-	III	.6
39 Rhizocarpon geographicum	-	-	2.1	1.1	-	II	.6
40 Peltigera spuria	1.1	1.1	-	-	-	II	.4
41 Solorina crocea	-	-	1.1	1.1	-	II	.4
42 Lecidea granulosa	-	-	+.+	1.1	-	II	.4
TOTAL SPECIES (incl.sporadics)	35	47	23	38	15		

Sporadic species

C layer

43 Antennaria monocephala 103(4.3)
44 Hierochloe alpina 103(1.1)
45 Loiseleuria procumbens 103(1.1)
46 Polygonum viviparum 103(+.+)
47 Gentiana glauca 103(+.+)
48 Taraxacum sp. 103(+.+)
49 Senecio lugens 109(4.2)
50 Aconitum delphinifolium 109(2.1)
51 Festuca altaica 109(2.1)
52 Arnica alpina 109(2.2)
53 Castilleja raupii 109(2.2)
54 Pedicularis sudetica 109(1.1)
55 Anemone richardsonii 109(1.1)
56 Polemonium acutiflorum 109(1.1)
57 Stellaria ciliatosepala 109(1.1)
58 Achillea borealis 109(1.1)
59 Salix reticulata 109(+.+)
60 Saussurea angustifolia 109(+.+)
61 Carex montanensis 110(4.1)

D layer (Lichenes)

62 Lecidea flavocaerulescens 102(3.1)
63 Lecidea lapicida 102(2.1)
64 Peltigera aphthosa 103(1.1)
65 Peltigera venosa 103(1.1)
66 Cetraria islandica 109(1.1)
67 Psoroma hypnorum 109(1.1)

(Bryophytes)

68 Brachythecium starkii 103(1.1)
69 Scapania hyperborea 103(+.+)
70 Andreaea rupestris 103(2.2)
71 Bryum bimum 103(1.+)
72 Dicranum mühlenbeckii 109(2.1)
73 Mnium punctatum 109(1.1)
74 Rhacomitrium lanuginosum 110(2.1)
75 Distichium capillaceum 110(+.+)
76 Scapania obliqua 110(+.+)
77 Pohlia rutilans 150(5.2)
78 Lophozia alpestris 150(2.1)
79 Calliergon stramineum 150(+.+)

formers, sedges and vascular plants. There are only three constant species in the association: Salix pseudopolaris, Carex lachenalii and Arenaria sajanensis. Three differential species characteristic of the Salicetum pseudopolaris are distinguished, they include Arenaria sajanensis, Epilobium anagallidifolium and Saxifraga rivularis. Ranunculus pygmaeus, Oxyria digyna and Sibbaldia procumbens are additional important chionophilous species present in the very late snow bed community. In later stages of development (longer snow free periods) such species as Artemisia tilesii, Anemone narcissiflora, Dodecatheon frigidum, Arnica lessingii, Ranunculus nivalis and Saxifraga punctata are found with very low coverage values.

In the D layer the most characteristic species present are Polytrichum norvegicum, Pohlia drummondii and Bartramia ithyphylla. Non-calcareous late snow areas are the characteristic habitat for P. norvegicum and Pohlia drummondii (Gjaerevoll, 1950). Additional late snow bed species are Drepanocladus fluitans, Bryum sp. and B. affine. Several species with broad amplitudes of tolerance are present in the later stages of development, they are Polytrichum juniperinum, Drepanocladus uncinatus, Pogonatum alpinum and Brachythecium albicans. Saxicolous lichens are very rare. However, two important lichens characteristic of these wet habitats are present, they are Lecidea granulosa, and Solorina crocea.

2. Salicecetum chamissonis Table 14 (a) & (b)

Habitats dominated by Salix chamissonis in the Canoe Lake area are very conspicuous both in mid-summer by their snow cover and in late summer after snow melt by their dense luxuriant plant growth. Salicetum chamissonis is poorly represented in the Trout Lake area. All sites have a predominantly south to southeast exposure and are usually on moderately steep creek bank slopes (between 10-28°). The association occurs between 1060-1800 ft elevation in the subalpine zone at Canoe Lake and at 625 ft at Trout Lake. There appears to be

Table No. 14 b

		Salicetum chamissonis														
		salicosum chamissonis							equisetosum arvensis		festucosum altaicae	caricosum montanensis \ arctagrostidosum latifoliae		salicosum pulchrae		
Plot No.		92	168	174	143	142	147	164	170	148	162	145	157	169	122	140
Plot size (m^2)		50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Date Analyzed		18/7 1965	8/8 1966	11/8 1966	13/7 1966	13/7 1966	14/7 1966	27/7 1966	8/8 1966	14/7 1966	26/7 1966	13/7 1966	25/7 1966	8/8 1966	22/8 1965	12/7 1966
PLOT DATA																
Locality		TL	CL	CL	CL	CL	CL	CL	CL	CL	DL	CL	DL	CL	CL	CL
Elevation (ft)		625	1070	1250	1550	1600	1640	1800	1060	1640	1100	1500	1100	1060	1200	1400
PHYSIOGRAPHY																
Land form		Lake edge	................Creek bank................						.Creek bank.		Lake edge	Creek bank	Lake edge	Bank slide	.Creek bank.	
Relief: Profile		.Straight..		Cvx-Hum	Stg-Hum.	Stg.	Stg	Stg	..Straight..		Cnv-Hum	Cvx	Stg	Cnv	..Concave...	
Exposure (°)		135	90	90	135	135	135	90	90	120	120	120	135	90	90	90
Slope gradient (°)		3	20	25	15	14	10	18	20	10	15	15	5	15	17	15
CLIMATE																
Snow duration		10 months	............11 months.....................						.10½ months.		10½ months	10½ months	10½ months	......10 months......		
STRATA COVERAGE (%)																
B_2 layer														80	5	20
C layer		100	100	100	98	100	100	100	100	100	100	100	100	75	100	98
D layer	Mosses	65	90	70	40	35	28	30	90	45	60	30	50	65	60	35
	Lichens	5		5	2		2	1			20	5		5	1	2
SOIL																
Drainage		....................Moderate.....................							..Moderate..		Moderate	Moderate	Moderate	.......Moderate......		
Hygrotope		.....................Moist.......................							...Moist....		.Moist..	.Moist..	.Moist..	........Moist........		
Depth of active layer (cm)		................greater than 1 meter..............							over 70 cm	40 cm	60 cm	over 50 cm	over 60 cm	......over 50 cm.....		
CHEMICAL ANALYSIS																
No.of samples		1	1	1		1	2	2	1	2	1	2	1	1	1	1
Organic layer	OM	48.3	74.9	87.5		54.6	84.4	78.8	71.0	79.8	67.9	83.4	73.8	57.3	87.3	71.4
	N%	1.26	1.59	1.59		.53	1.4	1.52	1.49	1.2	.95	1.35	1.3	1.34	1.61	1.08
	C/N	22.2	27.3	27.6		59.7	34.9	30.1	27.6	39.2	41.5	35.8	32.9	24.8	31.4	38.3
	P ppm	30	15	23		23	40	15	19	33	16	31	19	16	31	33
	Na	.46	1.06	1.22		.91	.94	1.14	.99	1.09	.93	1.24	.89	1.58	.68	1.2
	K	1.09	.57	1.04		1.43	.88	1.31	.63	1.26	.79	1.68	.69	.78	1.63	1.48
	Ca	20.4	12.6	13.9		6.4	37.3	18.1	21.3	40.2	17.3	15.9	17.9	16.8	22.8	20.2
	Mg	5.0	6.3	2.4		17.3	13.6	1.9	4.6	18.0	6.3	2.1	4.6	4.9	1.9	.9
	CEC	36.4	97.4	109.0		64.3	128.7	101.5	87.0	112.8	67.7	119.3	108.8	68.3	146.0	105.5
	pH	5.2	5.8	4.2		4.5	6.0	5.9	5.0	4.9	4.5	4.3	4.7	5.7	4.8	5.1
No.of samples				1	1			1					1			
Organic - Mineral layer	OM			18.6	15.5			28.4					11.6			
	N%			.65	.29			.65					.38			
	C/N			16.6	31.0			25.3					17.7			
	P ppm			20	19			19					8			
	Na			1.07	1.06			1.18					.74			
	K			.63	1.04			1.03					.37			
	Ca			12.6	6.4			17.3					11.3			
	Mg			1.2	1.6			1.3					2.1			
	CEC			31.6	34.9			54.4					64.3			
	pH			4.3	5.0			5.7					4.4			
No.of samples		2	3	3	1	4	1	1	3	2	4	1	2	4	3	3
Mineral layer	OM	2.2	.8	.9	.3	6.5	2.1	3.9	5.3	.9	1.3	4.8	4.8	2.7	5.3	3.9
	N%	.16	.04	.08	.03	.17	.1	.14	.14	.1	.09	.25	.17	.1	.14	.15
	C/N	8.5	10.1	4.8	5.8	20.8	12.7	16.2	17.4	6.4	7.6	9.4	15.2	12.5	19.6	15.1
	P ppm	10	3	6	5	17	5	5	5	7	5	13	7	6	10	8
	Na	.41	.75	.76	.84	.95	.83	.81	.73	.68	.81	1.2	.64	.85	.56	.98
	K	.1	.37	.38	.63	.82	.28	.71	.32	.24	.35	.87	.49	.22	1.19	.52
	Ca	4.8	1.8	3.0	6.1	4.4	29.4	9.0	6.4	29.0	5.3	17.6	6.2	2.7	8.1	13.5
	Mg	1.5	.38	.6	.6	6.1	5.2	.9	1.3	3.9	.78	3.8	1.5	1.8	.4	1.6
	CEC	31.8	17.7	21.5	28.4	27.7	32.5	13.6	14.4	27.1	19.2	37.9	26.6	17.9	26.6	22.4
	pH	4.8	5.5	5.3	5.3	4.7	5.5	5.7	6.2	5.5	5.1	6.9	4.5	5.8	4.8	4.5

Table No. 14 a

	Salicetum chamissonis																	
	salicosum chamissonis							equisetosum arvensis		festucosum altaicae	caricosum montanensis	arctagrostidosum latifoliae	salicosum pulchrae				
Number of Plots	1	2	3	4	5	6	7	1	2	1	1	1	1	2	3		
Plot No.	92	168	174	143	142	147	164	170	148	162	145	157	169	122	140		
Plot size (m^2)	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50		
Elevation (ft)	625	1070	1250	1550	1600	1640	1800	1060	1640	1100	1500	1100	1060	1200	1400		
B_2 layer																Constancy	Avg. Cover
1 Salix pulchra	-	-	-	-	-	-	-	-	-	-	-	-	8.4	4.2	5.3		
2 Spiraea beauverdiana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.2		
C layer																	
3 Equisetum arvense	2.1	7.2	5.1	5.1	6.1	8.2	8.2	8.3	8.2	-	5.1	1.1	7.2	5.1	4.1	V	5.2
4 Arctagrostis latifolia	-	2.1	4.1	1.1	6.2	2.1	1.1	3.1	1.1	2.1	1.1	8.2	2.1	5.2	4.1	V	2.8
5 Aconitum delphinifolium	1.1	5.1	1.1	4.1	3.1	2.1	4.1	1.1	3.1	2.1	1.1	2.1	3.1	3.1	-	V	2.3
6 Salix chamissonis	7.2	6.2	7.2	6.2	7.3	7.2	8.3	-	2.1	-	2.1	-	5.2	8.4	7.3	IV	4.7
7 Carex montanensis	-	-	5.2	6.2	6.2	5.1	6.2	1.1	5.1	2.1	8.2	-	-	3.1	4.2	IV	3.6
8 Artemisia arctica	-	-	7.2	+.+	6.2	+.+	-	1.1	+.+	6.2	4.1	7.2	2.1	3.1	6.2	IV	3.0
9 Petasites frigidus	-	1.1	5.1	-	4.1	1.1	-	2.1	-	6.1	2.1	6.1	5.1	1.1	3.2	IV	2.6
10 Carex lachenalii	-	2.1	4.2	2.1	2.1	2.1	3.1	4.2	-	3.1	2.1	4.2	1.1	4.1	2.1	IV	2.3
11 Dodecatheon frigidum	3.1	-	3.1	6.2	3.1	4.1	3.1	-	2.1	-	-	+.+	-	2.1	6.2	IV	2.2
12 Anemone richardsonii	5.1	4.1	1.1	3.1	-	1.1	3.1	2.1	2.1	-	-	-	5.1	1.1	3.1	IV	2.0
13 Saxifraga punctata	-	2.1	3.1	1.1	3.1	2.1	3.1	2.1	4.1	-	1.1	-	2.1	-	4.1	IV	1.8
14 Poa arctica	-	2.1	1.1	-	3.1	1.1	3.1	4.2	1.1	1.1	+.+	2.1	2.1	1.1	2.1	IV	1.6
15 Trisetum spicatum	+.+	4.1	-	-	1.1	1.1	3.1	5.1	-	1.1	1.1	2.1	2.1	2.1	-	IV	1.6
16 Polemonium acutiflorum	1.1	3.1	2.1	-	2.1	+.+	3.1	1.1	3.1	1.1	1.1	1.1	-	2.1	-	IV	1.4
17 Ranunculus nivalis	2.1	3.1	-	3.1	1.1	1.1	-	2.1	1.1	1.1	1.1	-	-	-	2.1	IV	1.1
Salix pulchra	-	1.1	1.1	-	-	1.1	-	-	-	-	-	-	?	?	?	III	1.3
18 Pedicularis sudetica	-	+.+	3.1	2.1	-	3.1	-	-	-	-	-	2.1	2.1	2.1	1.1	III	1.1
19 Polygonum bistorta	-	-	2.1	+.+	2.1	1.1	-	-	-	2.1	3.1	-	+.+	-	+.+	III	.9
20 Valeriana capitata	2.1	-	-	1.1	-	1.1	3.1	-	1.1	-	-	1.1	-	+.+	-	III	.5
Spiraea beauverdiana	-	-	6.2	-	1.1	-	-	-	-	3.2	6.2	5.2	-	-	?	II	1.7
21 Artemisia tilesii	-	5.2	-	-	2.1	-	4.1	7.2	-	-	-	1.1	3.2	-	-	II	1.5
22 Festuca altaica	-	-	6.2	+.+	2.2	1.1	-	-	-	7.2	2.1	-	-	-	-	II	1.3
23 Salix reticulata	5.2	-	-	2.1	-	6.2	7.2	-	2.1	-	-	-	-	-	1.1	II	1.5
24 Senecio lugens	-	2.1	-	-	-	1.1	4.1	2.1	1.1	-	-	2.1	-	-	-	II	.8
25 Myosotis alpestris	-	-	-	-	2.1	2.1	2.1	-	5.1	-	-	-	-	-	-	II	.7
26 Epilobium angustifolium	-	-	-	-	-	-	-	-	-	3.1	4.1	2.1	2.1	-	-	II	.7
27 Polygonum viviparum	-	2.1	1.1	-	-	1.1	2.1	-	-	-	-	-	+.+	3.1	-	II	.6
28 Vaccinium vitis-idaea	-	-	1.1	-	1.1	-	-	-	-	3.2	-	1.1	-	-	-	II	.4
29 Carex aquatilis	3.1	-	-	+.+	-	-	-	-	-	-	-	+.+	-	+.+	-	II	.4
30 Rumex arcticus	-	-	-	-	-	1.1	2.1	1.1	-	-	-	-	-	1.1	-	II	.3
31 Vaccinium uliginosum	-	-	1.1	-	-	-	-	-	-	2.1	1.1	-	+.+	-	-	II	.3
32 Viola epipsila	-	-	-	-	4.2	-	-	-	-	-	-	-	-	4.1	2.1	I	.6
33 Luzula wahlenbergii	-	-	5.2	-	-	-	-	-	-	4.2	-	-	-	-	-	I	.6
34 Anemone narcissiflora	-	-	-	2.1	2.1	-	-	-	-	-	-	-	-	-	4.1	I	.5
35 Stellaria ciliatosepala	-	-	-	-	-	-	2.1	-	-	-	-	-	+.+	-	1.1	I	.3
36 Gentiana glauca	-	-	3.1	-	-	-	-	-	-	-	2.1	-	-	-	-	I	.3
37 Parnassia kotzebuei	-	-	-	-	-	4.1	1.1	-	-	-	-	-	-	-	-	I	.3
38 Stellaria longipes	-	-	-	-	-	-	-	3.1	-	-	-	1.1	-	-	-	I	.3
39 Arnica alpina	-	-	2.1	-	1.1	-	-	-	-	-	-	-	-	-	-	I	.2
40 Betula glandulosa	1.1	-	1.1	-	-	-	-	-	-	+.+	-	-	-	-	-	I	.2
41 Rubus chamaemorus	-	-	-	-	-	-	-	-	-	-	1.1	+.+	-	-	1.1	I	.2
42 Empetrum hermaphroditum	-	-	-	-	-	-	-	-	-	-	-	1.1	1.1	-	-	I	.1
43 Arnica lessingii	-	-	-	-	-	-	1.1	-	-	-	-	1.1	-	-	-	I	.1
D layer (Bryophytes)																	
44 Drepanocladus uncinatus	8.3	6.2	6.2	5.2	6.3	+.+	5.2	5.2	-	6.2	2.1	7.2	5.2	4.2	4.2	V	4.7
45 Bryum pseudotriquetrum	-	+.+	-	5.2	1.1	6.2	4.2	-	6.2	+.+	-	2.1	-	-	1.1	III	1.8
46 Pogonatum alpinum	-	-	6.2	1.1	5.2	-	-	3.1	-	6.2	-	-	-	-	5.3	II	1.8
47 Aulacomnium palustre	4.1	5.2	-	-	-	-	2.1	5.2	-	-	-	-	5.2	+.+	-	II	1.5
48 Polytrichum juniperinum	1.1	-	-	-	+.+	-	-	-	-	+.+	5.2	-	-	-	5.3	II	.9
49 Cinclidium stygium	-	4.1	-	-	-	+.+	+.+	-	-	-	-	-	4.1	-	+.+	II	.7
50 Brachythecium turgidum	-	1.1	-	1.1	+.+	1.1	-	-	-	-	-	-	3.1	-	1.1	II	.5
51 Tomenthypnum nitens	-	5.2	-	2.2	-	-	-	-	-	-	-	-	5.2	-	-	I	.8
52 Dicranum scoparium	1.1	-	5.2	-	-	-	-	-	-	5.2	-	-	-	-	-	I	.7
53 Pohlia nutans	1.1	-	-	-	1.1	-	-	-	-	-	-	-	-	-	4.2	I	.4
54 Dicranum mühlenbeckii	-	-	-	-	+.+	-	-	-	-	1.1	3.1	-	-	-	-	I	.3
55 Dicranum fuscescens	-	-	-	+.+	-	-	-	-	-	1.1	-	-	-	-	-	I	.1
56 Lophozia quadriloba	-	-	-	+.+	-	-	-	-	-	-	-	-	1.1	-	-	I	.1
57 Scapania lingulata	-	-	+.+	-	1.1	-	-	-	-	-	-	-	-	-	-	I	.1
58 Amblystegium serpens	-	-	-	-	-	+.+	-	-	-	-	-	-	+.+	-	-	I	.1
(Lichenes)																	
59 Peltigera canina	1.1	5.2	-	1.1	-	-	-	-	-	-	-	-	3.1	+.+	-	II	.7
60 Peltigera aphthosa	2.1	-	1.1	-	-	1.1	-	-	-	2.1	-	-	2.1	-	-	II	.5
61 Cetraria islandica	-	-	1.1	-	-	-	-	-	-	3.1	2.1	-	-	-	-	II	.3
62 Peltigera scabrosa	-	-	1.1	-	-	-	-	-	-	2.1	1.1	-	-	-	1.1	II	.3
63 Peltigera spuria	+.+	-	-	-	-	1.1	+.+	-	-	-	-	-	-	-	1.1	II	.3
64 Cladonia gracilis	-	-	-	-	-	-	-	-	-	2.1	1.1	-	-	-	-	I	.2
TOTAL SPECIES (incl.sporadics)	22	24	38	31	32	35	33	24	19	37	29	24	31	29	32		

Sporadic species

C layer

65 Potentilla fruticosa 92(3.1)
66 Pedicularis capitata 92(2.1)
67 Cardamine pratensis 122(1.1)
68 Carex lugens 122(1.1)
69 Luzula confusa 122(3.1)
70 Oxyria digyna 142(2.1)
71 Sibbaldia procumbens 143(3.1)
72 Carex vaginata 145(2.1)
73 Castilleja raupii 145(2.1)
74 Linnaea borealis 145(5.2)
75 Ranunculus turneri 147(3.1)
76 Cardamine digitata 148(1.1)
77 Anemone parviflora 164(2.1)
78 Cerastium beeringianum 164(1.1)
79 Chrysosplenium tetrandrum 164(1.1)
80 Eriophorum angustifolium 164(1.1)
81 Ranunculus pedatifidus 164(2.1)
82 Saxifraga radiata 164(1.1)
83 Stellaria monantha 169(2.1)
84 Ranunculus pygmaeus 170(4.2)

D layer (Bryophytes)

85 Brachythecium albicans 122(6.2)
86 Plagiothecium roeseanum 122(4.2)
87 Polytrichum commune 122(3.1)
88 Lophozia alpestris 140(2.1)
89 Drepanocladus fluitans 140(1.1)
90 Scapania irrigua 143(2.2)
91 Scapania hyperborea 143(+.+)
92 Scapania lingulata 143(+.+)
93 Lophozia latifolia 162(5.2)
94 Lophozia hatcheri 162(4.2)
95 Barbilophozia barbata 162(1.1)
96 Lophozia porphyroleuca 162(1.1)
97 Cephalozia stellulifera 162(+.+)
98 Mnium hymenophyllum 147(1.1)
99 Amblystegium juratzkanum 148(4.2)
100 Bryum sp. 170(8.3)
101 Mnium rugicum 170(1.1)
102 Brachythecium sp. 170(+.+)
103 Hylocomium splendens 174(2.1)
104 Polytrichum norvegicum 174(2.1)
105 Ptilidium ciliare 174(2.1)
106 Pleurozium schreberi 174(1.1)
107 Lophozia kunzeana 174(1.1)

(Lichenes)

108 Stereocaulon alpinum 143(1.1)
109 Cladonia squamosa 162(1.1)
110 Lobaria linita 162(1.1)
111 Nephroma expallidum 162(3.1)
112 Cladonia fimbriata 169(1.1)
113 Cetraria cucullata 174(+.+)

no visual evidence of downslope movement of surface materials in any of the sampled plots, however, quantitative measurements would likely show that there is downslope movement. During the annual summer thaw the soil is waterlogged and sticky for some time after the snow completely disappears, after which the site always exhibits a certain moistness but no waterlogging. The latter is due to the moderately steep slope of the habitat.

The upper limits of the creek bank usually support a shrub Salix pulchra community. If this is absent, then a vertical cut bank up to three feet high is present. Snow accumulates with the first autumn snow fall, usually before freezing sets in. Because the protective blanket of snow is generally present before freezing sets in each autumn, the active layer is very thick when compared with the majority of other habitats in the subalpine zone. No temperatures were taken at ground level below the snow cover, but it is assumed that readings would be slightly above freezing even in mid-winter. During the winter wind blown snow is packed into the meadow sites. In the following spring the snow bank, because of its compactness, is very slow to thaw. Several factors influence this phenomena, they are related to the degree of slope, exposure, amount of seepage from surrounding higher ground and the amount of direct sunlight received by the snow bank.

Six variants are recognized in the Salicetum chamissonis, four of them being represented by only one or two plots. Little mention has been made in earlier studies undertaken in northern Alaska concerning these snow bed/meadow habitats so no comparisons are possible. In Scandinavia and Scotland (Ratcliffe, 1964) herb and fern dominated communities have been described from the subalpine and alpine areas of deep snow lie. However, there appear to be no true floristic similarities between the European and North American types.

(a) salicosum chamissonis (Figure 24)

The salicosum chamissonis is the most common of all the late snow bed communities in the subalpine zone. Seven plots were analyzed. Plant cover is generally dense and low because of the prostrate habits of Salix chamissonis, the dominant species. Associated species with high constancy and coverage values are: Arctagrostis latifolia, Equisetum arvense, Carex lachenalii, C. montanensis, Aconitum delphinifolium, Saxifraga punctata, Polemonium acutiflorum, Anemone richardsonii, Dodecatheon frigidum, Ranunculus nivalis and Trisetum spicatum. The majority of the soils are rich in available nutrients (Ca and Mg) and this is reflected in the presence and high coverage values in certain plots of such species as Salix reticulata and Parnassis kotzebui. All of the associated species generally have low sociability values, tending to form scattered clumps throughout the plot between the mats of Salix chamissonis.

Figure 24. Salicetum chamissonis salicosum chamissonis. Close up of habitat. Shiny green leaves and aments are Salix chamissonis, 3-notched leaves - Sibbaldia procumbens and the flowering composite plant on right is Arnica lessingii. (Photo by Krajina)

Drepanocladus uncinatus, a species of wide ecological amplitude, dominates the moss flora in the meadow habitats. In this habitat it is a good indicator of moist conditions. Other important bryophytes are: Bryum pseudotriquetrum, Pogonatum alpinum, Brachythecium turgidum and Aulacomnium palustre. Lichens are never abundant in any plot, only Peltigera species showing any consistency of occurrence.

Only one chionophilous community was analyzed in the Trout Lake area (plot 92). This community is at the north end of the lake and at one time was submerged. At the time of sampling, July 18, 1965, there was no snow present. Snow duration is obviously shorter here than at Canoe Lake and an indication of this is the presence of scattered Betula glandulosa, Salix chamissonis, the major species, is associated with Anemone richardsonii, Salix reticulata, Dodecatheon frigidum, Potentilla fruticose, Carex aquatilis, Ranunculus nivalis, Polemonium acutiflorum and Aconitum delphinifolium. The major mosses are Drepanocladus uncinatus and Aulacomnium palustre.

(b) equisetosum arvensis

Two plots (148 and 170) dominated by Equisetum arvense with little or no Salix chamissonis were analyzed. Snow duration is estimated to be less in this variation than in the salicosum chamissonis. This fact is reflected in the more abundant growth of the taller herbaceous species that combine to shade out the prostrate Salix chamissonis. Plot 170 is at 1060 ft just above the lake shore flood zone. Seepage is more prevalent here because of direct drainage from above. The site also gives evidence of past slumping. Equisetum arvense is a common species on disturbed sites where seepage waters are close to the surface.

Associated species commonly found with Equisetum arvense include Artemisia tilesii, A. arctica, Myosotis alpestris and Senecio lugens. Late snow bed species commonly associated with the salicosum chamissonis are present and include Aconitum delphinifolium, Carex montanensis, Saxifraga punctata, Anemone richardsonii, Polemonium acutiflorum and Ranunculus nivalis. Mosses are sparse with only Drepanocladus uncinatus, Bryum pseudotriquetrum, Pogonatum alpinum and Aulacomnium palustre present. There are no lichens present in either plot.

(c) festucosum altaicae

The only site (plot 162) dominated by Festuca altaica was found in the northeast corner of Divided Lake at 1100 ft. There is no higher ground above this site so that moisture conditions are generally drier near the surface because of a lack of seepage. Festuca altaica is known to be characteristic of drier more sheltered slopes. The snow cover had disappeared from this site by mid-July. An indication of the longer snow free period is the presence of Vaccinium uliginosum, V. vitis-idaea, Spiraea beauverdiana and Betula glandulosa. While this habitat is probably drier than those of the other variations, it is moister for a longer period after the snow has disappeared. This assumption is based on the high coverage of Petasites frigidus and Luzula wahlenbergii. Drepanocladus uncinatus, Pogonatum alpinum and Dicranum scoparium are present with high coverage values. Lichen coverage is estimated to be twenty percent.

(d) caricosum montanensis

Associated with subalpine and alpine meadows and a common species in the salicosum chamissonis, Carex montanensis is present as a dominant in only one plot (145). This habitat lies between a sparsely covered shrub Salix pulchra plot and a salicosum chamissonis at 1500 ft. A clearly defined area approximately 60 ft wide and 100 ft long is distinguishable. Snow melt is completed several weeks before the lower salicosum chamissonis and the site had dried out appreciably by late July.

The major species associated with Carex montanensis are not typical late snow bed species. Those present with high coverage values include Spiraea beauverdiana, Artemisia arctica, Polygonum bistorta, Epilobium angustifolium and Equisetum arvense. The typical snow bed species such as Carex lachenalii, Aconitum delphinifolium and Polemonium acutiflorum are scattered throughout the plot. Mosses and lichens are sparse with only Polytrichum juniperinum, Dicranum muehlenbeckii and Cetraria islandica having relatively high coverage values.

(e) arctagrostidosum latifoliae

Only one plot (157), at 1100 ft on the north shore of Divided Lake and dominated by the ubiquitous Arctagrostis latifolia was analyzed. The habitat appears to be a more advanced late snow bed as it is estimated to be free of snow several weeks before the salicosum chamissonis. The majority of the Arctagrostis culms are estimated to be between 2-3 ft high in late July. Seepage occurs well into the summer, coming from the higher ground above the site.

Sub-dominant species with high coverage values such as Carex lachenalii, Artemisia arctica, Petasites frigidus and Spiraea beauverdiana are present. Scattered throughout the plot are typical chionophilous species such as Aconitum delphinifolium, Polemonium acutiflorum, Dodecatheon frigidum and Trisetum spicatum. Drepanocladus uncinatus is the dominant moss in the plot, while lichens are absent.

(f) salicosum pulchrae

Included as a variation in the synthesis table describing the Salicetum chamissonis are three plots (122, 140 and 169) all characterized by a shrub layer of Salix pulchra. Present, however, in the C layer are large mats of Salix chamissonis. As far as could be determined all three plots give evidence of past downslope movement of surface materials. Plot 169 is bordering a salicosum chamissonis while the other two plots are not. Snow duration in these habitats is estimated to be between 9 1/2 to 10 months each year. The sampled plots range in elevation from 1060-1400 ft and are excluded from a higher more exposed position on the slopes by their tall growth. Aside from the presence of Salix pulchra, species composition in the C layer is similar to that in the salicosum chamissonis. This includes vascular plants, bryophytes and lichens.

3. Salicetum pulchrae   Table 15 (a) & (b)

This association is considered to be only slightly chionophilous because of the presence and high coverages of several shrub species. Habitats dominated by Salix pulchra are of limited occurrence in the subalpine zone. The most important characteristics of the association are that the plots are associated with drainage pathways (between 1050-1825 ft) or border late snow bed communities where seepage is prevalent throughout the summer. Shrub height is frequently reduced to less than 3 ft at elevations above 1500 ft.

In the Canoe Lake region no large drainage pathways are present on west facing slopes. This can probably be related to the fact that the cuestas are so orientated that the scarp faces with their westerly exposures do not allow a similar type of melt water run off and continual seepage as experienced on the dip slopes. Additionally, the winds that are predominantly from the northwest allow little accumulation of snow and, therefore, less protection for tall shrubs.

Three variations are recognized and described below for this association.

(a) salicosum pulchrae   (Figure 25)

The salicosum pulchrae is distinguished by the presence of tall (over 6 ft) shrub Salix pulchra. Sites are present only on the east facing slopes or along sheltered creeks at lower elevations (below 1500 ft). At the lower elevations the thousands of small drainage pathways that cover the upper slopes converge to form recognizable creeks. The increased amount of run off water cuts deeper into the slope causing a thawing of the permafrost and resulting in a widened channel. The beds of many of these drainage pathways are from 5-20 ft below the level of the bordering tundra slopes. The communities that develop in these protected sites are naturally shielded from the abrasive and desiccating winter winds. Snow accumulates early, as early as in the meadow habitats, and winter winds cause further build up during the winter by wind. In the spring and early

Table No. 15 b

		Salicetum pulchrae												
		salicosum pulchrae								betulosum glandulosae				
Plot No.		105	126	111	165	175	141	182	149	88	129	39	125	119
Plot size (m^2)		..........................100..........................								...............50...............				
Date Analyzed		12/8 1965	23/8 1965	13/8 1965	27/7 1966	11/8 1966	12/7 1966	13/8 1966	14/7 1966	18/8 1965	24/8 1965	2/7 1966	23/8 1965	21/8 1965
PLOT DATA														
Locality		CL	CL	CL	CL	CL	CL	CL	CL	TL	CL	CL	CL	CL
Elevation (ft)		1075	1150	1230	1260	1260	1375	1400	1500	630	1120	1160	1210	1825
PHYSIOGRAPHY														
Land form		....Old creek.......			Drainage way		Exposed slope	Drainage way		Lake edge	Old creek	...Drainage way.....		
Relief: Profile		Cvx	Flat	Cnv	...Cvx-Hum..		Cnv	..Straight..		...Flat.....		Cvx	Cnv	Stg
Exposure (°)		120	0	135	90	70	90	90	180	200	0	90	180	120
Slope gradient (°)		9	0	10	15	5	10	5	5	0	0	9	13	12
CLIMATE														
Snow duration		........................10½ months........................								...............10 months............				
STRATA COVERAGE (%)														
B_1 layer		80	30	80	85	70	90	80	85					
B_2 layer		20	85	15	50	45	20	20	20	85	85	50	80	95
C layer		95	90	90	70	80	90	90	85	15	70	60	90	80
D layer	Moss	75	85	85	90	95	40	90	50	100	90	65	70	95
	Lichen	5	1	10	5	1	2	3	2	5	10	5	1	10
SOIL														
Drainage		.....................Semi-percolating.....................								..........Semi-percolating.........				
Hygrotope		..........................Hydric..........................								..........Hydric to semi-hygric.....				
Depth of active layer (cm)		......................Undetermined......................								30	32	25	62	36
CHEMICAL ANALYSIS														
No.of samples		1	1	1	1	1	1		1	1		1	1	2
Organic layer	OM	63.1	49.5	64.6	88.3	84.7	33.0		91.5	54.5		57.2	47.8	68.1
	N%	1.68	1.68	1.96	1.83	1.73	.68		1.3	1.54		1.4	1.33	1.61
	C/N	21.8	17.1	19.1	28.0	28.4	28.1		40.8	20.5		23.7	20.8	24.7
	P ppm	42	16	21	12	31	20		29	13		40	10	41
	Na	.94	.67	.8	.99	1.07	.87		.81	.9		1.05	.69	.74
	K	1.81	.89	1.76	.94	.89	.72		.94	1.27		2.8	1.43	1.81
	Ca	12.8	21.9	36.2	21.7	20.5	15.2		24.3	23.0		19.2	14.1	31.9
	Mg	4.8	2.3	8.3	5.9	3.4	.9		12.0	10.3		6.5	3.8	5.1
	CEC	121.0	53.8	96.0	100.8	127.5	22.7		87.4	103.0		141.0	83.4	88.1
	pH	4.9	5.1	4.9	6.2	4.5	4.6		6.3	5.3		5.2	4.9	5.0
No.of samples					1				1	1			1	
Organic - Mineral layer	OM				24.1				17.3	25.3			17.3	
	N%				.51				.48	.76			.7	
	C/N				27.4				20.9	19.3			14.3	
	P ppm				12				27	6			4	
	Na				.98				.64	.44			.54	
	K				.91				.97	.29			.14	
	Ca				11.1				26.1	9.6			7.6	
	Mg				4.5				6.3	4.4			1.6	
	CEC				38.5				63.5	48.3			29.3	
	pH				6.1				5.8	5.2			4.8	
No.of samples		3	2	3	2	3	3	3	2	1	3	1	3	2
Mineral layer	OM	2.2	7.0	2.6	4.1	0.3	2.2	2.0	8.9	3.2	1.8	8.8	1.1	4.6
	N%	.4	.31	.11	.13	.05	.08	.09	.29	.32	.27	.17	.14	.33
	C/N	7.4	10.7	15.4	16.9	3.0	15.1	9.2	16.8	5.5	4.6	30.0	4.8	7.4
	P ppm	9	3	11	5	4	12	4	15	13	13	11	5	15
	Na	.54	.51	.58	.82	.86	.86	.85	.57	.65	.69	.87	.48	.52
	K	.12	.15	.2	.26	.21	.34	.19	.81	.31	.22	.21	.12	.19
	Ca	3.5	12.6	6.9	3.2	3.5	9.1	2.7	18.6	8.8	7.2	3.7	3.0	7.9
	Mg	1.1	1.2	1.8	1.3	.7	1.7	.6	4.4	1.4	1.7	1.2	.8	3.7
	CEC	13.7	42.8	24.3	13.5	16.0	15.0	10.8	44.1	34.6	33.5	43.7	23.2	24.6
	pH	4.7	5.2	5.0	6.1	4.6	4.7	4.6	5.5	4.9	4.8	4.8	4.7	4.9

Table No. 15 a

		Salicetum pulchrae														
		salicosum pulchrae								betulosum glandulosae						
Number of Plots		1	2	3	4	5	6	7	8	1	2	3	4	5		
Plot No.		105	126	111	165	175	141	182	149	88	129	39	125	119		
Plot size (m^2)		100	100	100	100	100	100	100	100	50	50	50	50	50		
Elevation (ft)		1075	1150	1230	1260	1260	1375	1400	1500	630	1120	1160	1210	1825		
B layer	sub layer														Constancy	Avg. Cover
1 Salix pulchra	1	9.4	?	9.4	8.3	8.3	9.3	9.4	9.4							
Salix pulchra	2	?	9.4	?	?	?	?	?	?	9.4	8.3	7.2	9.4	9.4	V	8.4
2 Betula glandulosa	2	1.1	-	-	-	-	-	-	-	2.1	-	-	-	2.1		
3 Vaccinium uliginosum	2	3.1	-	-	-	-	2.1	-	-	-	7.3	-	-	-		
4 Spiraea beauverdiana	2	4.2	-	-	-	7.2	6.2	-	-	-	-	2.1	2.1	-	II	1.6
5 Alnus crispa	2	-	6.2	-	-	-	-	-	-	2.1	-	-	-	-		
C layer																
6 Equisetum arvense		8.3	7.2	7.3	5.2	-	7.2	5.2	9.2	2.1	5.2	1.1	6.2	-	V	4.7
7 Petasites frigidus		8.3	6.1	6.2	5.2	5.2	7.2	6.2	5.2	-	4.1	-	5.2	1.1	V	4.4
8 Arctagrostis latifolia		4.1	4.1	3.1	-	4.1	-	6.2	-	-	4.1	1.1	2.1	-	IV	2.1
9 Saxifraga punctata		-	2.1	4.1	2.1	1.1	2.1	4.1	2.1	-	1.1	-	-	1.1	IV	1.4
10 Polemonium acutiflorum		1.1	3.1	4.1	3.1	1.1	1.1	3.1	2.1	-	-	-	-	-	IV	1.4
11 Poa arctica		3.1	-	2.1	2.1	2.1	-	2.1	-	+.+	2.1	-	2.1	-	IV	1.2
12 Anemone richardsonii		-	5.2	2.1	2.1	-	5.1	6.2	2.1	-	3.1	-	-	-	III	1.9
13 Rubus chamaemorus		3.1	1.1	-	-	-	4.1	-	-	-	4.1	4.1	3.1	3.1	III	1.7
Betula glandulosa		?	-	-	-	-	-	-	-	?	4.2	3.1	3.1	?	III	1.6
Vaccinium uliginosum		?	-	-	-	3.1	-	-	-	1.1	?	1.1	-	1.1	III	1.4
14 Valeriana capitata		-	2.1	1.1	4.1	-	2.1	-	4.1	-	1.1	-	-	-	III	1.0
15 Pedicularis sudetica		2.1	-	-	-	1.1	-	-	2.1	-	2.1	2.1	2.1	2.1	III	1.0
16 Aconitum delphinifolium		1.1	-	+.+	3.1	-	-	3.1	2.1	-	1.1	2.1	-	-	III	1.0
17 Carex aquatilis		4.1	-	-	-	-	-	-	1.1	3.1	-	5.2	2.2	-	II	1.0
18 Dodecatheon frigidum		-	3.1	-	4.1	-	1.1	-	4.1	-	2.1	-	-	-	II	1.0
19 Linnaea borealis		3.2	-	-	-	6.3	1.1	-	-	-	2.2	2.1	-	-	II	1.0
20 Artemisia arctica		-	1.1	+.+	-	6.2	-	-	-	-	2.1	-	-	-	II	.8
21 Eriophorum angustifolium		-	-	-	-	-	-	-	-	-	-	4.2	3.1	3.2	II	.8
22 Artemisia tilesii		-	2.1	2.1	-	-	3.1	2.1	-	-	-	-	-	-	II	.7
23 Carex lugens		1.1	-	-	-	-	-	-	-	-	-	1.1	-	7.3	II	.7
24 Vaccinium vitis-idaea		2.1	-	-	-	2.1	-	-	-	-	-	2.1	+.+	1.1	II	.7
25 Stellaria monantha		3.1	3.1	+.+	1.1	-	-	-	-	-	-	-	-	-	II	.7
26 Pyrola secunda		2.1	-	-	-	-	+.+	-	-	-	-	2.1	-	-	II	.4
27 Pyrola grandiflora		-	-	-	-	-	-	-	-	1.1	1.1	-	-	2.1	II	.3
28 Carex lachenalii		-	-	+.+	-	2.1	-	1.1	-	-	-	-	-	-	II	.3
29 Stellaria ciliatosepala		-	-	-	-	1.1	-	2.1	1.1	-	-	-	-	-	II	.3
30 Stellaria longipes		-	-	-	-	-	-	-	-	-	2.1	1.1	1.1	-	II	.3
31 Empetrum hermaphroditum		-	-	-	-	1.1	-	-	-	-	2.2	-	+.+	-	II	.3
32 Ranunculus lapponicus		-	-	-	-	-	-	-	-	-	-	2.1	-	4.1	I	.5
33 Ledum decumbens		-	-	-	-	-	-	-	-	-	1.1	4.1	-	-	I	.4
34 Ranunculus nivalis		-	-	1.1	-	-	-	4.1	-	-	-	-	-	-	I	.4
35 Senecio lugens		-	2.1	-	2.1	-	-	-	-	-	-	-	-	-	I	.3
36 Polygonum viviparum		-	-	-	2.1	-	-	-	-	-	-	-	-	1.1	I	.2
37 Viola epipsila		-	-	1.1	-	-	-	2.1	-	-	-	-	-	-	I	.2
38 Saxifraga radiata		-	-	-	1.1	-	-	-	2.1	-	-	-	-	-	I	.2
39 Carex montanensis		-	-	+.+	-	1.1	-	-	-	-	-	-	-	-	I	.1
40 Myosotis alpestris		-	-	+.+	+.+	-	-	-	-	-	-	-	-	-	I	.1
41 Epilobium angustifolium		1.1	-	1.1	-	-	-	-	-	-	-	-	-	-	I	.1
D layer (Bryophytes)																
42 Drepanocladus uncinatus		7.3	5.2	3.1	2.1	7.3	6.2	6.2	+.+	3.1	3.2	+.+	6.2	2.1	V	4.0
43 Hylocomium splendens		3.2	-	-	8.3	4.2	-	-	-	5.2	8.3	-	-	7.3	III	2.7
44 Aulacomnium palustre		4.2	+.+	-	2.1	-	-	-	-	7.3	5.2	5.2	-	6.2	III	2.3
45 Sphagnum girgensohnii		1.1	-	-	-	-	2.1	-	-	-	6.3	5.3	5.2	-	II	1.4
46 Mnium rugicum		-	7.2	2.1	-	-	-	-	-	-	4.2	+.+	-	2.1	II	1.2
47 Bryum pseudotriquetrum		-	3.2	4.1	-	-	1.1	5.2	3.1	-	-	-	-	-	II	1.2
48 Pogonatum alpinum		-	1.1	1.1	-	4.2	2.1	5.2	-	-	1.1	-	-	-	II	1.0
49 Dicranum scoparium		-	1.1	-	-	6.2	2.1	-	1.1	1.1	-	-	-	-	II	.8
50 Calliergon stramineum		-	+.+	-	-	-	1.1	-	1.1	1.1	-	1.1	-	-	II	.4
51 Sphagnum squarrosum		-	-	-	-	-	-	-	-	4.2	-	1.1	-	5.2	I	.8
52 Brachythecium turgidum		1.1	-	8.3	-	-	-	-	-	-	1.1	-	-	-	I	.8
53 Plagiothecium roeseanum		-	3.2	-	-	-	1.1	2.1	-	-	-	-	4.2	-	I	.8
54 Bryum affine		-	-	-	1.1	-	-	-	6.2	2.1	-	-	-	-	I	.7
55 Brachythecium sp.		-	-	-	1.1	-	1.1	-	4.1	-	-	-	-	-	I	.5
56 Sphagnum rubellum		-	-	-	-	-	-	1.1	-	4.2	-	-	-	1.1	I	.5
57 Calliergon cordifolium		-	-	-	-	-	-	5.2	1.1	-	-	-	-	-	I	.5
58 Sphagnum teres		-	-	-	-	-	-	-	-	-	2.2	-	-	4.2	I	.5
59 Tomenthypnum nitens		-	-	-	2.1	-	-	-	-	2.1	-	-	-	+.+	I	.4
60 Sphagnum lenense		-	-	-	-	-	-	-	-	-	1.1	4.2	-	-	I	.4
61 Sphagnum recurvum		-	-	-	-	-	-	1.1	-	-	-	4.2	-	-	I	.4
62 Polytrichum juniperinum		2.1	-	-	-	1.1	-	-	-	1.1	-	-	-	-	I	.3
63 Mnium cinclidioides		-	-	-	+.+	-	-	-	3.1	-	-	-	-	-	I	.3
64 Lophozia ventricosa		-	-	-	-	-	1.1	3.1	-	-	-	-	-	-	I	.3
65 Lophozia sp.		-	-	+.+	-	-	-	-	-	-	-	1.1	-	1.1	I	.2
66 Ceratodon purpureus		-	-	+.+	-	-	-	1.1	1.1	-	-	-	-	-	I	.2
67 Lophozia kunzeana		+.+	-	+.+	-	-	-	-	-	-	-	-	-	-	I	.1
68 Pohlia nutans		-	-	-	-	-	+.+	+.+	-	-	-	-	-	-	I	.1
69 Climacium dendroides		-	1.1	-	-	-	-	-	-	-	1.1	-	-	-	I	.1
(Lichenes)																
70 Peltigera canina		-	1.1	3.1	2.1	-	-	-	2.1	-	4.2	-	-	2.2	III	1.0
71 Peltigera aphthosa		-	-	-	-	2.1	-	-	-	1.1	2.1	1.1	+.+	3.2	III	.8
72 Cetraria pinastri		1.1	-	1.1	2.1	1.1	1.1	2.1	-	1.1	-	-	-	-	III	.7
73 Peltigera spuria		+.+	+.+	+.+	-	-	-	1.1	-	-	-	-	+.+	+.+	III	.5
74 Peltigera scabrosa		2.1	-	-	-	-	1.1	-	-	1.1	-	-	-	2.2	II	.5
75 Parmeliopsis ambigua		-	-	+.+	-	-	-	-	-	-	-	+.+	-	-	I	.1
76 Lecidea sp.		1.1	-	+.+	-	-	-	-	-	-	-	-	-	-	I	.1
TOTAL SPECIES (incl. sporadics)		36	30	36	32	24	30	29	24	27	34	33	21	28		

Sporadic species

C layer

77 Pedicularis lanata 39(+.+)
78 Pedicularis capitata 88(1.1)
79 Pedicularis lapponica 88(+.+)
80 Potentilla palustris 88(1.1)
81 Lycopodium annotinum 105(1.1)
82 Calamagrostis canadensis 111(1.1)
83 Ranunculus pygmaeus 111(+.+)
84 Pedicularis arctica 119(1.1)
85 Polygonum bistorta 119(2.1)
86 Arnica lessingii 125(1.1)
87 Polygonum alaskanum 129(1.1)
88 Rosa acicularis 129(2.1)
89 Anemone parviflora 165(2.1)
90 Cardamine digitata 165(+.+)
91 Delphinium glauca 165(+.+)
92 Ranunculus pedatifidus 165(1.1)
93 Salix richardsonii 165(7.3)
94 Lycopodium selago 175(3.2)

D layer (Bryophytes)

95 Sphagnum inundatum 39(+.+)
96 Lophozia bicuspidata 88(1.1)
97 Dicranum mühlenbeckii 105(2.1)
98 Encalypta rhaptocarpa 105(+.+)
99 Polytrichum commune 105(1.1)
100 Brachythecium albicans 111(1.1)
101 Scapania irrigua 111(+.+)
102 Cinclidium arcticum 125(+.+)
103 Blepharostoma trichophyllum 126(+.+)
104 Lophozia obtusa 126(+.+)
105 Marchantia polymorpha 126(+.+)
106 Nardia scalaris 126(+.+)
107 Aulacomnium turgidum 141(2.2)
108 Cinclidium stygium 141(2.1)
109 Dicranum elongatum 141(1.1)
110 Mnium punctatum 141(2.1)
111 Drepanocladus aduncus 149(2.1)
112 Mnium hymenophyllum 165(+.+)
113 Mnium rostratum 165(2.1)
114 Pleurozium schreberi 165(+.+)
115 Dicranum fuscescens 182(2.1)
116 Lophozia excisa 182(1.1)
117 Plagiothecium curvifolium 182(1.1)

(Lichenes)

118 Cetraria nivalis 39(1.1)
119 Peltigera polydactyla 39(1.1)
120 Cetraria sepincola 88(1.1)
121 Peltigera malacea 88(+.+)
122 Nephroma expallidum 105(1.1)
123 Psoroma hypnorum 105(1.1)

summer one may walk across these creeks without realizing that there are Salix shrubs over 8 ft high under the snow.

Figure 25. Salicetum pulchrae salicetosum pulchrae, drainage pathway bordering lake edge, Canoe Lake. Equisetum arvense and Petasites frigidus dominate the C layer (Photo by Krajina)

The prolonged snow cover in the salicosum pulchrae can, in part, be attributed to the dense canopy which acts as an insulation thereby retarding ground snow melt. Flowering and leafing out by the shrubs generally occurs in late May and early June. The ground surface topography is very irregular, consisting of dips and ridges that are a result of rapid downslope movement of melt water that occurs under the snow during the thaw and after snow has disappeared. The species groupings and soil profiles vary within each habitat and can be related to the meandering surface water that deposits both organic and inorganic materials throughout the site during the annual thaw. Shrub composition, however, remains constant and is little affected by flooding.

Perennially frozen ground was never reached in any soil pit (the deepest was 53 cm). This depth, however, is no indication that permafrost is either absent or present. Krajina (personal communication) stated that frozen ground was recorded close to the surface (20 cm) in one site on the bank at Canoe Lake in 1963. However, it is felt that this could be part of the unthawed active layer or buried ice as the vegetation was sampled in July.

Root penetration is deep in relation to the majority of other associations - up to 46 cm. The Salix pulchra roots are predominantly in the upper 30 cm where they form an extensive network. The water table is normally high in these habitats, although seepage levels depend on degree of slope and extent of area of upper slope being drained by the creek that supports the shrub Salix pulchra. Seepage water is always present within 15-20 cm of the surface even in late August and created a problem in describing and collecting soil profile data.

Scattered low shrubs (between 1/2-2 ft high) associated with Salix pulchra are: Betula glandulosa, Vaccinium uliginosum and Spiraea beauverdiana. The C layer species composition is generally similar to the late snow bed communities with Equisetum arvense and Petasites frigidus having the highest constancy and coverage values. Salix chamissonis was absent from all sampled plots. Typical chionophilous species that are present in the shrub association include Polemonium acutiflorum, Anemone richardsonii, Aconitum delphinifolium, Dodecatheon frigidum, Carex lachenalii and C. montanensis. These species are of rather scattered occurrence usually being present on the higher areas bordering the flood zone. Differential species in the salicosum pulchrae are: Polemonium acutiflorum, Artemisia tilesii, Stellaria monantha, S. ciliatosepala, Carex lachenalii, Ranunculus nivalis and Senecio lugens.

The bryophyte flora is dominated by Drepanocladus uncinatus and Bryum pseudotriquetrum. These, and other minor species, generally form cushions in sheltered positions or on the bases of the Salix pulchra. Corticolous mosses are present in the majority of plots. Peltigera species are the major ground lichens present, all with very low coverage values.

(b) betulosum glandulosae

Dwarf shrub communities (less than 3 ft high) dominated by Salix pulchra are rare in the two study areas. They are never associated with late snow bed communities. This is borne out by the absence of chionophilous vascular species usually found under such conditions. The sampled plots are restricted to both upland and lowland drainage pathways except in one case (plot 88) an exposed lake edge. At Canoe Lake the plots are present at elevations between 1120-1825 ft and at 630 ft at Trout Lake. Slope gradients vary from 0-13° with exposures generally to the southeast. The sites are constantly wet because of free water flowing downslope during the entire summer. The smaller overall height of the shrub Salix pulchra does not necessarily mean that the sites are younger than the salicosum pulchrae. The sampled plots and surrounding areas are almost equally exposed to winds from any direction.

The microrelief in the betulosum glandulosae is similar to that in the salicosum pulchrae. Moss mounds are present, or in the process, of forming. Their growth and development is further related to the movement of the drainage water in the site. The betulosum glandulosae is probably an intermediate stage related to mass movement of slope materials that result in a channelling of drainage water over a particular site. This free flowing water is insufficient to erode the substrate and produce a habitat able to support tall shrubs. Further mass movements cause a change in direction of flow and the pathways dry out. Bordering communities encroach and, in time, replace the low shrub. This is naturally a very slow process.

Duration of snow cover is estimated to be between 9-9 1/2 months, depending on exposure and elevation. The low shrub cover is not effective in retaining snow during the winter and the canopy does not greatly reduce the amount of insolation reaching the ground level. Permafrost was recorded in every sampled plot, although great variations in depth was found (20-62 cm).

The transitional position of this variation is indicated by the presence of only two constants - Betula glandulosa and Salix pulchra. Many broad ranging species are present, not one in more than seventy-five percent of the plots, such as Arctagrostis latifolia, Saxifraga punctata, Vaccinium vitis-idaea, V. uliginosum, Ledum decumbens, Spiraea beauverdiana, Equisetum arvense and Petasites frigidus. Vascular plants generally associated with poorly drained and/or seepage habitats are also present: Alnus crispa, Rubus chamaemorus, Valeriana capitata, Pedicularis sudetica, Carex aquatilis, Eriophorum angustifolium and Pyrola grandiflora.

In the D layer the ground lichens are mainly Peltigera species, while Cetraria pinastri, a corticolous species, is present on the Salix pulchra shrubs. The downslope movement of free flowing melt water restricts the establishment of Sphagnum species to raised areas. These areas are covered by combinations of Sphagnum girgensohnii, S. rubellum and S. lenense. Small wet pockets with limited water movement support Sphagnum squarrosum and S. teres. The major bryophytes that occur in the flood zone are: Drepanocladus uncinatus, Aulacomnium palustre and Mnium rugicum. Around the bases of the shrubs and in sites above the flood zone Hylocomium splendens is abundant.

(c) salicosum richardsonii

Two plots dominated by shrub size (under 6 ft) Salix richardsonii were analyzed at Canoe Lake. Both sites have westerly exposures the gradient in plot 177 is 50°, while in plot 124 only 1°. Snow duration is estimated to be 9 months. Plot 177 could possibly be considered as slightly chionophilous because of the high coverage of Cassiope tetragona. Moisture conditions are considered to be hygric with seepage continuous throughout the summer. Both plots are probably transitional as they have high indices of similarity with plots from different associations. Salix richardsonii has not been recognized by any of the earlier workers in western arctic North America as a dominant shrub due to its rather scattered occurrence. S. richardsonii is not abundant at Canoe Lake(it is absent at Trout Lake), and where present is associated with disturbed sites where seepage is prevalent.

The highest quantity of available calcium in the upper horizon of any soil profile was recorded in plot 124 (75 meq/100 gm). Major species associated with Salix richardsoni in the two sample plots are: Vaccinum uliginosum, V. vitis-idaea, Salix reticulata, Dryas octopetala, Arctagrostis latifolia, Empetrum hermaphroditum, Petasites frigidus, Ledum decumbens, Arctostaphylos alpina and Equisetum scirpoides. In both plots the D layer coverage is over ninety-five percent, with mosses predominant. Species with high coverage values include Tomenthypnum nitens, Hylocomium splendens, Aulacomnium turgidum, A. palustre, Sphagnum rubellum, Dicranum angustum and Ptilidium ciliare. Lichen coverage is not high, only thirty percent in plot 177 and only ten percent in plot 124. The only constant species are Cetraria cucullata, Cladonia amaurocraea and C. mitis.

SOILS

To assist in providing a basic set of information on subalpine arctic soils as well as to determine the edaphic environment of subalpine plants and plant communities soil samples were collected for analysis from a soil pit dug within each community analyzed. From each pit information was collected on thickness and depth of horizons, depth of active layer or later in the season to permafrost, colour, moisture, stoniness and structure. The presence and depth of rooting within each horizon was also determined. Chemical analysis[1] of the soils included pH, organic matter content, total nitrogen, adsorbed phosphorus, cation exchange capacity and exchangeable calcium, magnesium, potassium and sodium. Carbon/Nitrogen (C/N) ratios were calculated from these data. Additionally, the texture of each soil sample was subjectively determined by hand in the laboratory. Pebble sized rocks present in the horizons were collected and determined.

Methods of Soil Sampling, Description and Analysis

The location of the soil pit was determined in relation to the vegetation and topographic features of the community. Pits were dug to either permafrost (the active layer in the early part of the season), water table, coarse ice shattered parent material or bedrock. Generally permafrost can be said to be the limit of root penetration but where the active layer had not thawed no positive determination of depth of rooting could be made.

Soil samples for laboratory analysis were collected from all recognizable horizons. While some horizons were extremely thin or discontinuous, they were taken where possible as they generally tended to be organic inclusions within coarse material. Samples of the litter and fermentation (L and F) horizons were not always collected due to the scarcity and distribution of such material. Samples were air-dried in the Inuvik Research Laboratory, sieved with a U.S.

1. All chemical analyses with the exception of pH were carried out by Mr. B. von Spindler, Department of Soil Science, University of British Columbia.

series No. 10 (2.00mm) sieve and stored in plastic bags.

A total of 498 soil samples were collected and chemically analyzed from the 166 plots studied. These soil samples and profile descriptions represent different as well as similar plant communities within two basically similar geological areas. The topographic positions and exposures were variable as were the elevations of many of the similar plant communities.

Soil pH was determined electrometrically, utilizing a Beckman Model N pH meter, on samples mixed to a paste consistency. Percent organic matter was determined using the Walkerly-Black wet combustion ($K_2Cr_2O_7$ oxidation) method as adapted by the Department of Soil Science, University of British Columbia. For total nitrogen a macro-Kjeldal method for soil (NH_3 distilled in boric acid, titrated with sulphuric acid) was used. C/N ratios were calculated from these data on the accepted assumption that organic matter contains 58 percent carbon (Jackson, 1958). Adsorbed or available phosphorus (Metson, 1961) was determined colourimetrically using the dilute acid-fluoride extraction method (method 1) of Bray and Kurtz (1945) as adapted by the Department of Soil Science, University of British Columbia.

Exchangeable cations (Ca,Na,K and Mg) were extracted from the soil with 1N ammonium acetate (pH7) and concentrations of the four cations were determined on a Perkin-Elmer flame photometer as adapted by the Department of Soil Science, U.B.C.

Cation exchange capacity (CEC) was determined using the leached soil after washing with ethyl alcohol, and then distillation of ammonia into boric acid and titration with dilute sulphuric acid. Percent base saturation can then be determined by expressing the exchangeable cations (Ca,Na,K and Mg) as a percentage of the cation exchange capacity.

Soil Chemical Characteristics

Summarized results of the chemical analyses were obtained by averaging values for the organic, organic-mineral and mineral horizons in all 166 plots for each of the identified soil classes (Table 16). This system is used in place of the conventional horizon designations because the profiles show considerable variation[1]. Local factors, such as the complex pattern and effects of ground ice and the amount and character of organic material at the surface leave their marks on the profile morphology. In addition, profile characteristics vary in relation to parent material, relief and time. Great variations cannot be expected because of the lack of variation in parent material. Relief is more important as it relates to drainage and degree of moisture retained in individual habitats. Previous arctic soil studies have given more stress to physical than chemical properties, consequently few comparisons can be made. Where such comparisons are possible, the one outstanding difference is always in percent organic matter. Except in cases of raw soils the percent organic matter in the surface horizons in the present study are very high compared to earlier presented data (Douglas and Tedrow, 1959, 1960, Hill and Tedrow, 1961, and Tedrow and Hill, 1955).

Organic matter content is high in the surface horizons of all soils with the exception of the Oligotrophic Gyttja, Snow Basin Rutmark and the Arctic Rawmark classes. In all cases there is a rapid decrease with depth. The thickness of the organic layer is an important feature of all the poorly or non-drained soils where it ranges from raw residues to fibrous disintegrated material. Where an organic-mineral layer is indicated, it generally suggests buried decomposed or undecomposed organic matter intermingled with mineral matter. This buried layer when present in classes other than the Arctic Brown is indicative of alluvial deposition or soil movement within the profile due to intensive frost action. While some of the buried organic matter may be associated with downslope movement (solifluction) or congeliturbation (MacKay, 1958),

1. The organic, organic-mineral and mineral data for individual plots is presented in tabular form with the vegetation data in the chapter describing the vegetational units.

Table 16

Summary of soil chemical analyses of the organic,organic - mineral and mineral horizons. Averaged for each of the major divisions.

Association		A.f.	E.a.		C.a.		E.s.	C.r.	S.p.		S.c.	S.ps.	B.- C.		B.- E.v.		V.- B.g.		B.- L.d.		L.- D.a.		S.ph.
Subassociation/Variation			e.a.	s.p.	c.a.	s.a.			b.g.	s.p.			b.- c.	a.c.	e.v.	s.r.	*(a)	*(b)	b.- l.	c.t.	d- s.r	d.a.	
Organic layer	Organic matter (%)		55.8	63.1	70.3	87.1	81.3	91.3	56.9	67.8	72.9		71.8	79.8	74.5	51.6	54.8	63.8	55.0	60.7	71.5		
	Nitrogen (%)		1.26	1.11	1.36	1.28	1.55	1.37	1.47	1.55	1.3		1.13	1.29	1.2	1.34	1.13	1.35	1.1	1.16	1.53		
	C/N ratio		27.5	39.8	30.9	41.7	35.3	39.9	22.4	26.2	33.8		40.0	37.5	38.4	24.3	29.3	27.2	29.3	31.9	30.0		
	Adsorbed P (ppm)		21	11	13	13	12	19	26	24	24		13	24	15	11	23	30	24	24	21		
	Na^+) Exchangeable cations		.75	.85	1.01	1.35	.78	1.49	.84	.88	1.02		.91	.87	.9	.8	.68	.77	.71	.79	.99		
	K^+)		1.34	.52	.47	.68	.31	.84	1.83	1.13	1.09		.77	.94	.8	.56	1.25	1.17	.74	.95	.96		
	Ca^{++})		15.8	8.6	10.5	19.7	10.5	21.4	22.1	21.3	20.1		17.2	21.6	13.2	27.7	16.9	18.0	6.7	13.5	30.6		
	Mg^{++})		7.6	2.0	3.2	3.6	1.5	5.5	6.4	5.4	6.4		4.4	5.0	3.4	10.9	5.8	5.7	1.9	3.3	8.0		
	CEC (meq)		62.4	95.1	72.4	126.4	123.3	117.7	103.8	87.0	96.6		121.6	107.8	121.6	115.6	100.4	133.6	82.9	101.9	102.4		
	pH		5.5	4.7	4.4	4.4	4.4	4.4	5.1	5.2	5.0		4.4	4.4	4.4	6.1	4.8	4.6	4.0	4.2	6.2		
Organic - Mineral layer	OM	3.7	19.9	17.1	27.3		22.1		21.3	20.7	18.5	25.6	32.8	17.5	24.7		18.5	18.0	19.5	23.8	22.8	14.9	2.9
	N(%)	.14	.3	.34	.89		.38		.73	.49	.49	.75	1.08	.62	.61		.43	.59	.32	.66	.72	.38	.1
	C/N	20.0	18.7	39.5	20.3		53.2		16.8	24.1	22.6	20.5	18.6	16.4	31.1		29.4	18.1	18.8	22.6	18.1	42.3	17.1
	P ppm	12	12	7	13		8		5	19	16	25	10	16	6		8	5	11	16	14	18	7
	Na	.73	.65	.66	.73		.54		.49	.81	1.01	.46	1.01	.55	.71		.51	.5	.69	.68	.65	.66	.76
	K	.17	.1	.43	.19		.05		.21	.94	.77	.67	.34	.25	.3		.41	.2	.36	.47	.44	.62	.17
	Ca	4.8	3.1	4.0	7.2		6.3		8.6	18.6	11.9	10.9	11.1	10.9	6.9		9.4	12.1	2.3	8.5	18.4	11.0	.12
	Mg	.6	.92	1.4	1.5		.6		3.0	5.4	1.5	3.2	1.8	2.5	2.0		2.5	3.6	.6	1.6	2.4	2.9	.3
	CEC	15.2	49.5	61.7	42.7		60.8		38.8	51.0	46.3	42.6	56.0	29.3	58.1		37.8	55.1	39.7	58.1	56.6	40.2	20.4
	pH	5.1	4.6	4.7	4.4		4.6		5.0	5.9	4.8	5.3	4.3	4.4	4.5		4.8	5.2	3.9	4.2	6.1	5.8	4.7
Mineral layer	OM	1.2	3.2		7.9	1.3		2.8	3.9	3.7	3.0	3.2	4.7	7.6	2.4		3.8	5.1	3.6	3.7	3.3	2.3	0.9
	N(%)	.12	.49		.21	.07		.17	.25	.18	.12	.21	.19	.26	.1		.19	.15	.13	.14	.12	.12	.6
	C/N	6.2	8.7		23.6	10.8		9.6	10.4	11.8	12.2	8.2	11.3	15.9	13.1		12.8	22.1	16.8	14.8	22.4	15.4	8.8
	P ppm	5	7		14	7		12	11	8	7	8	9	14	5		6	6	10	9	8	8	8
	Na	.85	.64		.51	.71		.74	.64	.7	.78	.58	.54	.81	.78		.54	.58	.71	.72	.71	.69	.81
	K	.26	.18		.17	.3		.18	.21	.28	.5	.21	.2	.49	.16		.25	.28	.2	.2	.35	.16	.11
	Ca	3.0	4.8		5.2	6.1		3.6	6.1	7.5	9.8	7.5	5.4	8.7	6.3		5.3	5.1	1.2	4.5	9.1	1.9	.8
	Mg	.5	1.0		1.1	1.0		1.3	1.8	1.6	2.0	1.6	.65	1.4	1.0		1.6	1.6	.2	.7	2.5	.4	.1
	CEC	20.7	20.2		37.8	32.4		36.1	31.9	22.5	24.3	21.1	27.2	24.8	19.9		25.6	34.5	30.0	27.8	24.2	11.7	12.2
	pH	4.5	4.6		5.0	4.4		4.0	4.8	5.1	5.3	5.3	5.0	4.7	4.7		4.7	4.6	4.5	4.7	6.5	4.8	4.9

*(a) vaccinio -betulosum glandulosae (fruticulosum) *(b) vaccinio - betulosum glandulosae (fruticosum)

to follow page 95

concentrations at greater depths have been attributed to periods when the local climate was warmer than that of the present day (Douglas and Tedrow, 1960).

Total nitrogen is high in the majority of organic horizons and very low in the mineral soil following closely the pattern for organic matter. The highest total nitrogen averages are recorded in the surface horizon of the Arctic Brown soils. In the organic horizons the C/N ratio is wide, ranging from 23.0 to 41.4 and in the mineral horizons from 5.0 to 39.0. Holowaychuk et al. (1966) report that the content of nitrogen relative to carbon is lower in Bog and Half-Bog soils and increases with advanced decomposition in western Alaska, this does not appear to be the case with these subalpine soils. At increased depths high C/N ratios and low nitrogen content indicate buried organic matter with little or no decomposition taking place due to poor aeration, low temperatures and high moisture content. This is especially so in the poorly drained soils. Soil bacterial activity is very slow and is one of the major reasons for the low amounts of available nitrogen present in the soil just below the surface, consequently nitrates are deficient in many soils of the Arctic. De and Sarker, as reported by McNamara (1964) have shown that denitrification occurs in waterlogged soils.

The highest values of adsorbed phosphorus are found in the Arctic Brown soils (21-35 ppm). Greatest concentrations are present in the organic layers of all soils with an appreciable decrease in the organic - mineral and mineral horizons. Soil reaction in the majority of soils is moderately to strongly acid. There is generally little variation with depth. In the Arctic Brown soils this is due to the close proximity of non-calcareous parent material to the surface. Only in the case of the Lupino - Dryadetum *alaskensis dryado - salicetosum reticulatae - glaucae associated with the Arctic Brown shallow phase is there a general decrease (pH 6.1 - 6.7).

Exchangeable cations (Ca,Na,K and Mg) are present in greatest quantities in the organic horizon and decrease with depth. Calcium is the dominant basic cation followed by magnesium,potassium and sodium in the surface horizon. The high values of exchangeable potassium and magnesium in the surface horizon appears related to the high organic matter content and greater cation exchange capacity. In the mineral soils sodium is usually present in greater quantities than potassium. An interesting factor revealed in the analyses is the high amount of exchangeable calcium (average 30.9 meq/100 gm) in the dryado - salicetosum reticulatae - glaucae when little calcareous parent material was found in the two study areas. This subassociation, however, is generally associated with highly calcareous soils in Europe. McNamara (1964) has pointed out that errors can easily be made in determining amounts of exchangeable cations because moisture conditions are so variable during the short active season.

Cation exchange capacity (CEC) values vary between horizons and profiles because of differences in organic matter content. However, in the surface horizons they are generally very high, while base saturation is low. With increased depth C.E.C. values decrease and base saturation increases. The high C.E.C. values of the surface horizons indicate that the exchange complex is largely saturated with hydrogen (H+) resulting in the moderately to strongly acid condition.

The above results appear to indicate general agreement with those of earlier workers with regard to soil development. A problem arises in determining the true chemical status of these soils because of changing moisture conditions during the period of vegetation sampling. Few generalizations may be made from the data regarding the soils of this region of the Subalpine/ Foothill Zone. They include; cation exchange capacity decreases with depth; exchangeable calcium is higher in the surface horizons where, after initial waterlogging, a considerable degree of drying occurs; pH values are low and increase slightly with depth on the upper slopes while in the wetlands there is little variation; organic matter content drops rapidly with depth; where high amounts of exchangeable cations are present in the mineral soil they are usually tied up in clay lattices and are, therefore, unavailable to the plants.

Parent Material and Rock Identification[1]

Pebble sized rocks collected in soil samples at Canoe Lake and Trout Lake can be divided into two distinct groups: those that are angular to sub-angular and are derived locally, and the rounded to sub-rounded that have been carried in from a distant source.

In the Canoe Lake area the locally derived rocks are classed as ferruginous and sometimes argillaceous quartz sandstones which in some instances grade into quartzose subgreywackes with the addition of lithic fragments and mica. The rocks are characterized by an overall buff colour with their reddish-brown coloured layers present in a randomly parallel distribution. The fragments tend to have a tabular shape with the cleavage coincident with the deeper coloured layers. In its present condition the rock is non-resistant and in some cases friable, in addition it is generally quite porous and permeable. The individual quartz grains, which comprise up to 80 percent of the rock, are cemented by the clays and iron oxides present. These grains are well sorted and generally sub-rounded. Deposition of the source rocks is considered to have occurred under relatively stable marine conditions during the Upper Jurassic.

Rocks derived from a distant source include light coloured quartzites, darker micaceous quartzites, grey to black cherts with minor occurrences of greywacke, opal and volcanics. These pebbles are approximately equidimensional and generally rounded to well rounded. A brachiopod fossil was present in one of the chert fragments. The source of these rocks is unknown, however, grey and black cherts and quartzites have been reported to occur in the Cambrian and

1. Rock samples were identified by Mr. R. MacDonald, Department of Geology, University of British Columbia, and the following description is based on that information.

and Ordivician rocks that outcrop to the south.

Samples from Trout Lake may be similarly divided into two distinct groups as above. Rocks derived from a distant source are the same as those in the Canoe Lake sample i.e. quartzites and grey and black cherts. The quartzose sandstones which appear to dominate the Canoe Lake sample are absent in the Trout Lake area.

Locally derived rocks are classed as greywackes, greywacke siltstones and shales. The greywacke and greywacke siltstones are generally dark grey to black in colour, fairly resistant, permeable and with an equidimensional to tabular shape. Their local derivation is indicated by their angularity, however, many have undergone some movement probably by stream action. The grain size ranges from medium sand to silt. A light iron oxide stain is sometimes present, but cementation is probably due to clay minerals. The rocks of the area have been fractured and the fractures filled with crystalline quartz. The source of this silica could be either igneous or from solution within the sediments, but it is considered to be the latter. Present in the soil profiles were several pieces of crystalline quartz derived from locally wider veins.

The shale fragments are thought to have the same mineral composition as the greywacke siltstones but with a much smaller average particle diameter. A stratigraphic section across the study area would probably show a gradation from greywackes and greywacke siltstones to shales. The shale fragments are tabular and angular. This, coupled with their low resistance, indicates little or no transport. These types of sediment are much less mature than the quartzose sandstones. The environment of deposition was probably marine in a techonically active area where high rates of erosion and deposition existed.

CLASSIFICATION AND DESCRIPTION OF THE SOILS

The lack of knowledge of Canadian Arctic soils makes it necessary to follow designations prescribed by other qualified workers from other areas. An arctic soil classification has been proposed by Tedrow et al. (1958) and Tedrow and Cantlon (1958) in which the soil profiles are arranged in a drainage sequence, the Arctic Brown representing the mature well drained soil of the region. With restricted drainage gleization occurs immediately above the permafrost table. Complete saturation of the profile gives rise to a very high permafrost table and organic matter accumulates leading to bog formation. In grading from Arctic Brown to shallow well drained conditions there is no change in the type of soil-forming process, but only a reduction in profile thickness. A point is reached where there are no acquired soil features as those associated with Lithosols. The classification of Arctic Alaskan soils by Tedrow and his co-workers covers only those associated with chionophobous plant communities, for those associated with chionophilous vegetation Kubiena's Soils of Europe has been a major source of information.

Soil profiles from 166 plots were described in detail in the field and samples taken for chemical analysis. The following descriptions summarize these data and are used to indicate particular morphological and development characteristics of the soil types into which individual profiles have been placed. Nine major classes of soil are recognized for this region of the Arctic Subalpine Zone and these classes represent twelve different soil types. In the following description soils are described as closely resembling types derived from Kubiena (1953) in Europe and similar to those designated by Tedrow et al. (1958) in Alaska where applicable. In Table 17 a provisional classification using nomenclature proposed by the above workers is presented for the soils.

to follow page 100

TABLE 17

Provisional Soil Classification for the Low Arctic Subalpine/Foothill Zone

I. Sub-Aquatic Soils	
(A) Sub-Aquatic not peat forming	
(a) Oliogotrophic Gyttja	(Arctophiletum fulvae)
(B) Sub-Aquatic peat forming	
(a) Carex Fen	(Caricetum aquatilis)
(b) Low-Centered Polygon Mire	
(i) Brown Moss	(Eriophoretum scheuchzeri)
(ii) Peat Moss	(Caricetum rariflorae)
II. Semi-Terrestrial (Groundwater) Soils	
(A) Semi-Terrestrial Raw Soils	
(a) Snow Basin Rutmark	(Salicetum pseudopolaris)
(B) Anmoor-like Soils	
(a) Snow Basin Anmoor	(Salicetum chamissonis)
(b) Tundra Anmoor	(Salicetum pulchrae)
(C) Semi-Terrestrial Peat Soils	
(a) Tundra Moss	(Betulo - Chamaemoretum and Betulo Eriophoretum vaginati)
(b) Peat Anmoor	(Eriophoretum angustifolii)
III. Terrestrial (Land) Soils	
(A) Terrestrial Raw Soils	
(a) Arctic Rawmark	(Salicetum phlebophyllae and Lupino Dryadetum *alaskensis depauperatum
(B) Ranker-like Soils	
(a) Tundra Ranker	(Betulo - Ledetum decumbentis cassiopeetosum tetragonae)
(C) Rendzina Soils	
(a) Arctic Brown shallow phase	(Lupino - Dryadetum *alaskensis)
(D) Brown Earths	
(a) Arctic Brown normal phase	(Vaccinio - Betuletum glandulosae and Betulo - Ledetum decumbentis)

1 Sub-Aquatic Soils (Kubiena, 1953)

Soils always covered with water either peat forming or not. Characterized by simple profile structure.

(A) Sub-Aquatic not peat forming (Kubiena, 1953)

Always characterized by a very simple profile structure in which the B horizons are lacking. Profile development limited to (A)C,AC or AG. Mull humus is completely lacking in this soil.

(a) Oligotrophic Gyttja (Kubiena, 1953) Regosol (Tedrow et al., (1958)

Low in nutrients, generally with shallow horizons in acid immature waters, low in electrolytes.

Four profiles were studied under this category and all belonged to the Arctophiletum fulvae. Sites are present at Canoe Lake and Divided Lake and have a snow free period of 3-4 months. Profiles are limited to an (A)C. In plots 116 and 171 surface horizons are sandy-loam overlying thick clay horizons, and in plots 159 and 160 surface horizons consisted mainly of clay. Due to low plant growth in the shallow waters there is a low supply of plant material, therefore, low humus production. There is relatively strong oxidation and little reduction. Percent organic matter is very low, being no greater than 4.6 percent in the surface horizon (plot 171). The structure in all profiles is loose, running easily through one's fingers when wet. The pH of both soil and water is (moderately) to strongly acid. Perennially frozen ground was never reached in any of the plots. At Canoe Lake a compact bed of pebbles was encountered below the C horizon in both soil pits.

(B) Sub-Aquatic peat forming (Kubiena, 1953)

Characterized by a strong accumulation of little decomposed plant remains due to low humification. Buried peat layers well preserved owing to prolonged inertness of the environment are either parent material for new soil formation or mere substrate.

(a) Carex Fen (Kubiena, 1953) Bog (Tedrow et al., 1958)

Soils formed under stagnant freshwater with peat humus form, composed primarily of culms, leaves, rhizomes and roots of sedges.

In the two study areas the Carex Fen soil studied occurs in the Caricetum aquatilis in old lake beds and drainage pathways at lower elevations. Snow free period is estimated to be 3 1/2 months. The habitats are characterized by a cool summer microclimate with a wide range in diurnal temperatures and a close plant cover. The soils are waterlogged throughout the summer with surface water resulting primarily from snow melt. Gravitational water is present only in the old drainage pathways.

The upper peat layer is composed of recognizable plant remains derived from, in part, the existing vegetation. In thickness, it varies from 12-35 cm. The underlying material is less fibrous and approaches a muck-like condition. The mineral horizons are composed mainly of silt and clay combinations with a low percent or organic matter. Aeration is very poor due to the super-saturated condition of the peat and the low temperatures that prevail at all times during the summer. No glei horizon is discernible due to the high water table. What gleization there is can probably be found in the upper part of the permafrost. Oxidizing conditions do prevail later in the summer as the water table slowly recedes. This results in a yellowing of the old root channels and other openings where access to oxygen is afforded (Lutz and Chandler, 1965).

Available exchangeable cations are low in these Carex Fen soils because of the slow rate of decomposition of plant materials due to low temperatures and are, therefore, considered as oligotrophic. Values are highest in the upper peat layer and decrease with depth following approximate changes in percent organic matter. Cation exchange capacity of the soil is generally high and base saturation low and are indicative of the strongly acid reaction in all horizons. Depth to permafrost appears relatively consistent for all sampled plots of this soil type, between 29-40 cm. Although Sphagnum mounds give the impression later in the summer, with drying out, of being similar to the Half-Bog sites the level of permafrost appears constant and has no undulations.

(b) Low-Centered Polygon Mire   Half-Bog (Tedrow et al., 1958)

Soil formation peat forming characterized by a simple profile structure and considered oligotrophic - permesotrophic.

Soils in this category are not discussed by Kubiena (1953). They are unique to arctic regions because they develop as a result of impeded drainage, intensive frost action and a high permafrost table. Wetness of the ground is maintained by melting snow and to a slight degree gravitational water which results in a high water-table. The water-table in the Mire soils recedes more rapidly than that in the Carex Fen so that moisture conditions are more hygric than hydric. Two variations are distinguished (Krajina, 1967, personal communication) the early stage or Brown Moss type and the later Peat Moss type.

i) Brown Moss

Soils in the Brown Moss variation are commonly associated with the Eriophotetum scheuchzeri and are restricted to early stage development in low-centered polygons. The moss layer in the early stages of development is dominated by Drepanocladus exannulatus and D. aduncus with Sphagnum species becoming established as the surface water disappears. The type of topography associated with the Brown Moss is not common in the Subalpine/Foothill Zone due to the irregular relief. Drainage is virtually non-existent and surface water is present throughout the summer. The waterlogged condition prevents much organic decomposition and organic matter (mosses and sedges) tends to accumulate. Tedrow et al. (1958) have pointed out a feature of these soils is the presence of a black organic colour immediately above the permafrost, this feature was noted in plot 94. Organic accumulations are always greater than 22 cm and up to 48 cm in thickness. In plot 53 an underlying mineral horizon of high clay content is present above and included in the perennially frozen layer.

Chemical analyses show that where there are variations within the profile these follow approximate changes in organic matter. Cation exchange capacity is higher in the surface horizons and decreases gradually with depth. Exchangeable cations, dominated by calcium, were low throughout the profiles. Percent nitrogen and C/N ratios are high and reflect the slow rate of decomposition in these soils. Soil pH is strongly acid with little variation with depth. In more advanced stages of the Eriophoretum scheuchzeri soil conditions approach the Peat Moss type.

ii) Peat Moss

Sites considered as transitional between low-centered and high-centered polygon topography are dominated by Caricetum rariflorae. The Peat Moss soil is not well represented in either of the two study areas for reasons similar to those given for the Brown Moss soil. Water-logging is still characteristic of these sites, however, the development of micro-relief features allows for improved drainage and drier conditions within Sphagnum dominated mounds. Woody species are present in increasing numbers on these mounds and reflect the semi-terrestrial condition of the raised micro-relief. Frost action plays a vital role in producing the characteristic micro-relief features associated with these habitats.

Aeration is improved and organic matter decomposition and humification is more active in the Caricetum rariflorae due to the more hygric conditions. Surface water is never present in these sites after mid-August. Exchangeable cations, especially calcium, are available in greater quantities and C/N and percent nitrogen values are lower than in the Brown Moss and indicate the more active condition of this soil type. Cation exchange capacity is high throughout the profiles. Soil reaction is still strongly acid with little variation in depth. Permafrost is close to the surface and, in many cases, included part of the organic layer in its upper surface.

II. Semi-Terrestrial (Groundwater) Soils (Kubiena, 1953)

Not or temporarily covered by water, however, completely or partially waterlogged. Major source of parent material for humus formation derived from higher plants.

(A) Semi-Terrestrial Raw Soils (Kubiena, 1953)

Soils low in humus, but with a slight to strong gleization. The soils are waterlogged when free of snow or surface water.

(a) Snow Basin Rutmark (Kubiena, 1953) (Figure 26)

Little gleyed alluvial soil of the high mountains and arctic regions associated with very late snow. Periods of vegetational activity restricted to 2-6 weeks. Plant coverage is always sparse and never closed.

Only five plots were studied and they occurred in the Salicetum pseudopolaris. All sites are in sheltered areas with deep snow accumulation and only on south to east facing slopes. The soil is covered by snow 10 1/2 - 11 1/2 months of every year. During snow melt the soil adsorbs large quantities of melt water and is temporarily waterlogged. Soil surface materials are constantly moving downslope due to snow creep in summer and erosion by the many rivulets crossing the exposed soil surface after snow melt. Precipitation, in the form of rain during the summer generally has little effect on these sites other than compacting the snow.

A very weak surface (A) horizon is present, however, its development is limited to a darkening of the upper 3-5 cm of surface soil. The darkening is primarily a result of fine organic matter deposition on the snow and its infiltration into the soil following snow melt. Underneath is either a slightly gleyed or ungleyed generally grey-brown coloured (C) horizon. Percent organic matter varies considerably, ranging from a low of 4.8 to a high of 61.7. This latter site closely resembles the Salicetum chamissonis. Cation exchange capacity is low as are the exchangeable cations (Ca,Mg,K and Na). Soil pH is strongly acid in the surface horizon and increases with depth, becoming moderately acid. Permafrost was never reached in any soil pit, due to the solid mass of packed unconsolidated parent material encountered every time at depths from 21 - 75 cm.

Figure 26. Snow Basin Rutmark soil (Kubiena, 1953) associated with the Salicetum pseudopolaris. The upper (A) horizon is distinguished by a darkening of the surface soil. The relatively deep C horizon is light coloured and shows evidence of gleying. (Photo by Krajina)

(B) Anmoor-like Soils (Kubiena, 1953)

Soils with a distinct humus horizon or, failing that, at least with a distinctly developed B horizon, strongly gleyed, under the influence of impeded water due to low permeability of the soil. Soils waterlogged for long periods of the year. Gyttja-like humus has characteristic 'inky' smell.

(a) Snow Basin Anmoor (Kubiena, 1953) (Figure 27)

Soils occurring in sheltered depressions and cut banks, covered by snow for most of the year. Prior to, and after, snow removal soils are temporarily waterlogged, after which the soils exhibit a certain moistness but no waterlogging. Sites characterized by prostrate willows and herbaceous plants of alpine meadows.

Snow Basin Anmoor soils occur only in the Salicetum chamissonis in sheltered areas along creek banks and lake shores at elevations between 1060-1800 ft and always with easterly to southerly exposures. Snow free period is estimated to be between 2-6 weeks. All sites are characterized by luxuriant plant growth during the short snow free period. Soils are generally fine-textured and stratified by sedimentation from wind-blown materials on adjacent exposed ridges and escarpments. Profile development is characteristically A-B-C. The dark grey humus horizon varies between 3-8 cm in depth and overlies several gley horizons that are mainly blue-grey in colour with numerous rust specks. Texture of the B horizon is mainly silty loam with varying amounts of fine rock debris. Root penetration is between 25-56 cm becoming sparse at lower depths.

Figure 27. Snow Basin Anmoor soil (Kubiena, 1953) associated with the Salicetum chamissonis. The dark grey humus horizon is evident in the upper right hand corner. The gley horizons are clearly distinguished. Root penetration is to approx. 30 cm. (Photo by Lambert)

Chemical analyses indicate a high percentage of organic matter in the A horizon (between 48-87 percent) in all plots except plot 143. Cation exchange capacity and percent base saturation are both high. Values for the basic cations (Ca,Mg,K and Na) are high in the surface horizon and as the pH is generally moderately acid it must be implied that a certain percentage must be available as a free source. Lower quantities, but still high, in the B horizon suggest the basic cations are mostly unavailable and probably fixed between silty-clay lattices. The soil edaphotope is considered to be mesotrophic to permesotrophic. Soil reaction is variable. If the surface horizon is strongly acid there is a decrease with depth and if it is moderately acid then it always appears to increase in acidity with depth. In the latter case it would suggest that waterlogging by the ground water causes leaching. Perennially frozen ground was never reached in any of the fifteen soil pits that ranged in depth from 40-70 cm.

In the low lying snow bed habitats in the Canoe Lake and Divided Lake region the anmoor character of the soil is lost. The vegetation is dominated not by Salix chamissonis, but by such species as Equisetum arvense (plots 148 and 170), Festuca altaica (plot 162), Carex montanensis (plot 145) and Arctagrostis latifolia (plot 157). In these sites the humus approaches a mull-like moder form (Mull-Gley Soil, Kubiena 1953). The soils are always moist and never, or only temporarily, waterlogged. The texture of the (G) gley horizon is usually loamy and clayey.

(b) Tundra Anmoor (Kubiena, 1953)

Waterlogged soil of shrub dominated drainage pathways. Characterized by a muddy dystrophic anmoor formation and a very thick active layer.

Soils in this category are associated with the slightly chionophilous shrub Salicetum pulchrae which is present in drainage pathways and on lake edges at elevations ranging from 1075-1825 ft. The majority of the sites are on gradients of 5-15° with easterly or southerly exposures. Snow accumulation is great with a snow free period of 6-10 weeks. Shrub growth is in excess of six feet with herbaceous vascular plants dominating the C layer. The moss layer (D) is conspicuous by the absence of Sphagnum species and can probably be related to the free flowing drainage water present throughout most of the summer, especially at lower elevations. This drainage water deposits both organic and inorganic materials throughout the habitats during the high water or flood period.

Profiles are variable because of the annual deposition of materials. The organic horizon is generally thin (3-10 cm thick) and blackish in colour with a pH range from 4.9 to 5.5. In two plots (149 and 165) the pH was 6.2 Underlying the A horizon are usually one or more brown coloured gley horizons that are predominantly clay-loam to clay-like in texture. The plots have a high water table due to continual seepage. Aeration in the profiles is mostly very poor. Salix pulchra leaves and other plant materials that accumulate on the ground during the autumn are packed down by snow in winter, at which time little or no decomposition occurs. The following spring, if flood waters do not remove the compressed organic debris, alluvial materials are deposited over them and further breakdown is prevented. It is, therefore, not uncommon to find undecomposed plant remains in the gley horizons. In the soil profile in plot 141 the organic horizon is overlain by a clay-loam horizon 3 cm thick.

(C) Semi-Terrestrial Peat Soils (Kubiena, 1953)

Surface layer of well developed peat. Sites poorly drained and waterlogged in early part of summer.

(a) Tundra Moss (Kubiena, 1953) Meadow Tundra (Tedrow et al., 1958) (Figure 28)

Soil characteristic of hummocky slopes that are strongly affected by intensive frost action. Permafrost surface uneven but generally close to the ground surface.

Relatively high C/N ratios are found in the gley horizons with correspondingly low total nitrogen values. Cation exchange capacity and the major exchangeable cations (Ca,Mg,K and Na) are generally high in the organic layer and suggest a free source is made available by alluvial deposition. All values decrease rapidly in the gley horizons, but where a high quantity is recorded it is probably not accessible to the plant roots or tied up in the clay lattice and not in an available form. Soil reaction remains available but fairly constant throughout each profile and is moderately to strongly acid. This would suggest that the pH is controlled by the groundwater.

Two associations (Betulo - Eriophoretum vaginati and Betulo - Chamaemoretum) are associated with the soil of this category and both occur at lower elevations - below 1500 ft. Slope gradients vary but are generally moderate to shallow. Drainage is, therefore, poor and the soils waterlogged (hydric) during and just after snow melt, becoming hygric during the summer. A hummock-depression microrelief is common in both associations, however, it is more pronounced in the Betulo - Eriophoretum vaginati. The snow free period varies from between 10-12 weeks depending on the depth of the depression.

The profiles are characterized by the presence of moss (mainly _Sphagnum_) overlying one or more compact layers of raw humus or old moss. The upper moss layer retains large quantities of moisture and acts as an insulation and prevents deep thawing. Consequently, the perennially frozen ground is always close to the surface. The active layer, however, is deeper under the hummocks and/or _Eriophorum vaginatum_ tussocks than in the depressions. Below the organic horizons there are usually one or more discernible gley horizons depending on the position of the permafrost. Soil texture is variable depending on the degree of soil movement (congeliturbation). In the Betulo - Chamaemoretum the mineral soil is mainly silty-loam, and in the Betulo - Eriophoretum vaginati it is silty-clay or silty-loam.

Figure 28. Tundra Moss soil (Kubiena, 1953), Meadow Tundra (Tedrow et al. 1958) associated with the Betulo - Chamaemoretum. Surface layer of living Sphagnum overlying raw humus or old Sphagnum. Depth to permafrost 27 cm. Sampled August 4/65. (Photo by Krajina)

Biologically the soils are inert. The unfavourable conditions such as the presence of permafrost close to the surface, long snow duration, persistent waterlogging, frost action and wind help to favour low aeration, acidification and a lack of nutrients and bases. The chemical analyses clearly indicate the high cation exchange capacity and low base saturation. Exchangeable cations, dominated by calcium, are low in the surface horizons and decrease with depth. In the Betulo - Chamaemoretum exchangeable cations are higher in the surface horizon and this is related to the increase in leaching by the free flowing drainage water passing over the ground surface of the alnetosum crispae from the upper slopes in the early part of the summer. Total nitrogen, although low in the mineral horizons, is high in the organic horizon (average 1.16

percent). C/N ratios are high in the surface horizons and are a good indication of the slow rate of decomposition in these Tundra Moss soils. A C/N ratio of 102.0, the highest present in the organic horizon, occurred in plot 54 and consisted of light brown fibrous peat. Douglas and Tedrow (1959) in studies on rates of organic matter decomposition in arctic soils concluded that while they were slow they are influenced more by temperature than moisture content. Soil reaction is strongly to very strongly acid in the majority of the profiles, however, the pH does increase with depth. The soil edaphotope is considered to be suboligotrophic to submesotrophic.

In the Betulo - Eriophoretum vaginati saliĉetosum reticulatae present at higher elevations, profile morphology is similar to those at lower elevations. However, as is pointed out in the vegetation synthesis, these sites are bordered by more calcareous communities (Lupino - Dryadetum *alaskensis). Drainage water from these calcareous slopes flowing into the saliĉetosum reticulatae are retained and are probably an important source for basic cations. The cation exchange capacity is high as is also base saturation (over 50 percent). Exchangeable cations (Ca,Mg,K and Na) have high values compared to the lower elevations, and the soil pH in the surface horizons is only slightly acid but decreases with depth. The soil of this subassociation is considered mesotrophic.

(b) Peat Anmoor (Kubiena, 1953)

Soil formation from partially drained peat layer with fluctuating water level. Plant cover is generally closed.

Soils in this category are commonly associated with the Eriophoretum angustifolii which occurs at both high and low elevations in drainage pathways in the subalpine zone. Gradients on the upper slopes range from 2-13° with easterly exposures. On the lower slopes gradients are negligible (0-2°). The snow free period is from 3 1/2 to 4 months. Free flowing drainage water in the spring is more rapid on the slopes than at lower elevations, and the sites are generally better drained by the end of the summer.

The soils are characterized by having either a thick accumulative surface horizon of raw fibrous reddy-brown peat or very little at all (plots 42 and 152). In the latter few plant remains are present in the predominantly silty-clay surface soil horizon. Under the accumulated peat horizon there is also a silty-clay (C) horizon. Buried undecomposed organic layers of very small thickness and size are present in the mineral horizon.

Under ice free conditions, there develops from the inert peat humus an active humus formation with good decomposition. When the peat anmoor is present in a region of continuous permafrost the yearly alternation of waterlogging and drying out is reduced to a period of no longer than four months, the period when the active layer is free from ice. Edaphically this soil is relatively low in nutrients and can be classified as between oligotrophic and permesotrophic. Cation exchange capacity of the A horizon varies from 39.4 to 149.0 meq/100 gm and accordingly the quantities of exchangeable cations indicate a varying degree of hydrogen (H+) saturation. Lower quantities of available cations with increased depth reflect a decrease in percent organic matter. Soil reaction is generally strongly acid, however, in plot 49 the pH of the surface peaty horizon was 7.2 and dropping to 4.2 between 13-28 cm below the surface. As this plot was analyzed in mid-June, it probably reflects the recently free flowing drainage water that had drained through the site.

III. Terrestrial (Land) Soils (Kubiena, 1953)

Soil formation practically never covered with water or waterlogged, transitions to semi-terrestrial division may have gleying.

(A) Terrestrial Raw Soils (Kubiena, 1953)

Occurring either in very dry and hot regions as well as very cold regions. Appearing above the tundra zone as a climatic form, but also reaching into the tundra zone. Physical weathering predominates over chemical weathering. Humus development rare, with profile development very variable. Soils always well drained.

In the arctic subalpine zone soils of this category are present on exposed ridge tops and escarpments. Profile development is generally restricted by the instability of the surface materials and the presence of only limited amounts of organic materials. The snow free period is longer on these higher elevated more exposed sites than any other within this zone. The active layer is thick due to the degree of slopes and coarseness of the materials.

(a) Arctic Rawmark (Kubiena, 1953) Lithosol (Tedrow et al., 1958)

Coarse textured and well drained soils on non-calcareous parent material. Owing to rawness of the soil and low chemical weathering no gleying occurs. Continuous movement of materials (frost heaving) is a result of intense alternation of freezing and thawing.

In addition to the Arctic Rawmark soils described below, other soils having characteristics of Rawmark-like soils have been noted. They are associated with transitions close to the Salicetum phlebophyllae and include the Arctic Hamada Rawmark and Structure Rawmark.

Four profiles were studied in the Salicetum phlebophyllae. All sites were on northerly exposed slopes with a snow free period of 4 1/2 months. The profiles generally consist of a thin poorly developed A horizon (under mats of higher plants only), a loose C horizon usually light in colour and a hard parent rock (C_2 horizon). Percent organic matter is very low, being no greater than 4.1 percent in any one surface horizon. The mineral soil is nearly always coarse and consists mainly of a stony gritty sand. In contrast to the low chemical weathering, the physical weathering is important, being active in winter and summer. In winter the abrasive winds and hard ice crystals are instrumental in eroding fine fractions from exposed parent material and vegetation. During the snow free period freeze-thaw cycles and wind are primary sources of mechanical breakdown. Chemical analyses show that the soil is very poor in available basic cations and is, therefore, considered oligotrophic.

The active layer is generally very thick although difficult to determine due to the coarseness of the unconsolidated parent material. In plot 62 a silty-clay loam is present at a depth of 44 cm. Soil pH is moderately to strongly acid with little variation in depth.

Soils in the Lupino - Dryadetum *alaskensis (depauperatum) on less exposed sites at high elevations in the Subalpine Zone are also considered as belonging to the Arctic Rawmark type. Four profiles were studied. In all profiles organic matter in the upper horizon is greater (13 percent) than that in the Salicetum phlebophyllae. Exchangeable cations (Ca,Mg,K and Na) and cation exchange capacity values are low. Soil reaction in plots 2 and 73 is strongly acid and only slightly acid in plots 25 and 137. These latter two are considered as transitional between the Arctic Rawmark and the Arctic Brown shallow phase.

(B) Ranker-like Soils (Kubiena, 1953)

Soil formation, low in lime, whose humus horizon lies immediately on the parent material which consists usually of lime deficient siliceous or silicate rock (AC soils in parent material low in lime).

(a) Tundra Ranker (Kubiena, 1953)

Soil without waterlogging or peat formation, but with a very inactive humus formation of matted little decomposed plant remains occurring on dry tundra.

Few soil profiles can be considered as Tundra Ranker, those that are associated with the Betulo - Ledetum decumbentis cassiopeetosum tetragonae. Where present they are characterized by a thin matted brown, mineral deficient surface horizon (A_0) overlying a more or less mineral rich blackish A_1 horizon which lies directly on the C horizon consisting of ice shattered parent rock. Chemical weathering is of relatively minor importance with a tendency to strong acidification. Perennially frozen ground is present but because of the coarse unconsolidated parent material, it is not close to the surface. Decomposition and humification are generally low because the dominant species contain decomposition impeding substances.

These soils closely resemble the 'amorphorus tundra soils of the solifluction slope' described by McNamara (1964) in northern Alaska. Additional studies are needed before any definite statements can be made concerning the true presence of this soil type.

(C) Rendzina Soils (Kubiena, 1953)

Humus blackish, dark-grey to light grey coloured. Soil usually calcareous to extremely calcareous. Chemical weathering is poor with physical weathering predominant in arctic regions.

(a) Brown Rendzina (Kubiena, 1953) Arctic Brown shallow phase (Tedrow et al., 1958) Rendzina-like (McVean, 1964)

These soils are rare because of the scattered occurrence of calcareous rocks. They are usually shallow of almost neutral reaction with Rendzina-like features but are not necessarily true Rendzina.

On somewhat sheltered ridge slopes and escarpments in the two study areas are habitats supporting Lupino - Dryadetum *alaskensis dryado - salicetosum reticulatae - glaucae. Tedrow et al. (1958) consider this soil type to be closely related to the Arctic Brown shallow phase. The soil is present where bedrock is close to the surface and the sites are well drained. The surface horizon overlies little weathered sandy to silty mineral layers which indicate a degree of melanization with moder formation.

High concentrations or organic matter are present in the thin A horizon and decrease rapidly with depth. This decrease with depth can be related, in part, to fewer roots present at the lower depths (Tedrow and Hill, 1955). The profiles usually display narrow colour variations, the upper horizon is dark brown grading to yellow-brown. Small stone fragments are present throughout the profile and are continually forced to the surface by intensive frost action.

The soils thaw early in late spring and remain in an unfrozen state throughout the summer. The active layer is thick as a result of good drainage and there is a dry frost condition during the winter[1]. A high percentage of the active layer consists of ice-shattered unconsolidated parent material.

Physical weathering is more intense than chemical weathering in these profiles due to low temperatures and insufficient moisture which restrict microbial activity to a minimum. In the surface horizons cation exchange capacity is high and base saturation very inconsistent, ranging from 23-81 percent. Exchangeable cations with calcium dominating, are present in greatest quantity in the organic horizon and decrease rapidly with depth. This soil edaphotope is considered as mesotrophic. A magnesium value of 20.3 meq/100 gm, the highest in any organic horizon, occurred in plot 133. Soil pH is high for the surface horizons of the dryado - salicetosum reticulatae - glaucae ranging from 5.4 to 7.3. McVean (1964) has described the soils of the Dryas - Salix reticulata stands in Scotland as Rendzina-like owing to the high calcium content and irrigation from nearby calcareous rock.

Krajina (personal communication) found that certain parts of exposed rocks that were subjected to the HCL test gave positive reactions for calcium. This would account for the more calcareous nature of the surface horizon and, at the same time, their slightly acid condition.

(D) Brown Earths (Kubiena, 1953)

Neutral to moderately acid A (B) C soil. B horizons are indicative of deep reaching chemical weathering with good aeration and not excessive moisture. There are many transitions between the Arctic Brown and other types.

1. Mineral matter in a frozen state, but containing only small quantities of ice, most of the pore space is filled with air (Tedrow and Hill, 1955).

(a) Arctic Brown normal phase (Tedrow et al., 1958) (Figure 29)

Occurring only in alpine and arctic regions on moderately to well drained slopes. Soils are loose with restricted clay formation and usually have a rich precipitation of free ferric hydroxides. The soil has a high water permeability but owing to insufficient rainfall and absence of humus soil formation, podzolization does not occur.

Soils in this category are characteristic of the 'climatic climax' Vaccinio - Betuletum glandulosae in this region of the low arctic Subalpine Zone. The association is present on the mid to upper slopes as well as in exposed areas along lake shores. On the upper slopes it is present in sheltered depressions. Sampled plots varied in elevation from 1100-1900 ft. All sites are moderately well drained and have a snow free period of 10-12 weeks. The undulating microrelief is indicative of frost action, and downslope movement (solifluction) occurs in habitats on the steeper slopes. Unconsolidated parent material is always close to the surface and small fragments are present throughout the profile. Physical and chemical weathering are probably equally important (there is no actual experimental evidence to support this hypothesis).

In more temperate retions lacking perennially frozen ground heavy soils are practically non-existent. In this area of continuous permafrost clay (hand texture determination) horizons are discernible in the terrestrial soils. However, these are probably silicate clays that are derived from comparative slight physical and chemical alteration of the primary minerals. Profiles are generally shallow with distinctly developed, frequently humus rich dark-brown to blackish A horizons. The (B) horizon is usually lighter in colour and heavier with combinations of clay-loam or sandy-loam grading into a 'silicate' clay that overlies the parent material.

Percent organic matter is high in the surface horizons and decreases rapidly with depth. Cation exchange capacity is high, while base saturation is generally low. Exchangeable cations, dominated by calcium, are present in moderate amounts. Magnesium values are higher in the organic layer of the Vaccinio - Betuletum glandulosae than in any other association. Soil pH is moderately to strongly acid and shows little variation with depth. The soil edaphotope is considered to be permesotrophic.

Figure 29. Arctic Brown soil normal phase (Tedrow et al., 1958) associated with the Vaccinio - Betuletum glandulosae betuletosum glandulosae (fruticulosum). Soil profile taken through hummock. The A horizon is not clearly distinguishable, however, the B horizon is well developed and light in colour. (Photo by Krajina)

Morphologically these profiles indicate a degree of decomposition and humification in the upper portion of the surface horizons. Microstructure consists principally of loosely arranged, physically weathered mineral grains.

Also included in the Arctic Brown normal phase soil type is the Betulo - Ledetum decumbentis betulo - ledetum decumbentis. This association is present on the upper slopes in more exposed positions. Soil profiles are shallower than those of the Vaccinio - Betuletum glandulosae, between 19-33 cm in depth over packed unconsolidated sandstone felsenmeer. The profiles indicate greater stability relative to frost displacement by the continuity of profile morphologies. Colour changes are distinctive and range from dark brown to reddish and highly organic in the upper horizon, grading to grey-brown sandy loam to yellow silty-clay. Because of the coarse texture, aeration is much improved and the sites are considered well drained. Percent organic matter is high in the surface horizon and drops rapidly with depth. Exchangeable cations are low and the cation exchange capacity is high. The indication that the exchange complex is saturated with hydrogen ($H+$) is reflected in the strongly acid surface horizons (3.7 to 4.3). Perennially frozen organic-mineral soil was never found because of the close proximity to the surface of felsenmeer.

Profile morphology in the Betulo - Ledetum decumbentis cassiopeetosum tetragonae is more closely aligned to the Arctic Brown normal phase, however, as has been pointed out, there are several profiles that because of their more disturbed nature are considered as Arctic Ranker-like. The major difference in the cassiopeetosum tetragonae is the longer snow cover. Scattered accumulations of litter are present and packed down by snow in depressions. Chemical analyses of the major base nutrients, cation exchange capacity and soil pH indicate a close association with the Betulo - Ledetum decumbentis betulo - ledetum decumbentis. All soil edaphotopes in the Arctic Brown normal phase are considered to be mesotrophic.

Soil-Vegetation Relationships

In summarizing the relationships between soil and vegetation in the Low Arctic Subalpine Zone the process of congeliturbation must be considered to play a major role in both soil profile development and plant species distribution. Intimately related to this process is the development of patterned ground. The major forms of patterned ground in the Arctic have been studied and described by geomorphologists (Washburn, 1956). Several soil scientists (Drew, 1957 and Brown, 1962) have attempted, with some success, to relate certain forms of patterned ground to genetic soils. Botanists have also made several important contributions in the field of ecology (Tedrow, 1963).

In addition to the physical processes occurring in the soil, moisture changes brought about by changes in microrelief also have an influence on plant distribution. Alterations of a site produce changes in drainage and other physical characteristics, and some pedologic processes alter soil morphology very slowly toward the new condition, the biota is frequently altered drastically from the edaphic conditions under which the soil morphology developed (Tedrow, 1963). This condition is perhaps best illustrated in the transformation from low-centered polygons to high-centered polygons. Ridges increase in height and number as a result of developing ice wedges. The more elevated areas of the ridges are better drained and this is reflected in an increase in the abundance of more mesic vegetation dominated by dwarf shrub and ericaceous species. The depressions, on the other hand, remain dominated by more sub-aquatic vegetation. This change in species is related to a reduction in soil moisture due to improved drainage within the ridge or hummock.

It may be implied from the vegetation and soil analyses presented here, that there is a correlation between the semi-terrestrial (chionophilous) and terrestrial soils and their vegetation (Table 16). Because of this correlation, at least in the two study areas, one should be able to describe the soil type by the plant association of the habitat. In the wetlands, excluding the chionophilous habitats, it would be difficult to positively correlate both soil and vegetation. While this has been tentatively outlined it must be remembered that both the Eriophoretum scheuchzeri and Caricetum rariflorae are underrepresented and considered to be in a state of flux due to excessive frost heaving. No soil profiles were described for the low-centered polygon ridges. However, several sections were made through ridges to observe profile morphology. In all cases, except for the upper few centimeters, the profile consisted of undecomposed Sphagnum similar to that found in the depressions.

DESCRIPTION OF HIGHER UNITS OF CLASSIFICATION - ALLIANCES AND ORDERS[1]

Following the analysis and description of the major plant associations in the two study areas units of higher rank were determined using characteristic species combinations (Table 18). A total of 6 Orders and 9 Alliances were recognized. Many of the higher units bear a close relationship to units of similar rank in Europe (Braun-Blanquet, 1932, Krajina, 1933, Nordhagen, 1943 and Dahl, 1956).

The Betuletalia glandulosae is the dominant order in the two study areas where it is generally present at higher elevations on xeric to mesic soils that are moderately to slightly acid. The order is characterized by dwarf shrub species, usually less than 2 1/2 ft high, with high cover and constancy values. In the more xeric sites lichen coverage exceeds that of the bryophytes whereas in the more mesic sites the reverse is the case. Two alliances are recognized. The Betulo - Dryadion *alaskensis on xeric, moderately to slightly acid soils, and the Betulion glandulosae on sub-xeric to mesic, moderately acid soils. The latter is the major alliance with Vaccinio - Betuletum glandulosae considered to represent the climatic climax for this area of the Low Arctic Subalpine Zone.

All hummock dominated communities in the semi-hydric to hygric habitats belong to the order Sphagnetalia. Communities are dominated by hummock-building Eriophorum vaginatum, Sphagnum species, dwarf shrubs or ericaceous vascular plants. The soils are strongly to moderately acid. The order is second in importance after the Betuletalia glandulosae and is restricted in the majority of cases to the lower slopes. In Alaska the Sphagnetalia or Eriophorum vaginatum dominated sites are considered to dominate larger areas than any other vegetation type (Hanson, 1953, Churchill, 1955, Porsild, 1951 and Spetzman, 1959). In Europe the Sphagnetalia show some affinity to the

1. The following description of higher units of classification were derived with the assistance of Dr. V. J. Krajina.

Table 18

Classification of plant communities of the Low Arctic Subalpine Zone on the basis of characteristic species combinations.

ZONE: Subalpine/Low Arctic (Betula glandulosa) characteristic species combination

	S.p.	L.- D.a.	B.- L.d.	V.- B.g.	B.- C.	B.- E.v.	S.pul.	S.c.	S.ps.	C.r.	E.s.	C.a.	E.a.	A.f.
Betula glandulosa	#	III 1.3(+-5)	V 4.6(1-7)	V 5.5(2-9)	V 5.8(4-8)	V 3.1(1-5)	III 1.6(1-4)	I .2(+-1)		IV 2.7(3-5)	II 2.5(3-7)	II .2(2-3)	III .9(1-3)	
Salix pulchra			II .7(1-4)	IV 2.5(1-7)	IV 3.4(3-6)	III 1.6(1-5)	V 8.4(7-9)	III 1.3(1-8)				II .5(1-4)	II 2.0(2-8)	
Salix glauca		II 1.0(1-6)	I .2(1-2)	III 1.1(1-5)	II .8(1-5)	I .2(1-2)						#		
Alnus crispa				#	II 2.8(7)	#								
Empetrum hermaphroditum			IV 2.3(1-6)	III 1.3(1-6)	V 4.5(2-8)	V 1.8(1-4)	II .3(+-2)	I .1(1)					#	
Ledum decumbens	#	#	V 3.6(1-6)	V 2.3(1-6)	V 4.0(2-6)	V 3.0(+-5)	I .4(1-4)			IV 1.7(2-3)	#	I .1(+-1)	III .5(1)	
Spiraea beauverdiana			II .4(1-2)		III 1.8(1-5)	#	II 1.6(2-7)	II 1.7(1-6)						
Vaccinium uliginosum		IV 2.4(1-7)	V 2.5(1-6)	V 4.0(1-7)	V 4.4(3-6)	V 2.1(1-3)	III 1.4(1-7)	II .3(+-2)		IV 1.0(+-2)	#	I .3(1-4)	II .7(+-3)	
Vaccinium vitis-idaea	#	I .2(1-2)	V 3.5(1-6)	V 2.3(1-6)	V 3.3(1-6)	V 4.1(1-5)	II .7(+-2)	II .4(1-3)				#	II .3(+-1)	
Poa arctic	#	III 1.0(+-3)	III .5(+-3)	III .9(+-3)	II .8(+-3)	II .4(+-3)	IV 1.2(+-3)	IV 1.6(1-4)	IV 1.2(1-2)					
Artemisia arctica	II .4(1)	II .5(+-2)	I .2(1-2)	I .2(1)			II .8(+-6)	IV 3.0(+-7)	III 1.6(1-5)					
Polygonum bistorta ssp.plumosum		II .3(+-1)	IV 1.1(+-4)	IV 1.3(+-3)	IV 1.2(1-3)	III .8(1-2)		III .9(+-3)	III 1.0(+-2)					
Arctagrostis latifolia		II .6(1-4)	II .5(+-3)	III 1.2(+-3)	IV 1.3(1-3)	I .5(+-2)	IV 2.1(1-6)	V 2.8(1-8)					#	
Eriophorum vaginatum		#		I 1.0(3-6)	III .7(1-2)	V 7.0(5-8)							I .2(1)	
Rubus chamaemorus				#	V 5.2(2-8)	IV 1.6(1-4)	III 1.7(1-4)	I .2(+-1)		#	#		II .5(1-2)	
Stellaria ciliatosepala		II .3(1-2)	#	III .6(+-2)	I .4(2)	I .2(+-1)	II .3(1-2)	I .3(+-2)	#					
Stellaria longipes		II .3(+-1)	#	I .2(+-1)			II .3(1-2)	I .3(1-3)						
Aulacomnium palustre		I .3(1-3)	I .4(2-4)	III 1.0(+-5)	III 1.5(2-5)	I .4(+-5)	III 2.3(+-7)	II 1.5(+-5)				II .6(1-4)	II 1.1(+-5)	
Aulacomnium turgidum		III 1.8(1-6)	IV 1.5(1-5)	V 3.7(+-7)	IV 1.2(+-5)	V 2.5(1-3)				IV 1.3(+-3)	III .8(1-2)	II .2(+-4)		
Bryum pseudotriquetrum		I .2(1-2)					II 1.2(1-5)	III 1.8(+-6)	II .4(+-1)				I .2(+-1)	
Dicranum angustum		I .3(1-3)	I .3(1-3)	II .8(1-5)	II .5(+-3)	IV 1.7(+-5)								
Dicranum elongatum		II .7(+-5)	V 2.7(1-4)	IV 2.2(1-5)		III .9(1-3)								
Dicranum mühlenbeckii		II .5(+-2)		I .4(1-3)		I .1(1)		I .3(+-3)						
Hylocomium splendens var.alaskanum		I .8(3-5)	III 1.8(1-8)	IV 2.8(+-7)	III 1.4(1-6)	III 1.6(1-5)	III 2.7(3-8)							
Lophozia kunzeana				I .1(+-1)	III .6(+-1)		I .1(+)							
Polytrichum commune					II 1.1(2-4)	I .2(1-2)		II .9(+-5)	III 1.4(1-4)	IV 1.0(1-2)	V 3.0(1-4)	III 1.0(1-4)	II 1.0(2-4)	
Polytrichum juniperinum	II 1.2(1-5)	III 1.0(+-4)	IV 2.1(+-6)	V 2.0(1-5)	IV 2.3(1-5)	IV .9(+-3)	I .3(1-2)						I .5(1-4)	
Sphagnum girgensohnii			II .5(1-3)	III 1.5(1-7)	IV 5.6(4-9)	II 1.0(2-5)	II 1.4(1-6)						II 2.6(4-8)	
Sphenolobus minutus			IV 1.0(+-5)	III .7(1-2)	I .3(1-2)	IV 1.0(+-4)								
Tomenthypnum nitens				I .2(+-1)	II .4(1-2)	I .2(3-5)	I .4(+-2)	I .8(2-5)						
Alectoria nigricans	III 1.8(3)	II .3(1)	II .7(1-6)	I .2(1)		I .1(+-1)								
Alectoria ochroleuca	IV 1.0(+-2)	II .5(+-2)	III 1.0(+-6)	I .3(1-2)		I .2(+-1)								
Cetraria cucullata	III .8(+-2)	V 1.9(1-5)	V 2.0(+-6)	V 2.5(+-6)	II .4(+-1)	V 1.8(+-6)								
Cetraria islandica		III .5(+-2)	V 1.4(+-5)	V 1.6(1-4)	I .4(+-3)	IV .8(+-1)		I .4(1-3)						
Cetraria nivalis	IV 1.2(1-2)	V 1.3(+-3)	IV 1.5(+-4)	IV .7(+-2)		II .3(+-1)								
Cetraria richardsonii		III .7(+-3)	IV .9(+-2)	II .4(+-1)		I .2(+-1)								
Cladonia gracilis		II .3(+-2)	III .5(+-1)	III .6(1-2)		II .3(+-1)		I .2(1-2)						
Cladonia rangiferina			IV 1.3(+-5)	III 1.2(+-4)	II .4(+-2)	III 1.0(+-4)								
Cladonia mitis			V 2.0(+-6)	IV 1.4(+-4)		IV .9(+-4)								
Cornicularia divergens	V 2.8(2-4)	III .8(1-2)	III 1.1(+-5)	I .3(1-2)										
Dactylina arctica		II .3(+-2)	IV .8(+-2)	III .6(1-3)		III .7(+-2)								
Nephroma expallidum		III .6(+-2)	II .5(+-2)	III .6(+-2)		I .1(+-2)								
Ochrolechia frigida	III 1.2(+-3)	II .3(+-3)	III .8(+-3)	I .1(+)										
Parmelia omphalodes	V 1.0(+-1)	II .4(+-2)	II .4(+-1)	I .1(1)										
Peltigera aphthosa		II .4(+-2)	II .8(+-4)	V 1.3(+-3)		III .9(1-2)	III .8(+-3)	II .5(1-2)						
Peltigera canina		III .5(+-1)	I .2(+-1)	III .6(+-2)		II .3(1)	III 1.0(1-4)	II .7(+-5)	III .8(1-2)					
Peltigera scabrosa			II .5(1-4)	III .6(1-2)	II .5(+-2)	III .5(+-1)	II .5(1-2)	II .3(1-2)						
Peltigera spuria			I .7(+-3)	I .2(+-2)			III .5(+-1)	II .3(+-1)	II .4(1)					
Sphaerophorus globosus	V 1.0(+-1)	II .3(1)	III .8(+-5)	II .5(+-2)										
Stereocaulon alpinum		II .5(+-2)	III 1.5(+-7)	IV .9(+-3)	II .4(+-2)	II .3(1)								
Thamnolia vermicularis	IV .8(+-1)	IV 1.0(+-2)	IV .9(+-4)	IV 1.0(1-3)		II .5(+-2)								
BETULETALIA GLANDULOSAE														
Arctostaphylos alpina	III .6(+-1)	III 1.9(1-5)	V 2.7(+-6)	IV 2.4(2-5)	II .3(+-1)	II .9(2-4)								
Carex podocarpa	IV 1.2(1-3)	III .9(1-4)	IV 1.2(1-3)	#					II 1.8(3-6)					
Diapensia lapponica	#	I .3(1-3)	II .5(1-3)											
Hierochloe alpina	V 1.4(1-2)	IV 1.5(1-4)	V 1.7(1-3)	IV 1.1(+-4)	#	I .2(1)			#					
Pedicularis arctica		II .3(+-1)	I .1(+-1)	II .4(1-2)		#								
Pedicularis capitata		II .5(+-2)	I .2(+-2)	II .3(+-1)		#								
Pedicularis lanata		II .3(+-1)	II .2(+-1)	II .4(1-2)		I .2(+-1)								
Saussurea angustifolia		II .3(+-1)	II .4(1-4)	II .3(+-2)		#			#					
Senecio atropurpureus		I .2(+-1)	I .1(+-1)	II .4(1-2)	#	I .2(1)								
Tofieldia coccinea	#	III .7(1-2)	I .2(+-1)	II .4(+-2)										
Salix brachycarpa	#	I .2(1-2)	#	I .1(2-5)										
Rhytidium rugosum		IV 1.5(+-5)	II .7(+-5)	III 1.7(1-6)		I .3(+-2)								
Alectoria nitidula		II .7(1-4)		I .1(+-1)		I .1(+-1)								
Cetraria nigricascens	III 1.0(1-2)	I .2(+-1)	III .4(+-1)											
Lecidea atromarginata		I .3(+-3)	I .1(1-2)											
Lecidea flavocaerulescens	II .4(1)		I .1(+-1)											
Parmelia stygia	II .6(+-1)		II .5(+-4)											
Pertusaria coriacea	III 1.0(+-3)	II 1.0(+-6)	II .3(+-3)											
Pertusaria dactylina		I .1(+-1)	II .4(+-3)											
Pertusaria panyrga		III 1.3(+-6)	II .3(+-3)											
Umbilicaria hyperborea	III 1.4(1-4)	II .3(+-2)	II .5(+-3)											
Umbilicaria proboscidea	III 2.0(+-5)	I .1(+-1)	II .5(+-4)											
BETULO - DRYADION *ALASKENSIS														
Antennaria neoalaskana	IV 1.0(+-2)	III .8(+-3)	I .1(+-1)	I .3(1-2)										
Arenaria arctica	V 1.2(+-2)	V 1.2(+-2)	II .4(+-2)	I .1(1)		#								
Douglasia arctica	IV 1.0(1-2)	III .5(+-1)	II .3(+-1)											
Dryas octopetala ssp.alaskensis	IV 1.6(1-4)	V 6.4(4-9)	I .3(1-3)	II .6(1-3)		I .3(1-2)								
Festuca baffinensis	#	#												
Festuca brachyphylla	#	I .3(+-2)												
Oxytropis nigrescens	IV 1.8(+-3)	III 1.3(+-4)	II .4(1-2)											
Potentilla nivea	#	I .3(+-2)												
Salix phlebophylla	V 4.5(4-6)	IV 2.0(+-5)	III 1.1(+-4)	III 1.2(1-4)		I .1(1-2)								
Cetraria chrysantha	IV 1.0(+-2)	IV 1.2(1-5)	II .3(+-1)	I .1(+-1)										
Hypogymnia subobscura	III .6(+-1)	III .8(+-3)		I .2(+-1)										
SALICETUM PHLEBOPHYLLAE														
Selaginella sibirica	IV .8(+-1)	I .2(+-1)	I .2(+-1)	#	#									
Smelowskia calycina	II .4(+-1)	#	#											
Aster pygmaeus	#													
Potentilla vahliana	#													
Gymnomitrium corallioides	IV 1.6(+-4)		I .2(+-2)											
Polytrichum piliferum	III 1.0(+-2)	II .4(+-3)	I .3(2)											
Cetraria scholanderi	II .4(1)													
Haematomma lapponicum	IV 1.8(1-4)		II .2(+-1)											
Parmelia alpicola	II 1.0(1-4)													
Parmelia separata	V 1.4(1-2)	I .1(1)	II .3(+-2)											
LUPINO - DRYADETUM *ALASKENSIS														
Antennaria pedunculata		#												
Arenaria rossii		I .1(+)												
Arnica alpina		III .6(+-3)												
Astragalus australis		I .5(3-4)												
Astragalus umbellatus		I .4(1-4)	#											
Bupleurum americanum	#	II .6(+-3)												
Campanula uniflora		II .3(1-2)												
Cardamine microphylla		#												
Carex capillaris		II .3(+-1)												
Carex scirpoidea		III .7(1-3)												
Carex williamsii		#												
Eritrichium splendens		#												
Gentiana propinqua		#												
Geum glaciale		#	#											
Kobresia hyperborea		I .1(1)												
Kobresia myosuroides		III .7(1-3)												
Lupinus arcticus	#	V 2.5(1-5)	I .2(+-2)	III .8(1-4)		#								
Melandium apetalum		#												
Oxytropis maydelliana		IV .9(+-3)		I .3(1-2)		I .2(+-1)								
Papaver macounii		II .5(+-3)												
Parrya nudicaulis		I .2(1)												
Phlox richardsonii		#												
Poa glauca	#	III .5(+-1)	I .1(1)											
Polygonum viviparum		V .9(+-2)	II .3(1)	II .4(+-3)		I .1(1)	I .2(1-2)	II .5(+-3)	#					
Rhododendron lapponicum		II .7(2-3)												
Salix arctica		II .4(1-2)												
Saxifraga bronchialis		II .5(1-2)	I .2(1-3)	#										
Saxifraga davurica		I .1(+-1)												
Saxifraga flagellaris		II .4(1-3)												
Saxifraga hieracifolia		II .4(+-2)				I .1(+-1)								
Saxifraga hirculus		II .4(1-3)												
Saxifraga oppositifolia		#												
Saxifraga reflexa	#	III .7(+-2)												
Saxifraga tricuspidata	#	III 1.3(+-3)	#	I .2(1-2)										
Sedum roseum		#												
Senecio fuscatus		IV .8(+-2)	#	I .3(+-2)										
Senecio resedifolius		I .3(1-2)												
Silene acaulis		II .5(1-2)												
Woodsia alpina		#												
Woodsia glabella		#												
Abietinella abietina		II .5(+-3)												
Distichium capillaceum		III .7(+-2)		I .2(+-2)										
Myurella julacea		I .2(+-+)												
Cetraria tilesii	#	II .6(+-3)												
Cornicularia aculeata		II .3(1)												
Ochrolechia upsaliensis		II .9(+-4)												
Physcia muscigena		III .7(+-2)												
Solorina saccata		I .2(+-1)												
BETULION GLANDULOSAE														
Senecio yukonensis			#	#										
Cladonia uncialis		I .1(+-1)	II .4(+-2)	II .4(+-2)										
Lobaria linita			II .3(+-1)	II .3(1-2)										
Stereocaulon tomentosum			I .5(1-4)	I .1(1)										
BETULO - LEDETUM DECUMBENTIS														
Cassiope tetragona		II .9(1-4)	IV 3.2(2-8)	I .3(1-3)	#									
Calamagrostis lapponica			#											
Loiseleuria procumbens			III 1.0(1-7)											
Lycopodium selago			#											
Dactylina madreporiformis			I .1(+-1)											
Nephroma arcticum			I .1(+-1)											
VACCINIO - BETULETUM GLANDULOSAE														
Carex lugens		I .5(+-6)	II .5(+-4)	V 3.0(1-7)	III 1.4(+-5)	IV 2.2(1-5)	II .7(1-7)	#					II .4(+-2)	
Castilleja pallida				#										
SPHAGNETALIA														
CHAMAEMORO - ERIOPHORION VAGINATI														
Pedicularis lapponica			I .1(+-1)	I .2(+-1)	V 1.3(+-4)	IV 1.0(+-3)								
Pinguicula villosa					I .2(+-1)	II .4(1-2)								
Sphagnum rubellum			I .2(1-4)	I .3(1-3)	IV 1.6(1-5)	IV 1.9(2-6)	I .5(1-4)							
Cladonia amaurocraea		I .2(+-1)	I .1(1)	III .8(+-4)	II .5(+-3)	III .9(+-4)								
BETULO - CHAMAEMORETUM														
Luzula rufescens					#									
Lycopodium annotinum			#		III 1.8(1-6)									
Pedicularis labradorica			II .3(+-1)	II .4(+-1)	III .5(+-1)	I .1(+)								
Rubus chamaemorus				#	V 5.2(2-8)	IV 1.6(1-4)	III 1.7(1-4)	I .2(+-1)		#	#			
BETULO - ERIOPHORETUM VAGINATI														
Eutrema edwardsii						I .1(1)								
Juncus biglumis						I .1(+)								
Sphagnum lenense			I .2(1-2)		I .5(1-4)	IV 4.3(1-9)	I .4(1-4)			IV 2.7(+-7)		I .1(3-5)	II 1.1(1-5)	
PETASITETALIA FRIGIDI														
EQUISETO - PETASITION FRIGIDI														
Equisetum arvense		#	I .2(1-3)	I .3(1-5)	I .2(+-1)	I .1(+-1)	V 4.7(1-8)	V 5.2(1-8)	II 1.0(2-3)		#			
Petasites frigidus		I .1(+-1)	I .3(+-3)	III .6(+-3)	IV 1.3(+-5)	I .4(2)	V 4.4(1-8)	IV 2.6(1-6)	II .6(1-2)					
Polemonium acutiflorum							IV 1.4(1-4)	IV 1.4(1-3)	#					
Ranunculus pedatifidus							#	#						
Saxifraga punctata		III .6(+-2)	I .2(1-4)	I .2(1)		I .1(1)	IV 1.4(1-4)	IV 1.8(1-4)	III 1.0(1-2)					
Senecio lugens							I .3(2)	II .8(1-4)	#					
Valeriana capitata				#		#	III 1.0(1-4)	III .5(+-3)						
Viola epipsila					#	#	I .2(1-2)	I .6(2-4)						
Brachythecium turgidum							II 1.2(1-8)	II .5(+-3)						
Drepanocladus uncinatus			I .2(+-1)	I .2(+-1)	II .4(1-2)	I .1(+-1)	V 4.0(+-7)	V 4.7(+-7)	III .6(+-1)					
SALICETUM PULCHRAE														
Ranunculus lapponicus							I .5(2-4)							
Salix richardsonii							I 1.0(7)							
Stellaria monantha		#					II .7(+-3)	#						
SALICETUM CHAMISSONIS														
Aconitum delphinifolium							III 1.0(+-3)	V 2.3(1-5)	#					
Anemone richardsonii							III 1.9(2-6)	IV 2.0(1-5)	#					
Carex montanensis							I .1(+-1)	IV 3.6(1-8)	#					
Dodecatheon frigidum							II 1.0(1-4)	IV 2.2(+-6)	IV 1.4(1-3)					
Festuca altaica								II 1.3(+-7)	#					
Gentiana glauca								I .3(2-3)	#					
Parnassia kotzebuei								I .3(1-4)						
Ranunculus nivalis						#	I .4(1-4)	IV 1.1(1-3)	III 1.2(2)					
Ranunculus turneri								#						
Rumex arcticus								II .3(1-2)						
Salix chamissonis			#					IV 4.7(1-8)	II 1.8(+-8)					
Trisetum spicatum		II .3(+-1)						IV 1.6(1-5)	II .8(2)					
SALICETALIA HERBACEAE SALICION PSEUDOPOLARIS														
SALICETUM PSEUDOPOLARIS														
Arenaria sajanensis									V 2.0(1-5)					
Arnica lessingii			I .2(2-3)					I .1(1)	III 1.8(1-4)					
Carex lachenalii							II .3(+-2)	IV 2.3(1-4)	V 3.2(+-6)					
Epilobium anagallidifolium									II .8(1)					
Myosotis alpestris							I .1(+)	II .7(2-5)	II 1.0(1-4)					
Oxyria digyna								#	IV 2.4(2-5)					
Ranunculus pygmaeus								#	III 3.2(4-7)					
Salix pseudopolaris									V 5.0(2-8)					
Saxifraga rivularis									II .8(1-3)					
Sibbaldia procumbens								#	IV 1.8(1-4)					
Bartramia ithyphylla									II .4(1)					
Pohlia drummondi									IV 2.8(3-5)					
Polytrichum norvegicum									IV 2.8(1-6)					
Lecidea granulosa									II .4(+-1)					
Solorina crocea									II .4(1)					
CARICETALIA FUSCAE														
CARICO - ERIOPHORION SCHEUCHZERI														
Andromeda polifolia					III .9(+-3)	II .4(+-2)				IV 2.7(4)	III 1.0(1-3)	II .2(1-4)	#	
Carex rotundata					#	I .3(1-3)				V 3.0(2-7)	V 2.5(2-4)		#	
Sphagnum balticum						II .5(+-3)				V 4.3(6-7)	V 6.5(2-9)		II 1.2(1-5)	
CARICETUM RARIFLORAE														
Carex rariflora						#				V 7.3(7-8)		II .6(1-5)		
Oxycoccus microcarpus					#					IV 2.3(3-4)	#			
Salix arbutifolia						#				V 2.3(+-3)		IV 2.1(1-7)	II .9(1-5)	
Sphagnum compactum										IV .7(1)				
ERIOPHORETUM SCHEUCHZERI														
Eriophorum scheuchzeri										IV 1.3(2)	V 7.5(6-9)	II .6(1-5)	#	
Drepanocladus exannulatus											II 2.5(+-9)			
CARICION AQUATILIS														
CARICETUM AQUATILIS														
Carex aquatilis					I .2(+)	#	II 1.0(1-5)	II .4(+-3)		#		V 6.7(3-9)	II .3(1-2)	#
Carex chordorrhiza											#	II 1.2(+-7)	#	
Petasites arcticus												#		
Potentilla palustris												III 2.0(3-5)		
Ranunculus pallasii												II .2(+-1)		#
Sphagnum contortum												I .6(2-6)		
Sphagnum squarrosum							I .8(1-5)					III 2.1(1-8)		
ERIOPHORION ANGUSTIFOLII														
ERIOPHORETUM ANGUSTIFOLII														
Eriophorum angustifolium						#	II .8(3-4)	#		#	#	II 1.2(1-6)	V 7.7(7-10)	
ARCTOPHILETALIA FULVAE ARCTOPHILION FULVAE														
ARCTOPHILETUM FULVAE														
Arctophila fulva													#	V 8.5(6-10)
Cardamine pratensis								#			#			III .8(1-2)
Epilobium palustre														III 2.8(5-6)
Hippuris vulgaris														V 3.2(1-7)
Ranunculus gmelinii											#			III .8(1-2)
Senecio congestus														IV .8(1)
Drepanocladus aduncus												I .6(2-6)	II .7(2-3)	III 3.5(5-9)

COMPANION SPECIES

Vascular Plants

Calamagrostis purpurascens
Cardamine digitata
Cardamine microphylla
Castilleja raupii
Chrysosplenium tetrandrum
Draba nivalis
Epilobium angustifolium
Equisetum scirpoides
Eriophorum chamissonis
Lagotis glauca
Linnaea borealis
Luzula nivalis
Luzula wahlenbergii
Pedicularis sudetica
Potentilla fruticosa
Pyrola grandiflora
Pyrola secunda
Rosa acicularis
Salix farrae
Saxifraga cernua
Saxifraga radiata
Taraxacum sp.
Tofieldia pusilla

Bryophytes

Blepharostoma trichophyllum
Brachythecium albicans
Calliergon cordifolium
Calliergon stramineuum
Calypogeia trichomanis
Dicranum fuscescens
Dicranum groenlandicum
Dicranum scoparium
Encalypta vulgaris
Eurhynchium pulchellum
Funaria hygrometrica
Hypnum callichroum
Lophozia alpestris
Lophozia kunzeana
Lophozia quadriloba
Lophozia quinquedentata
Lophozia ventricosa
Mnium cinclidioides
Mnium orthorrhychum
Mnium punctatum
Mnium rugicum
Philonotis fontana
Plagiothecium roeseanum
Pleurozium schreberi
Pogonatum alpinum
Pohlia nutans
Ptilidium ciliare
Rhacomitrium lanuginosum
Sphagnum recurvum
Sphagnum teres
Tetraplodon paradoxus
Tetraplodon urceolatus
Ceratodon purpureus
Chandonanthus sediformis

Lichenes

Arctomia delicatula
Cetraria pinastri
Cetraria sepincola
Cladonia chlorophaea
Cladonia coccifera
Cladonia coniocraea
Cladonia fimbriata
Cladonia furcata
Cladonia gracilis
Cladonia pleurota
Collema tenax
Icmadophila ericetorum
Lecanora anseris
Lecanora atrosulphurea
Lecanora castanea
Lecanora epibryon
Lecanora polytropa
Lecanora rupicola
Lecanora lapicida
Leptogium saturninum
Parmeliopsis ambigua
Peltigera malacea
Peltigera polydactyla
Peltigera venosa
Rhizocarpon geographicum
Sphaerophorus globosus

Oxycocco - Ledetalia palustris (Nordhagen, 1943 and Dahl, 1956).

Only one alliance, the Chamaemoro - Eriophorion vaginati, is recognized with two associations. The Betulo - Eriophoretum vaginati is clearly the most conspicuous hummock community on the lower slopes in the two study areas. The pronounced hummock-depression microrelief is dominated by Eriophorum vaginatum and Sphagnum lenense. This association has a close floristic affinity with the Chamaemoreto - Sphagnetum acutifolii in the mires of the Rondane, Norway (Dahl, 1956). The Betulo - Chamaemoretum with a less pronounced hummock-depression microrelief is more hydric and is not present at altitudes where Betulo - Eriophoretum vaginati is present. The Betulo - Chamaemoretum is closely related to the Betuleto - Sphagnetum fusci in the Rondane, Norway and in the raised bogs of Central and South Sweden as described by Dahl (1956).

A new order, the chionophilous Petasitetalia frigidi, previously undescribed in North America and with no apparent counterpart in Europe is common in the Canoe Lake area, but has only limited distribution in the Trout Lake area. Occurrence is related to a more irregular topography and a southerly exposure. One alliance, Equiseto - Petasition frigidi, is recognized with two associations. The shrub community Salicetum pulchrae present in drainage pathways and considered to be slightly chionophilous and the more strongly chionophilous Salicetum chamissonis. Additional analyses of the latter are needed as six variations of this plant association were determined in this region of the Low Arctic Subalpine Zone.

The order Salicetalia herbaceae is used here because of a close floristic and environmental affinity with similar habitats in Europe (Braun-Blanquet, 1932, Krajina, 1933, Nordhagen, 1936, Dahl, 1956 and Gjaerevoll, 1956). Only one alliance Salicion pseudopolaris with one association is recognized. Habitats are associated with solifluction slopes and a very short growing season.

The grouping of wetland communities in this region of the Low Arctic Subalpine Zone is difficult because of their low areal coverage. Environmental factors related to position of the water table, water movement and depth of permafrost act on the vegetation in varying ways to produce a mosaic of different vegetation types. Many species present in the two study areas, however, are also present in Europe so that the use of the previously described order Caricetalia fuscae (Dahl, 1956) is in order in relating the three recognized alliances.

The Carico - Eriophorion scheuchzeri consists of mire communities in sites of stagnant water. Two associations are recognized. The Caricetum rariflorae with abundant Sphagnum coverage has a water table below or close to the surface. The Eriophoretum scheuchzeri in early stages of development is associated with low-centered polygons and is dominated by brown mosses (Drepanocladus and Calliergon) while Sphagna are of minor importance. Standing water is generally present throughout the summer. Eriophorum scheuchzeri is also present, at times in pure stands, along lake shores and in tundra mudflows. However, the low-centered polygon sites with stagnant water are the major sites which would appear to repudiate the statement made by Dahl (1956) that all authors seem to agree that Eriophorum scheuchzeri requires fresh oxygen-rich water. Caricion aquatilis, with only one association, covers large areas in old lake sites and is also present in drainage pathways that are subject to flooding during the annual thaw.

Eriophorion angustifolii is generally present where drainage water is running throughout most of the summer. One association and two variations are recognized. While the Sphagna dominate over the brown mosses in this order there is a possible association with the Eriophoretosum angustifolii as described from the Rondane, Norway by Dahl (1956).

A grouping of aquatic communities in the Subalpine/Zone is difficult because of a lack of detailed information on all the possible types present. Only emergent aquatics were found in the two study areas whereas Hanson (1953) and Spetzman (1959) have recorded submerged aquatics in the Subalpine/Foothill Zone in Central Alaska as well as emergent types. For the present the emergent aquatics are grouped under the order Arctophiletalia fulvae comprising one alliance and one association.

Two additional tables (19 and 20) are included to show the classification of plant communities of the Low Arctic Subalpine Zone on the basis of their sociological progression.

TABLE 19

Classification of plant communities of the Low Arctic Subalpine Zone on the basis of their sociological progression

Variation	Subassociation	Association
		Salicetum phlebophyllae
	dryadetosum *alaskensis (depauperatum)	Lupino - Dryadetum *alaskensis
	dryado - salicetosum reticulatae - glaucae	
	betulo - ledetosum decumbentis	Betulo - Ledetum decumbentis
	cassiopeetosum tetragonae	
vaccinio - betulosum glandulosae (fruticulosum)		Vaccinio - Betuletum glandulosae
vaccinio - betulosum glandulosae (fruticosum		
	betulo - chamaemoretosum	Betulo - Chamaemoretum
	alnetosum crispae	
	eriophoretosum vaginati	Betulo - Eriophoretum vaginati
	salicetosum reticulatae	
salicosum pulchrae		Salicetum pulchrae
betulosum glandulosae		
salicosum richardsonii		
salicosum chamissonis		Salicetum chamissonis
equisetosum arvensis		
festucosum altaicae		
caricosum montanensis		
arctagrostidosum latifoliae		
salicosum pulchrae		
		Salicetum pseudopolaris
		Caricetum rariflorae
		Eriophoretum scheuchzeri
caricosum aquatilis		Caricetum aquatilis
salicosum arbutifoliae		
	eriophoretosum angustifolii	Eriophoretum angustifolii
	salicetosum pulchrae	
		Arctophiletum fulvae

TABLE 20

Classification of plant communities of the Low Arctic Subalpine Zone on the basis of their sociological progression

Association	Alliance	Order
Salicetum phlebophyllae	Betulo - Dryadion *alaskensis	Betuletalia glandulosae
Lupino - Dryadetum *alaskensis		
Betulo - Ledetum decumbentis	Betulion glandulosae	
Vaccinio - Betuletum glandulosae		
Betulo - Chamaemoretum	Chamaemoro - Eriophorion vaginati	Sphagnetalia
Betulo - Eriophoretum vaginati		
Salicetum pulchrae	Equiseto - Petasition frigidi	Petasitetalia frigidi
Salicetum chamissonis		
Salicetum pseudopolaris	Salicion pseudopolaris	Salicetalia herbaceae
Caricetum rariflorae	Carico - Eriophorion scheuchzeri	Caricetalia fuscae
Eriophoretum scheuchzeri		
Caricetum aquatilis	Caricion aquatilis	
Eriophoretum angustifolii	Eriophorion angustifolii	
Arctophiletum fulvae	Arctophilion fulvae	Arctophiletalia fulvae

TUNDRA MUDFLOWS

Tundra mudflows are characteristic features of certain undisturbed tundra areas (Sigafoos and Hopkins, 1952). In the two study areas tundra mudflows are common on slopes bordering lakes and only rarely occurring on slopes away from lakes. They are a result of an oversteepening of the profile which may be due to solifluction or erosion of the base of a cut bank. Severe frost heaving due to freeze-thaw cycles in the autumn breaks up the vegetative mat overlying the mineral soil. In the following spring, the vegetative mat is unable to hold the saturated soil and there is a mass movement downslope (Figure 30). Islands of tundra vegetation are left scattered throughout the upper portion of the mudflow site below the original break (Figure 31). The mass of the vegetative mat, however, is piled up further downslope (Figure 32). Recent and past flows are readily identifiable along the shore of Canoe Lake and, although no detailed vegetation and soil analyses were made, the following secondary successional characteristics were determined.

During the summer following the mudflow the exposed silty soil on the upper portions is colonized by Senecio congestus and Eriophorum scheuchzeri. In following years clumps of Calamagrostis canadensis, Arctagrostis latifolia, Equisetum arvense, Petasites frigidus and numerous other species appear in association with the original colonizers (Figure 33). Bryophytes present on the exposed soil include Dicranella subulata and Pohlia sp.

Snow accumulation in these sites is deep and aids in packing down the tall grasses and herbs each winter so that in time a turf forms over the exposed soil thereby preventing further erosion. With the development of a more suitable substrate the tundra vegetation, primarily of the Vaccinio - Betuletum glandulosae, that remained as isolated islands on the silty soil is able to colonize the turf mat and replace the original grasses and herbs.

A possible explanation of the tundra mudflow might lie in the fact that the Vaccinio - Betuletum glandulosae, which borders the Betulo - Eriophoretum

Figure 30. Massive mud flow scar on slope at approx. 1400 ft, south of Canoe Lake. End of stick indicates surface of permafrost table. (Photo by Krajina)

Figure 31. Area immediately below mud flow scar. Isolated islands of vegetation are left during the downslope movement of the fluid soil. Waterlogged exposed silty soil dominates the area. (Photo by Krajina)

Figure 32. Irregular mounds of soil and vegetated turf are formed where the flow stops. (Photo by Krajina)

Figure 33. Within one or two years the silty soil is covered by vegetation. On the upper more hydric (seepage) area below the scar, Senecio congestus and Eriophorum scheuchzeri dominate, while on the drier areas below Calamagrostis canadensis forms the major cover. (Photo by Lambert)

vaginati, with its deeper active layer might retain an excessive amount of moisture during summers of high precipitation. The high permafrost table of the Betulo - Eriophoretum vaginati restricts rapid lateral drainage from above so that intensive frost action in the autumn, followed by a saturated soil condition the following spring, results in a mass flow of material downslope. Downslope movements, such as those around lakes, can lead to a build up of sediment, cut off drainage outlets and lead, in time, to the obliteration of the lake.

VEGETATION, ENVIRONMENTAL AND SUCCESSIONAL RELATIONSHIPS

An understanding of the vegetational units as they relate to each other is clearly indicated by the dendrogram (Figure 9) in which each plot is compared with every other plot. Cluster analysis groups those similar plots together at certain levels of similarity and they, in turn, are grouped with larger clusters at correspondingly lower levels. This objective classification of the vegetation provides a picture of the species variation to be found in this region of the Low Arctic Subalpine/Foothill Zone. The variations are due mainly to differences in environmental factors in the various habitats and are related to such conditions as snow duration,slope, exposure, soil moisture, elevation etc. The dendrogram, however, only compares species composition and does not distinguish environmental relationships. An understanding of the major environmental factors will allow a greater understanding of community occurrence and distribution.

Major vegetational discontinuities are more easily recognized in arctic regions because of the low prostrate nature of the vegetation and a general lack of trees and shrubs. Transitions between vegetation units are generally very narrow in most cases, however, in sites where they are broad, classification is more difficult. In several instances transitions were analyzed because their species composition was considered to be homogeneous. These plots are included in the general analysis because they help to emphasize the major environmental gradients that occur between related units. As Dahl (1956) has noted, the ecological gradients are unknown at the initiation of any study and cannot be implied.

Many of the taxa recorded in the plots have broad ranges of amplitude and, therefore, are poor indicators of environmental change. However, a large number of species, many with low constancy and coverage values, are excellent indicators of changes in environmental conditions. Several vegetation types with similar species composition are separated because they dominate different habitats and are distinguished by differential species. This follows the floristic structure approach as applied by Braun-Blanquet (1928) in Switzerland and Krajina (1933-1934) in Czechoslovakia and the biogeocoenotic approach as applied by Suchachev (1944) in the U.S.S.R. and by Krajina et al. (1952-1967) in western North America.

Long term observations are deemed necessary for a clear understanding of development and successional trends of any vegetational types. Both study areas in this low arctic subalpine region are generally considered to have been unglaciated during the last ice advance. However, small rounded granitic boulders are present on the higher elevated ridges in the Canoe Lake area. Whether this implies that glaciation did occur in this area during the last ice advance is open to further study. Payne et al. (1951) consider the land has been above the sea since Early Cretaceous and was not glaciated during the Pleistocene. Considerable time has, therefore, elapsed so that development toward a vegetational climax is doubtless well advanced. A characteristic feature of arctic vegetation is the general lack of competition. This suggests that the present day communities must be very long enduring and very slow to develop. Vegetational differences associated with the environmental gradients as they relate to increasing elevation, snow cover and soil moisture are shown in Figures 34, 35 and 36, and indicate potential successional changes.

Only Spetzman (1959) has made any comparative studies between the Coastal Plain, Subalpine/Foothill and Mountain Zones in Alaska. Few details are provided on environmental relationships within the Subalpine/Foothill Zone so that no detailed comparisons are possible. The Subalpine/Foothill Zone in the Richardson and British Mountains is narrow, ranging in elevation from 1000-2500 ft at Canoe Lake and 500-1500 ft at Trout Lake. In both study areas the subalpine region is considered as one unit and not divided into subzones.

The vetetation of the Subalpine/Foothill Zone is dominated by ground birch, ericaceous plants, mosses and lichens. The ecosystematic units are characterized by a diversity of environmental conditions due to the irregular topography. Basically, two types of zonal vegetation are distinguished: the chionophilous units that are present in sheltered late snow bed habitats along creek banks, lake shores and draws, and the chionophobous units that occupy the exposed tundra slopes and wetland areas. Environmental conditions vary considerably in the latter.

Terrestrial communities on well drained soils that are never waterlogged may be distinguished by their substrate, depending on whether coarse or fine materials prevailing. Both types of material are present on ridges and slopes and this permits recognition of distinct vegetational units.

On relatively stable surfaces of the exposed ridges and felsenmeer slopes large blocks of exposed ice shattered parent material support a vegetation consisting for the most part of lichens with a few bryophytes. No units of this type were analyzed. On more unstable surfaces associated with these sites primary stages of vascular plant establishment are indicated by the presence of the Salicetum phlebophyllae. Soil and vegetational development are limited by soil movement due to intensive frost action and wind. Habitats associated with this association are considered to be xeric. They are covered by snow for no longer than 7 1/2 months each year. Physical weathering provides the coarse gritty materials for plant colonization and forms the basis for the Arctic Rawmark soils associated with the Salicetum phlebophyllae. Lichens cover the larger rocks with mat-forming species such as Salix phlebophylla, Arenaria arctica, Potentilla vahliana and the liverwort Gymnonitrion corallioides colonizing the coarse gritty sand that predominates in the more sheltered microhabitats. The mat-forming species have extensive root systems that assist in holding the soil. Rapid runoff of melting ice and snow leaves these sites well drained and during extended dry periods in the summer shallowly rooted plants may suffer from a water shortage.

Further development of this association appears to depend on the development, by frost heaving, of sites that afford the slightest protection from winter desiccation. Colonization of new sites is very slow and frost action might produce a suitable habitat only to destroy it before the mat-forming species are established. All observed and analyzed plots were small, seldom covering more than 25 sq. m in any one locality.

On more northerly exposed, straight to concave slopes below the Salicetum phlebophyllae at elevations close to 1950 ft where moisture conditions are more mesic to sub-xeric the dwarf shrub heath or Betulo - Ledetum decumbentis becomes established. This association is considered to comprise the major heath type vegetation at high elevations in the Subalpine Zone and is the upper altitudinal limit for Empetrum hermaphroditum and all Sphagnum species. Exposed coarse parent material is scattered throughout the community and provides protected sites of greater stability for the establishment of such species as Betula glandulosa, Ledum decumbens, Vaccinium vitis-idaea, Arctostaphylos alpina and Empetrum hermaphroditum. This heath vegetation is generally low to prostrate and serves as a shield to the more succulent vascular plants that are present on the upper slopes. Present on rocks are numerous crustose and foliose lichen species which attest to the slow downslope movement of the substrate. Lichen coverage is greater in the Betulo - Ledetum decumbentis than any other association and in number of species exceeds both the vascular plants and bryophytes. Bryophytes are scarce with only Dicranum elongatum and Ptilidium ciliare of major importance in the more moist microhabitats.

Drainage from the upper slopes supplies additional moisture during the early part of the vegetative season and is sufficient to maintain a relatively dense plant cover. Downslope movement of materials is indicated by the non-continuous pattern of vegetation. However, this movement is considered extremely slow since the larger boulders have a slower rate of movement, and the dense vegetative cover also inhibits frost heaving. Soil profiles are shallow and Rendzina-like with a medium to coarse sandy loam forming a thin mantle over the unconsolidated parent material. The active layer is thick consisting predominantly of parent material. Further downslope the proportion of exposed rock is reduced and the plant cover becomes more closed and a low hummocky type microrelief prevails. Moisture conditions are mesic during the summer and this is reflected by an increase in moss coverage.

A line of development within the Betulo - Ledetum decumbentis takes place on northerly exposed concave slopes. In these habitats snow cover is deeper and duration up to three weeks longer than on surrounding slopes. Indicative of the prolonged snow cover is the presence of Cassiope tetragona (Betulo - Ledetum decumbentis cassiopeetosum tetragonae). At no time does Cassiope tetragona completely dominate a site, but is always associated with Betula glandulosa (a species unable to withstand prolonged snow cover) and Ledum decumbens. All twenty-four plots in the Betulo - Ledetum decumbentis have high indices of similarity and are joined together at the 34 percent level.

The depression sites are generally steeper, a result of past mass movement of parent material and have a low hummocky profile. Surface accumulations of wind blown debris and local organic matter coupled with the deeper and more prolonged snow cover give rise to the development of Tundra Ranker-like Soils in the deeper depressions. In shallower depressions where snow cover is less and snow duration shorter soils are Rendzina-like with profiles resembling those of the Betulo - Ledetum decumbentis betulo - ledetosum decumbentis. The additional snow cover means that more moist conditions prevail in the cassiopeetosum tetragonae during the summer. Moss establishment and coverage is greatly influenced by this additional moisture and is indicated by the high constancy and coverage of Hylocomium splendens.

Species composition on the tops of the hummocks in the Betulo - Ledetum decumbentis indicate a close environmental relationship with the Salicetum phlebophyllae. Mat-forming species such as Salix phlebophylla, Dryas octopetala, Arenaria arctica and Oxytropis nigrescens are present and suggest that the hummock tops are exposed at times during the winter to desiccating winds and abrasive ice crystals.

A further line of development from the Salicetum phlebophyllae occurs on slopes with less northerly exposures where surface materials appear more stable. Mat-forming vegetation increases in abundance and the plant cover is more continuous. Snow duration is longer and cover deeper thus giving more protection to the vegetation and surface soil materials from winter desiccation. Sites dominated by Dryas octopetala replace Salix phlebophylla as a major species, but the latter remains a prominent member of the community. Mats of Salix phlebophylla are generally smaller and occur on more exposed microhabitats and are usually surrounded by Dryas octopetala. The raised microhabitats would appear more susceptible to loss of snow cover and, therefore, having environmental conditions similar to the exposed sites of the Salicetum phlebophyllae. This unit of the Lupino - Dryadetum *alaskensis lupino - dryadetosum *alaskensis (depauperatum) is underrepresented in the study area and appears more as a transition between both the Salicetum phlebophyllae and Betulo - Ledetum decumbentis, and Salicetum phlebophyllae and Lupino - Dryadetum *alaskensis dryado - salicetosum reticulatae - glaucae. Coarse materials prevail in half of the analyzed plots, and in the remainder finer materials predominate.

More southerly exposed slopes and ridges between 1500-2390 ft with fine soils are dominated by the species rich Lupino - Dryadetum *alaskensis dryado - salicetosum reticulatae - glaucae. The slopes are well drained and generally have a more complete snow cover, however, where it is lacking such sites are recognized by eroded vegetation and soil. Fine soil is blown from the surface during the snow free period when not held by the vegetation and rock fragments are continually brought to the surface by frost action. Habitats generally appear stable compared to the highly frost influenced soils of the ridges and frost modified soils of the lower slopes and wetlands. The slopes are free of snow by late May and approach a sub-xeric condition by late summer. Periods of frost action are, therefore, relatively short although freezing temperatures may occur at any time during the summer. As Sigafoos (1951) has pointed out, although the slopes appear stable they are not, and this is indicated by the step-like shape of the mat-forming vegetation with their raised fronts.

The dominant species are principally the mat-forming types, however, the presence of many non-mat-forming species gives the Lupino - Dryadetum *alaskensis a very rich vascular flora. Bryophytes, while not rare, do not form a major component of the association. Species with high constancy include Distichium capillaceum, Rhytidium rugosum and Aulacomnium turgidum. Because of a lack of exposed rocks in the community, saxicolous lichens are rare. Crustose species on exposed soil and dead plant material are common as are the foliose Cetraria species.

Soils are Rendzina-like with a thin organic layer overlying a shallow mineral layer which, in turn, overlies unconsolidated parent material. The upper horizon is rich in calcium and has a high pH (average 6.1) Species that are indicative of the calcareous nature of the soil include Salix reticulata, Rhododendron lapponicum, Silene acaulis and the yellow lichen Cetraria tilesii. Due to the well drained nature of the soil permafrost is absent from at least the upper half meter.

At lower elevations, usually on steeper slopes, solifluction is more evident from the elongated step-like form of the vegetative mats that lie parallel to the direction of the slopes. Soil profiles are more moist due to increased seepage from the upper slopes. At this stage on the less exposed slopes there is rapid successional change toward the climatic climax Vaccinio - Betuletum glandulosae. On more exposed slopes the change is toward the Betulo - Ledetum decumbentis than to the Vaccinio - Betuletum glandulosae.

The Vaccinio - Betuletum glandulosae has an extensive distribution on the mid to upper slopes with southerly exposures and at lower elevations on the mid slopes with northerly exposures. It has a less extensive distribution on lake and creek banks. All sites are moderately well drained, although the rapidityof drainage varies between habitats. The association is characterized by a hummock-depression microrelief. The hummocks are elongated and lie parallel to the direction of the slope. Drainage from the upper slopes is channeled downslope in the depressions during the early part of the summer so that water is available to the plants that form a dense cover on the hummocks and in the depressions. Signs of mass movement of surface materials in the more recent past are not readily apparent. This phenomenon would appear more common on either the drier steeper upper slopes or the water saturated lower slopes. The Vaccinio - Betuletum glandulosae would, therefore, appear to be in the steady-state with respect to productivity, structure and population with the dynamic balance of the population related to the slow rate of downslope movement of surface materials. Moisture present in these sites is susceptible to freeze-thaw cycles for longer periods than in the drier more exposed upper slopes. Conversely, the Vaccinio - Betuletum glandulosae dominated slopes are not so poorly drained that frost action results in the destruction of the elongated hummocks.

Upland depressions with northerly exposures that have a deep but not prolonged snow cover (snow pockets, Porsild, 1951) are dominated by shrubs Betula glandulosa, Salix glauca and Vaccinium uliginosum. The sites are never as large as the Betulo - Ledetum decumbentis cassiopeetosum tetragonae sites. When produced as a result of mass movement of surface materials Betula glandulosa, Vaccinium uliginosum and associated species were probably left on isolated islands of debris in the depression and became the initial species in the recolonization of the site. Protected by the sides of the depression and the winter snow Betula glandulosa grows to shrub height. Cassiope tetragona, a species unable to tolerate shade, cannot become established and compete.

Shrub Betula glandulosa and Vaccinium uliginosum dominate less exposed sites on lake and creek banks where a protective snow cover appears unnecessary. Drainage in these habitats is generally rapid because of a reduction in hummock size, however, seepage water is more prevalent at lower depths coming from the poorly drained lower slopes above, Raup (1950) suggests that some of the most stable sites in high latitude regions are on creek banks whereas in temperate regions they are among the most unstable.

Characteristic species in the climatic climax Vaccinio - Betuletum glandulosae are limited to Carex lugens and Castilleja pallida. The abundance of Vaccinium uliginosum is attributed to the mesic condition of sites where it is present on hummocks and in depressions. This species is present on a wide variety of habitats ranging from half-bog to the xeric upper slopes and can withstand a certain degree of frost heaving. On the drier slopes Vaccinium uliginosum is present in the more moist depressions and on the lower slopes on the drier hummocks. In the depression and lower slope sites of the Vaccinio - Betuletum glandulosae fruticosum vascular species composition is restricted in degree of coverage by the shading effect of the shrubs. The number of lichen species present with high constancy and coverage values is greatly reduced in the Vaccinio - Betuletum glandulosae while that of the bryophytes is increased. The hummocks have an abundance of vascular plants because snow protection and, therefore, restrict lichen establishment, while the moister depressions favour additional bryophytes.

The range in elevation of the Vaccinio - Betuletum glandulosae indicates that a favourable snow cover is provided. However, the occasional presence of Salix phlebophylla, Dryas octopetala, Lupinus arcticus and Arenaria arctica on the elongated hummock tops would suggest that these microhabitats are exposed at times during the winter. Drainage is never as rapid as on the lower slopes or as restricted as on the lower slopes. Soils are classified as Arctic Brown and because of the mesic conditions profile development is generally deeper than the more sub-xeric sites. Soil profiles indicate a variation in profile morphology with the drier hummocks having a greater degree of genetic development than the depression. Solifluction has an affect on the continuous morphology of the profiles and amorphorous profiles are not uncommon, as is the case on any of the slopes at higher elevations in the mesic to xeric habitats. Permafrost lies close to the surface (within 60 cm) and unconsolidated parent material was not evident in any of the sampled profiles although coarser materials were found throughout, a result of frost heaving.

On the upper well drained slopes the successional sequence toward the mid-slope mesic Vaccinio - Betuletum glandulosae appears to be in a static state. Communities appear stable and uniform in both species composition and soil development. Transitions between communities are generally narrow although never as sharp as some in the poorly drained wetlands. Congeliturbation in the surface layers, while increasing in intensity from the xeric to the mesic sites, seems to have no great effect on the botanical landscape. Community zonation seems readily definable according to elevation, exposure and soil moisture. Vegetational differences associated with the environmental gradient of decreasing elevation and increasing soil moisture are diagrammatically outlined in Figure 34.

On northerly exposed draw slopes at higher elevations (1750-1850 ft) are several sites dominated by Betulo - Eriophoretum vaginati salicetosum reticulatae. The sites are bordered by sparsely vegetated slopes of the Lupino - Dryadetum *alaskensis lupino - dryadetosum *alaskensis (depauperatum) with no indication of any successional sequence between them. However, several species common in the Betulo - Dryadion are present on the hummock tops, they are: Dryas octopetala, Salix glauca, Lagotis glauca, Oxytropis maydelliana and Salix phlebophylla. Sphagnum lenense, a characteristic species of the Betulo -

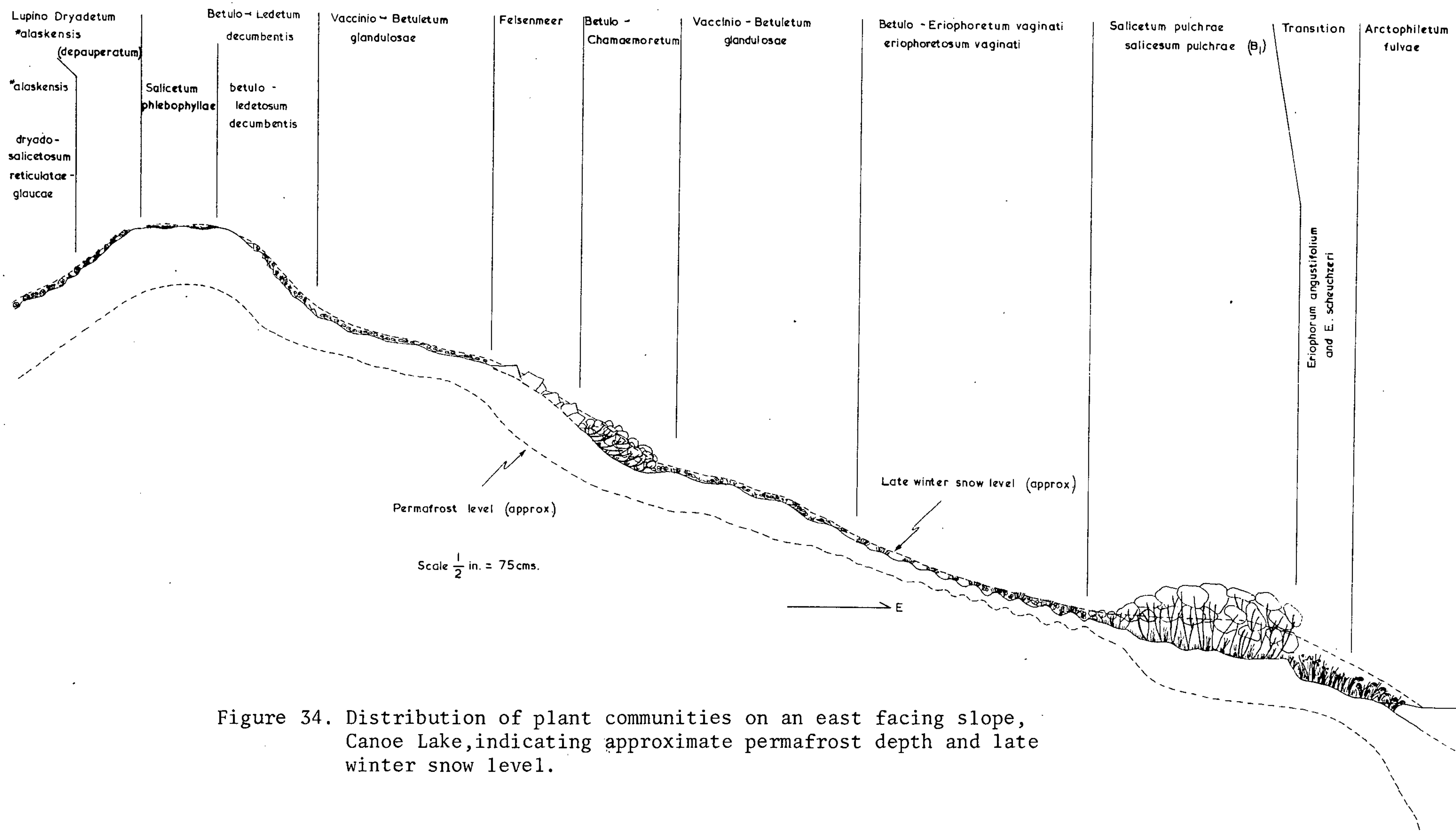


Figure 34. Distribution of plant communities on an east facing slope, Canoe Lake, indicating approximate permafrost depth and late winter snow level.

to follow page 138

Eriophoretum vaginati betulo - eriophoretosum vaginati on the lower slopes, is absent. Soil morphology is considered to represent the Tundra Moss type as profiles are similar to the *Eriophorum vaginatum* dominated sites on the lower slopes. These upland habitats appear to have a close relationship with the surrounding communities in regard to species composition, however, they do have richer soil profiles due to the drainage and seepage waters channelled into the draws.

The sequence of vegetation in the wetlands is initiated from both lakes and streams. A series of zones parallel to the water's edge dominated by different species is apparent. High cut banks invariably separate the lake shore communities from those of the tundra slope so that a potential successional change is not easily imagined. The shore line water is occupied by the emergent aquatic *Arctophila fulva* (Arctophiletum fulvae) and *Hippuris vulgaris*. Peripheral to the Arctophiletum fulvae and generally above the low water level may be successive narrow communities of *Carex aquatilis*, *Eriophorum scheuchzeri* and *Eriophorum angustifolium*. Such bryophytes as *Drepanocladus aduncus* and *Calliergon stramineum* are common in the flood zone. Changes in vegetation depend on changes in water and aeration relationships and peat accumulations. Rates of change may also be affected by any number of geomorphic factors as related to changes in drainage. *Sphagnum* species are not present in any of the lake shore communities which attests to the seasonal flooding and ice scouring along the shorelines that occurs in these microhabitats. The soils are primarily Oligotrophic Gyttja with increasing quantities of nutrients becoming available as the water level drops. Accumulation of organic material coupled with reduced water levels and a rising permafrost table are an important stage of development toward the bog or mire development.

Under conditions of impeded drainage lakes that have been obliterated by organic accumulations are dominated primarily by *Carex aquatilis* with additional

Carex species and _Eriophorum scheuchzeri_. Where open water occurs _Potentilla palustris_ is abundant. Changes in drainage patterns restrict water flow into the sites and this is reflected in an increase in the number and abundance of _Sphagnum_ species. A high water table is maintained by the permafrost which is close to the surface. Standing water comes from melting snow present on the site and any drop in its level is due to the thawing of the active layer. This type of habitat resembles the Alaskan bogs described by McNamara (1964). Surface topography is generally flat with little or no evidence of patterned ground. Where cutbanks are lacking on the old lake edges the Caricetum aquatilis is replaced by the Betulo - chamaemoretum.

In wetland areas, associated with impeded drainage, frost and geomorphic processes may produce micro-relief features that increase runoff and effectively reduce the moisture content of the upper soil horizon. Relatively few areas, and all of these small, fall into this category in the two study areas. In the initial stages of development of low-centered polygons the small low drier rims support small woody shrubs and ericaceous species. Britton (1957) has commented on the chaotic distribution of vegetation in the low-centered polygons in Alaska. However, this does not appear to be the case in this region of the Subalpine/Foothill Zone except in relation to bryophyte distribution where no two species ever appear to dominate more than one location.

The _Eriophorum scheuchzeri_ appears to be able to withstand environmental changes incurred by its own organic deposition for long periods and is only replaced by the gradual encroachment of _Sphagnum_ species. With the accumulation of organic matter there is a drop in water level and an increase in intensity of frost action. With an increase in size and number of ice-wedges peaty hummocks appear as unsorted features throughout what was originally a depression. Soil morphology is at times difficult to interpret because of the mixing of organic and inorganic components. The soil has been classified as low-centered polygon mire.

Developing out of the Eriophoretum scheuchzeri, following the break-up of the polygonal pattern of microrelief, are the Caricetum rariflorae mire sites. The process of peat accumulation is accentuated in the growth of the Sphagnum mounds with Carex rariflora and C. rotundata dominating the water filled depressions. When the mounds become sufficiently high an inadequate water supply restricts further Sphagnum growth. The peat undergoes changes the drier it becomes, showing increased oxidation and humification. During this desiccation the generally low nutrient status of the mire improves producing a more suitable environment for the establishment of broadly tolerant dwarf heath species, lichens and additional mosses. The potential successional development of the wet communities is outlined in Figure 35.

Closely associated with and generally bordering the mire or wetland communities is the Betulo - Chamaemoretum. This association is characterized by a low hummocky microrelief and is associated in many instances with old drainage pathways with seepage continuous throughout the summer. Low shrub species (Salix pulchra, S. glauca and Betula glandulosa) are present in many of the sites which indicate a deeper snow cover giving added protection against winter desiccation. There is close affinity between the Betulo - Chamaemoretum and Caricetum rariflorae due to the presence of such species as Andromeda polifolia and Pinguicula villosa and numerous Sphagnum species. The Betulo - Chamaemoretum closely resembles the Chamaemoreto - Sphagnetum acutifolii described from Central Norway and considered by Dahl (1956) to represent the climax of mire succession.

At lower elevations (between 1175-1475 ft) on steeper slopes the Betulo - Chamaemoretum is characterized by a shrub layer dominated by Alnus crispa with a mixture of Salix pulchra, Betula glandulosa and Spiraea beauverdiana. These sites are generally present below exposed felsenmeer and are, therefore, wet during the early part of the summer due to considerable seepage from the upper

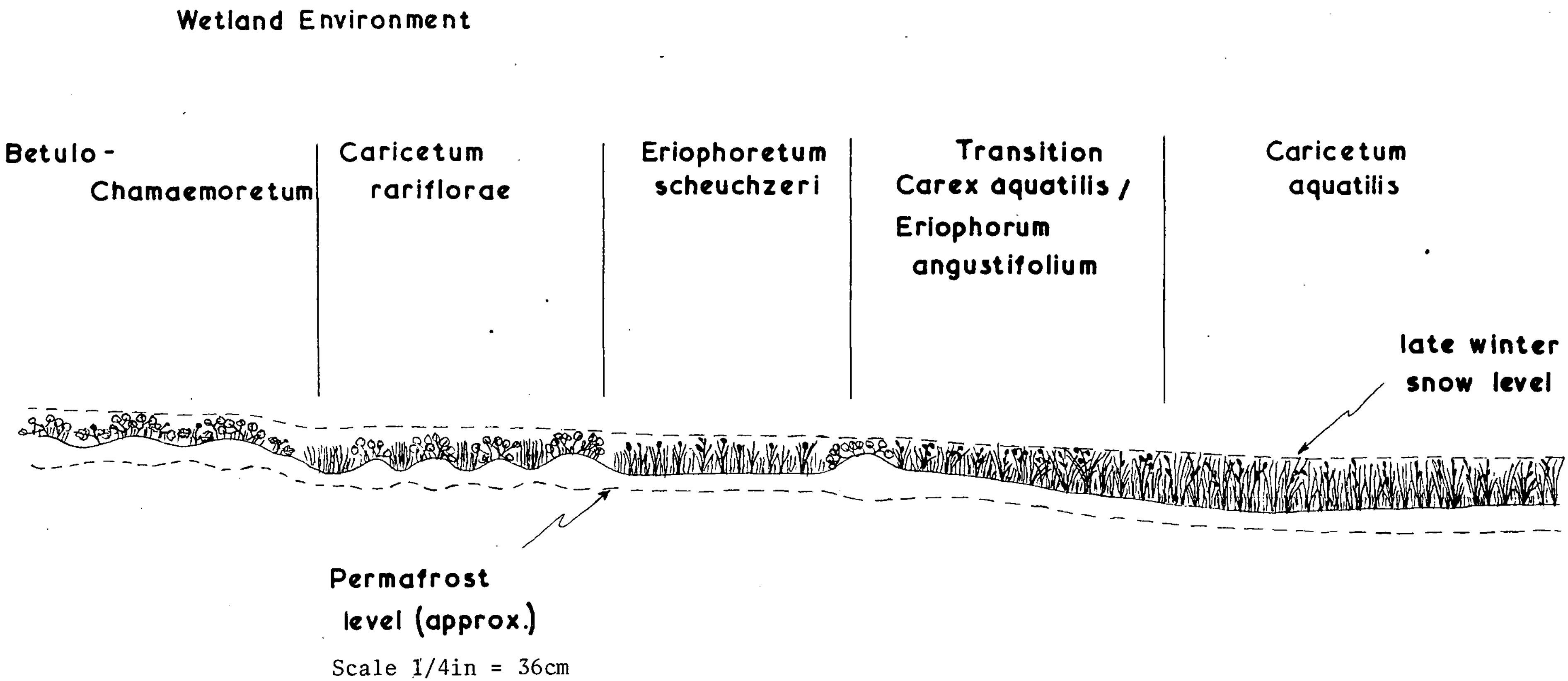


Figure 35. Distribution of semi-terrestrial communities in an area of impeded drainage, Canoe Lake, indicating approximate permafrost depth and late winter snow level.

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slopes. The C layer vegetation in the Betulo - Chamaemoretum alnetosum crispae is similar to the betulo - chamaemoretosum being characterized by high constancy of Rubus chamaemorus, Vaccinium uliginosum, V. vitis-idaea, Ledum decumbens, Empetrum hermaphroditum, Lycopodium annotinum and in the D layer by Sphagnum girgensohnii. Mesophytic lichens such as Cetraria cucullata and C. nivalis are present on the drier hummocks. The high constancy and coverage of Sphagnum girgensohnii suggests that the sites, while poorly drained, are only temporarily waterlogged in the upper soil horizons. Soil profiles are characterized by peat layers of varying thickness overlying a gleyed horizon. In the Betulo - Chamaemoretum alnetosum crispae the surface horizon has a relatively high average exchangeable calcium value. This would suggest the presence of calcareous materials in the exposed felsenmeer above the sampled habitats.

Alnus crispa is also present along sheltered creeks, but usually only as a sub-dominant to Salix pulchra or S. alaxensis. No plots of this type were analyzed. Hanson (1953) has described Alnus crispa dominated sites on slopes and bluffs in northwestern Alaska. Species composition is similar to the Betulo - Chamaemoretum alnetosum crispae in this study except that Hanson does not mention the presence of Rubus chamaemorus. Churchill (1955), Britton, (1957) and Spetzman (1959) have observed Alnus crispa dominated sites along creeks in northern Alaska.

Associated with the wetlands and generally separated by a sharp transition such as a cutbank, are the Betulo - Eriophoretum vaginati dominated lower slopes. The association occurs on fairly level to gently sloping ground and is characterized by intensive frost action as indicated by the tussock-depression micro-relief. The Betulo - Eriophoretum vaginati has been described by Porsild (1951) as climax in the unglaciated coastal plain region on northern Alaska. Similarly the association closely resembles the cottongrass - sedge - dwarf heath shrub in northwestern Alaska as described by Hanson (1953). In this region of the Subalpine/Foothill Zone it is poorly represented, probably due to the more irregular topography.

There appears little variation in uniformity of tussock growth between the lower and more elevated slopes except that on the former sites they are taller. This is related to an increase in soil moisture leading to an increase in intensity of frost action. Dwarf shrub species, Betula glandulosa and Salix pulchra are present only in the C layer along with several ericaceous species, notably Vaccinium uliginosum, V. vitis-idaea and Ledum decumbens. The increase in abundance of the dwarf heath species is an indication of the more mesophytic condition of the tussock substrate and the longevity of the individual Eriophorum vaginatum complex. Sphagnum species, especially Sphagnum lenense, are abundant in the wet depression with lichens present with increased abundance on the more open tussocks.

Moisture conditions vary from hydric to semi-hygric throughout the summer with drainage water from the upper slopes impeded by the tussocks. The soils are similar to those of the Betulo - Chamaemoretum and are classified as Tundra Moss. The surface horizons have a high organic content and the mineral horizon shows considerable gleying. Permafrost is close to the surface, however, levels vary being deeper under the hummocks than the depressions.

At higher elevations on the slope the Betulo - Eriophoretum vaginati grades into the climatic climax Vaccinio - Betuletum glandulosae. Tussocks are sparse and intermingled with short elongated hummocks and indicate lesser amounts of drainage water, more permeable soils, a lower permafrost table and reduced frost action in the mineral soil.

Drainage pathways are a major feature of the subalpine landscape. At higher elevations they appear as small linear depressions, downslope they converge to form recognizable small creeks that are several feet or more below the surrounding tundra surface. There is a successional sequence of progressively taller vegetation in the form of shrubs from the higher to the lower elevations.

On the upper slopes early stages of development in the small drainage pathways are distinguished by an abundance of *Eriophorum angustifolium* in association with *Salix pulchra* and *S. arbutifolia* (Eriophoretum angustifoli salicosum pulchrae). Free flowing surface water is present only during the early part of the summer with seepage generally occurring throughout the remainder of the vegetative season. Frost heaving is common during the spring and autumn and a tussock-type condition prevails in isolated instances. Downslope the smaller pathways converge and deeper, wider depressions form. Species composition is still predominantly *Eriophorum angustifolium*, however, *Salix pulchra* is more abundant. Snow coverage is deeper and remains longer than on the surrounding slopes. Free flowing surface water is present for longer periods because of the total area above involved in drainage. The presence of *Betula glandulosa* and other dwarf shrub heath species indicate that the water table must drop during the summer resulting in environmental conditions suitable for their establishment.

Mass movements of surface materials above the small drainage pathways may result in changes in direction of flow of surface melt water. The major source of soil moisture is then present in the form of seepage. The reduction in moisture leads to increased frost action in the mineral soil giving rise to a more hummock type of microrelief. Dwarf heath species bordering the 'old' drainage pathways migrate into the site and within time the hydrophilous *Eriophorum angustifolium* is replaced by more mesophytic species.

If the successional sequence is followed downslope the deeper and wider the drainage pathways become the more abundant and taller is the *Salix pulchra*. Excessive amounts of melt water during the summer and the heavy prolonged winter snow cover lead to the replacement of *Eriophorum angustifolium* by *Equisetum* arvense, Petasites frigidus and an increasing number of chionophilous species. Generally the sites with the tallest shrubs are on the lower reaches of the slopes bordering lakes and creeks. However, in sheltered positions on the slopes up to 1600 ft, stands of Salix pulchra over 8 ft high are not uncommon. These sites are covered by snow early in the autumn and thus protected from winter desiccation. Willow shrub types in northwest Alaska have been described by Hanson (1953). The Greenleaf Willow type associated with drainage pathways corresponds very closely to the Salix pulchra dominated sites in this region of the Subalpine/Foothill Zone.

Surface topography in the pathways where Salix pulchra dominates is generally hummocky, a result of meandering surface flood water and because of this soil profiles vary considerably from place to place. However, they all show the characteristic muddy dystrophic anmoor formation due to waterlogging and continual seepage and are classified as Tundra Anmoor. At higher elevations profiles are shallower, but, nevertheless, still have the typical Tundra Anmoor morphology. The thickness of the active layer increases in depth at the lower elevations due to the excessive amounts of drainage water that pass over the sites and the early and prolonged winter snow cover that shields the ground surface from sub-zero temperatures.

Communities bordering the drainage pathways on the lower slopes generally have a more abrupt transition and consequently lower indices of similarity than the neighbouring communities on the upper slopes where depressions are shallow. There is no observable pattern of development between the Salicetum pulchrae and such communities as the Betulo - Chamaemoretum or Betulo - Eriophoretum vaginati.

There is an additional line of development that does not necessarily lead to widening of drainage pathways and dominance by Salix pulchra. On shallower slopes above poorly drained areas or wetlands the linear depressions are dominated by a closed cover of Eriophorum angustifolium. Where running surface water is present during the summer, Sphagnum species are seldom present except above the flood zone. If the flow is stopped Sphagnum species colonize the wet depressions. Successional development in these habitats is toward the Betulo - Chamaemoretum or Betulo - Eriophoretum vaginati type. This is especially evident where mass movement of surface materials higher up the slopes have resulted in changes in direction of drainage water. Drainage is then primarily in the form of seepage. The annual affect of frost action over a prolonged period of time results in a hummock-depression micro-relief with a Tundra Moss soil type developing.

The occurrence of a persisting snow cover along creeks in the Alaskan Foothills has been reported by several workers (Hanson, 1953, Churchill, 1955, Britton, 1957, Spetzman, 1959 and Bliss, 1956) and in eastern Canada by Polunin (1948). However, there have been no detailed analyses of these habitats as to length of snow cover, species composition and soil type similar to the contributions in Scandinavia by Gjaerevoll (1950, 1956), central Europe by Braun-Blanquet (1932) Krajina (1933) and in Scotland by McVean (1964).

Sites where snow accumulates in winter and persists long into the summer have been termed 'snow-beds' by Porsild (1951). The microzonation of species is largely the result of adaptations to depth and duration of snow cover (Billings and Bliss, 1959). Gjaerevoll (1956) has suggested that the true snow-bed vegetation can only be distinguished when the vegetative season becomes too short to permit the establishment and growth of Vaccinium myrtillus. In arctic North America this would probably be equivalent to the absence of Vaccinium uliginosum, however, in this study all vegetation showing the influence of a persisting snow cover is considered to be snow-bed vegetation.

Early workers (Gjaerevoll, 1950, Dahl, 1956, Churchill and Hanson, 1958) have considered the dynamic approach to be unpromising when dealing with stable communities where the major influencing factor is a prolonged snow cover. It is evident as pointed out by Dahl (1956) that where there are considerable differences in snow cover little succession of any importance can take place between bordering communities because steep environmental gradients occur over a relatively small area. As long as the climate remains constant the same accumulation of snow will occur in the same localities each winter. The transition zone between the two habitats will fluctuate, but the general pattern of vegetation will remain constant. An understanding of this problem can only be found by describing the vegetation of the two communities and to relate the differences to environmental factors.

The true late snow-bed moss dominated or Schneetalachen are very rare in the two study areas and were not analyzed. The major late snow-bed association is the Salicetum pseudopolaris, which is generally present on moderately steep concave or straight slopes in draws or amphitheatres. Many of the species associated with Salix pseudopolaris are mat-forming and include Arenaria sajanensis, Saxifraga rivularis, Ranunculus pygmaeus and Sibbaldia procumbens with two mosses - Polytrichum norvegicum and Pohlia drummondii. A feature of these sites, that differs from the late snow-bed communities described in Europe, is that the persisting snow cover is generally below the community and seldom above. This implies thawing is more rapid on the upper levels and can be related to seepage water draining from the slopes.

Edaphic conditions indicate that the soils belong to the Snow Basin Rutmark. Profiles are poorly defined and subject to continual disturbance due to irrigation by melt water and seepage. The Salicetum pseudopolaris dominated sites, while unstable, appear to be static and give no indication of developing a more closed plant cover. This association has an affinity with the Salicetum herbaceae in Europe (Braun-Blanquet, 1964), however, from the species lists it would appear that it is a compilation of several associations. Krajina (personal communication) has recognized several of the associations listed by European workers in this subalpine region, however, these were not studied by me. More detailed studies are, therefore, needed on these very late snow-bed communities before any definite statements can be made concerning the different types, distribution and successional sequence.

Conspicuous snow-bed communities that are common on east to south facing sheltered creek banks in this region of the Subalpine/Foothill Zone at elevations between 1060-1800 ft are characterized by the Salicetum chamissonis. The association has not been described before in Arctic North America or in Europe, but can probably be considered to resemble the herb and fern meadows described from the subalpine and low alpine zones in Central Europe, Scandinavia and Scotland. In this region of the subalpine zone the snow-bed/meadow vegetation is dominated by herbs with ferns completely absent.

It has been stated earlier, that due to seepage from above, thawing starts on the upper side of the snow bank and progresses downslope. In the snow-bed/meadow communities the last areas to be free of snow are those closest to the creek, they represent the early stages in development of the Salicetum chamissonis. Prostrate Salix chamissonis forms the major coverage with individual clumps of sedges, grasses and herbs scattered throughout the habitat. Slightly further up the bank where the snow free period is longer coverage by Salix chamissonis is less and tall sedges, grasses and herbs form the dominant vegetation. Salix chamissonis is intolerant to their shade and is, therefore, unable to compete.

Moisture conditions in the Salicetum chamissonis salicosum chamissonis remain moist following snow melt because of a shorter snow free period while the Equisetosum arvensis; Festucosum altaica; Caricosum montanensis; Arctagrostidosum latifoliae dominated habitats, due to longer exposure, exhibit a greater degree of drying out. Soils are classified as Snow Basin Anmoor in the Salicosum chamissonis sites and those in the tall sedge, grass and herb as approaching a mull-like moder form (Kubiena, 1953). No statement can be made regarding any possible change in depth of permafrost under these snow-beds in relation to increase in snow free periods as the perennially frozen ground was never reached in any of the soil pits.

In several localities a successional sequence of development was observed starting with a very narrow band of Salicetum pseudopolaris just above the water followed by Salicetum chamissonis salicosum chamissonis with the taller sedges, grasses and herbs toward the top of the bank bordering either shrub Salix pulchra or a vertical cut bank. A potential successional change as related to annual snow duration is diagrammed in Figure 36.

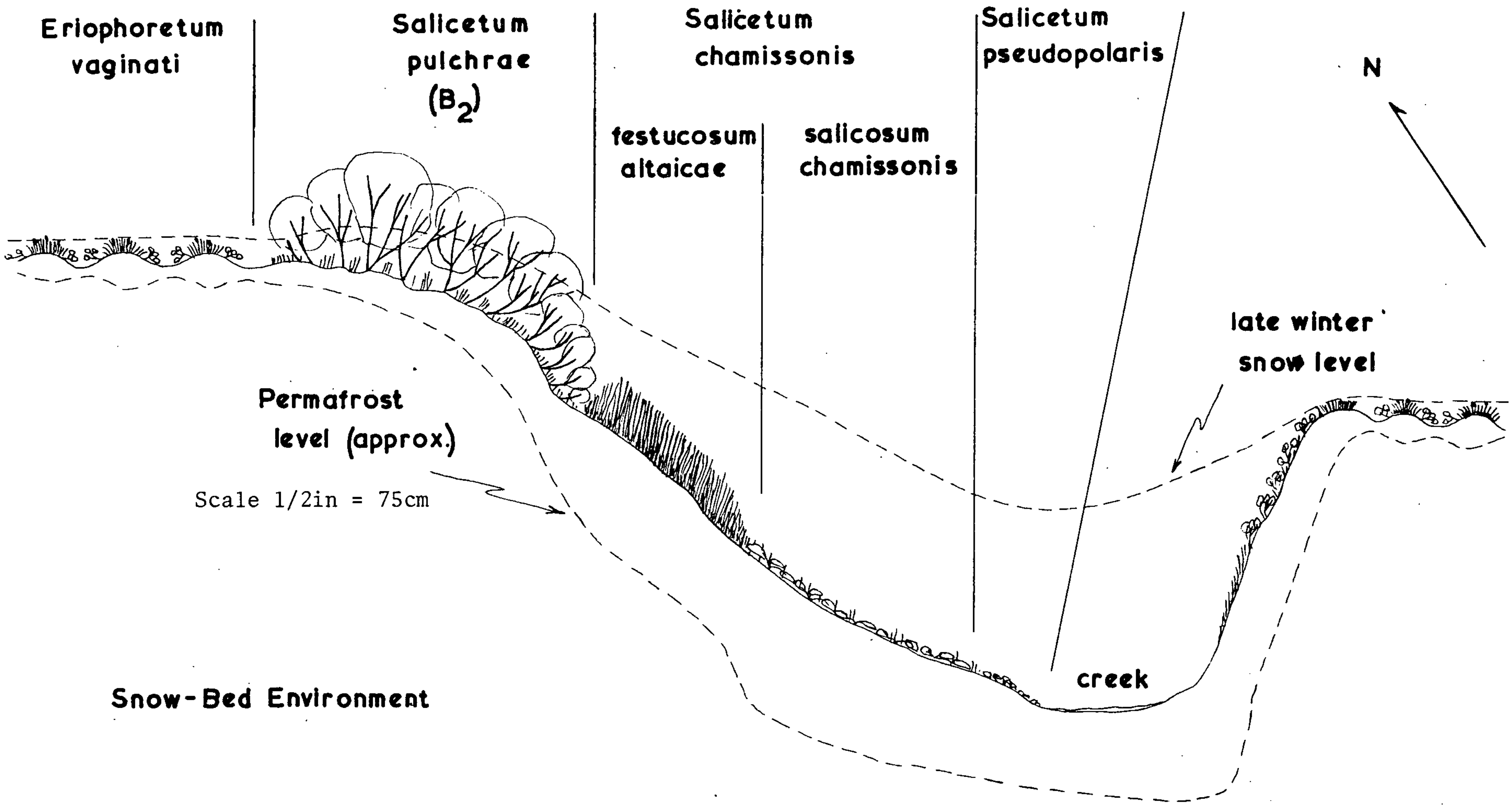

Figure 36. Distribution of chionophilous and slightly chionophilous communities on a southeast facing slope, Canoe Lake, indicating approximate permafrost depth and late winter snow level.

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SUMMARY AND CONCLUSIONS

The main objectives of this thesis are to describe the vegetation and soils and to determine the major environmental factors controlling their distribution and development and to incorporate these results, and those of earlier workers, into a usable classification of identifiable subalpine ecosystematic units. The main findings of this study are summarized below.

1. The Low Arctic Subalpine/Foothill Zone is defined altitudinally at its upper limits by the lack of a true Alpine Zone within the immediate are surrounding both Canoe Lake and Trout Lake. Alpine species are present in the upper limits of the Subalpine Zone indicating that exposed positions are environmentally similar to the lower limits of the Alpine Zone. Within the study area the topography varies from regular to irregular with increased diversity of environmental complexes and vegetation types. At lower elevations vegetation - environment relationships appear similar to those of the Coastal Plain in that they are less complex. In this study zonal limits were placed at 1000-2400 ft in the Canoe Lake and at 500-1500 ft at Trout Lake.

2. The Subalpine Zone can be readily identified in the field by the abundance of dwarf shrub and predominantly heath species that include Betula glandulosa, Vaccinium uliginosum V. vitis-idaea and Ledum decumbens. The generally prostrate nature of these species suggests that a minimal snow cover is sufficient to protect them from winter desiccation. At the lower limit of the zone the poorly drained condition of the soil restricts establishment of all four species to better drained microhabitats such as hummocks and mounds. The upper limit of the zone is marked by their absence.

3. The limited climatic data collected in this study allow no conclusive comparisons to be made with data collected at Umiat, Alaska, over the past ten years.

4. Snow duration is long (7 1/2 - 11 1/2 months). Accumulation is generally

not excessive except in certain habitats. Actual measurements to determine the depth of snow, however, were not made. Two major vegetation types are distinguished, the chionophilous and the chionophobous. The chionophobous vegetation dominates the ridges, slopes and wetland habitats. Snow accumulation is considered light to moderate with many exposed sites free of snow during the winter. Slopes with a hummock-depression microrelief tend to have greater accumulation of snow in the depressions with hummocks occasionally exposed during the winter. Wetland habitats generally have a complete even snow cover. Chionophilous vegetation is restricted to east-south facing sheltered slopes where considerable accumulation of snow and its long duration are a major microclimatic and environmental influence controlling species distribution.

5. Zonal features of the chionophobous vegetation can be related to elevation, exposure, soil moisture, soil type, thickness of the active layer, congeliturbation and topography. There are no strong macroclimatic differences within the zone to support its separation into subzones. While topographic differences occur, the historical and parent material characteristics are quite similar in the two study areas. Similar habitats, communities, soils, microclimatic conditions and patterns of development occur in both areas.

6. In sites where the topography is irregular, soil moisture conditions vary considerably. Coarse parent material on or close to the surface, sparse snow cover, a thick active layer and moderate slope generally give rise to xeric conditions. On the slopes melting snow, seepage from above, a high undulating permafrost table and finer soil materials result in more mesic conditions. In the wetlands impeded drainage due to a very high permafrost table result in hydric to semi-hydric conditions prevailing throughout the summer.

7. Glacial evidence indicate that the Low Arctic Subalpine Zone was free from ice during the Pleistocene glaciation, however, local glaciation may have

occurred. This speculation is based on the presence of pebbles in the soil profiles that are considered to have been derived from a distant source. Vegetation data presented here suggest that the dynamics favouring successional trends, while evidently occurring in the past, are proceeding at a very slow rate. Community development on the upper slopes and exposed ridges and escarpments is considered very stable under the present topographic and climatic conditions. Successional concepts appear to be of limited value because the communities tend to be discrete. Gradients do exist between communities, but they are generally narrow and reflect changes in elevation, exposure, slope gradient, snow accumulation and duration, soil moisture and varying intensities of congeliturbation. On the other hand, the lower slopes and wetlands, due to their impeded and poorly drained condition, coupled with intensive frost action, appear to be in a state of flux. Earlier workers (Gjaerevoll, 1950, 1956, and Dahl, 1956) concluded that the sharp environmental gradients between neighbouring chionophobus and chionophilous communities were evidence that the climate had undergone no significant change in the recent past. This finding is further supported by the data presented in this study.

8. On the basis of 166 plots which could be classified, six orders, eight alliances, fourteen associations, ten subassociations and thirteen variations were distinguished. Similarities between the Low Arctic Subalpine/Foothill Zone communities and those in other arctic regions, especially Scandinavia are indicated. The order Betuletalia glandulosae dominates the two study areas, and occurs on the moderately to well drained mesic to xeric slopes. The order Petasitetalia frigidi is distinguished for the first time in North America and includes the previously undescribed chionophilous Salicetum chamissonis.

9. Early stages of vegetational development are evident on the exposed ridges and escarpments, however, their further development is considered to be restricted by the unstable substrate. On lake shores scouring ice would appear

to restrict vegetational development beyond the initial stages. Local disturbances related to mudflows are evident in the two study areas mainly around the lakes. The pattern of development in the mudflow sites suggests a return to the original dwarf heath shrub vegetation after initial colonization by grasses, sedges and herbs.

10. The Vaccinio - Betuletum glandulosae most closely approximates the climatic climax in the Low Arctic Subalpine Zone within the two study areas where it occupies mesic habitats. Soil profiles are well drained and relatively deep with a narrow organic layer overlying a well defined mineral layer and are considered to represent the mature Arctic Brown soil type described by Tedrow et al. (1958). Two variations are distinguished a) fruticosum - shrub size birch present in depressions on the upper slopes and in sheltered sites on the lower slopes and lake shores; b) fruticulosum - birch prostrate (under six inches) present on the more exposed slopes at higher elevations.

11. Development in the wetlands appears toward the Betulo - Eriophoretum vaginati which is considered here to be the successionally most advanced community type on the poorly drained sites with permanent seepate. This pattern of development is proceeding at an extremely slow rate and the vegetation may be considered to have an autogenic influence in such sites as pools and mires, where humus is accumulated and vegetational changes from a hydric to a semi-hydric condition exist. Environmental conditions on the hummocks are similar to those in the mesic habitats and support a dwarf heath shrub vegetation type.

Additionally, Betulo - Eriophoretum vaginati occupies a limited number of exposed topographic positions on the upper slopes with temporary seepage from surrounding sparsely vegetated slopes. These two positions approximate the meadow tundra in the former case and the upland tundra in the latter as defined by Tedrow et al. (1958). The generally irregular topography limits the areal coverage of the association and reduces its overall importance in this region of the Low Arctic Subalpine Zone.

12. The most advanced chionophilous vegetation type is considered to be the Salicetum chamissonis (festucosum altaicae and arctagrostidosum latifoliae). In drainage pathways, dominated by Salicetum pulchrae, tall shrubs act as a barrier and cause deep accumulations of snow. Ground conditions are considered slightly chionophilous and this is substantiated by the high number of chionophilous herbs, grasses and sedges present in the association. The ability of these species to complete their vegetative and reproductive cycles suggest they would be physiologically unable to survive in habitats with a prolonged snow free period.

13. As a result of a short growing season and low soil temperatures organic matter accumulation and decomposition are very slow. On the upper slopes chemical weathering is considered to be more active because thawing occurs early in the season and soil temperatures are higher than in the wetlands. On the well drained ridges and escarpments, due to a lack of moisture, physical weathering is more prevalent than chemical weathering.

14. Major factors influencing soil development in the Low Arctic Subalpine Zone are the short snow free period (1/2 - 5 1/2 months), a thin active layer and a high moisture content, except for those soils on ridges, escarpments and upper slopes. Gleization appears to be the major soil forming process in this region of the zone. It is associated with a permafrost table close to the surface, as found on the mid to lower slopes and also in the chionophilous communities where the active layer is very thick. In the former case gleization is favoured by poor drainage and a hummock-depression relief, in the latter it is favoured by a slow snow melt, short snow free period and a water saturated soil profile prior to snow melt.

Earlier workers (Tedrow and Hill, 1955, Douglas and Tedrow, 1960, and MacNamara, 1964) have considered that the high organic content, cation exchange capacity and the low acidity and base saturation are important chemical characteristics of the subalpine soils. The soil data presented here supports conclusions.

15. Following criteria used by Kubiena (1953) and Tedrow et al. (1958), the 166 plots were tentatively classified as to a particular soil type. Twelve soil types were distinguished in the three major divisions, they are: Sub-Aquatic (Gyttja, Fen and Mire), Semi-Terrestrial (Rutmark, Anmoor-like, Tundra Moss and Peat Anmoor) and Terrestrial (Rawmark, Ranker, Arctic Brown shallow phase and Arctic Brown normal phase). Soil of the Terrestrial Division are present only on the mid to upper slopes under xeric to mesic habitat conditions. Semi-Terrestrial soils are related to poorly drained lower slopes (Peat soils) and chionophilous habitats (Rutmark and Anmoor-like soils). The Sub-Aquatic soils are restricted in their occurrence to lake shores (Gyttja) and wetland sites with impeded drainage (Fen) and polygon formation (Mire).

16. Solifluction processes on the steeper slopes (gradients over 20 degrees) are considered to be very active, however, no quantitative data was collected to substantiate this hypothesis. The annual freeze-thaw cycle, coupled with such congeliturbation as may occur in the top few centimeters of soil during the summer, is responsible for the variety of microrelief features common in the two study areas. Soil creep is primarily responsible in moving saturated surface material downslope following thaw in the very late snow bed sites (Salicetum pseudopolaris).

17. The techniques described in the initial grouping of communities based on similarity of species composition allow higher units of vegetation to be determined on a truly objective basis. The addition of data pertaining to environmental factors permit the development of a combined synthesis of vegetation - environment relationships which will provide information on ecosystematic units at both detailed and broad levels of generalization. The final results, using classification methods, allow the presentation of vegetation-environment relationships in a form which will provide information of a practical nature yet sufficiently detailed to serve as a basis for additional scientific studies.

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APPENDIX I

Table I

List of all vascular plants, bryophytes and lichens encountered in the 166 plots. In addition the constancy, average cover and maximum and minimum cover values are included for each species where present in any of the 14 recognized associations.

Vascular Species	S.p.	L.-D.a.	B.-L.d.	V.-B.g.	B.-C.	B.-E.v.	S.pul.	S.c.	S.ps.	C.r.	E.s.	C.a.	E.a.	A.f.
1 Achillea borealis Bong.									#					
2 Aconitum delphinifolium DC.							III 1.0(+-3)	V 2.3(1-5(	#					
3 Agoseris aurantiaca (Hook.)Greene				#										
4 Alnus crispa (Ait.)Pursh				#	II 2.8(7)	#								
5 Andromeda polifolia L.					III .9(+-3)	II .4(+-2)				IV 2.7(4)	III 1.0(1-3)	II .2(1-4)	#	
6 Anemone narcissiflora L.		III .7(+-2)	II .2(+-1)	III .8(+-2)		#		I .5(2-4)	IV 1.4(+-3)					
7 Anemone parviflora Michx.			#			#		#						
8 Anemone richardsonii Hook.							III 1.9(2-6)	IV 2.0(1-5)	#					
9 Antennaria monocephala DC.									#					
10 Antennaria neoalaskana A.E.Porsild	IV 1.0(+-2)	III .9(+-3)	I .1(+-1)	I .3(1-2)										
11 Antennaria pedunculata A.E.Porsild		#												
12 Arctagrostis latifolia (R.Br.)Griseb.		II .3(1-2)	II .5(+-3)	IV 1.3(1-3)	IV 1.3(1-3)	I .5(+-2)	IV 2.1(1-6)	V 2.8(1-8)					#	
13 Arctophila fulva (Trin.)Ands.													#	V 8.5(6-10)
14 Arctostaphylos alpina (L.)Spreng.	III .6(+-1)	III 1.9(1-5)	V 2.7(+-6)	IV 2.4(2-5)	II .3(+-1)	II .9(2-4)								
15 Arenaria arctica Stev.	V 1.2(+-2)	V 1.2(+-2)	II .4(+-2)	I .1(1)		#								
16 Arenaria humifusa Wahlenb.											#			
17 Arenaria rossii R.Br.		I .1(+)												
18 Arenaria sajanensis Willd.									V 2.0(1-5)					
19 Arnica alpina (L.)Olin		II .6(+-3)				#		I .2(1-2)	#					
20 Arnica lessingii (L.)Olin & Ladou			I .2(2-3)					I .1(1)	III 1.8(1-4)					
21 Artemisia arctica Less.	II .4(1)	II .5(+-2)	I .2(1-2)	I .2(1)			II .8(+-6)	IV 3.0(+-7)	III 1.6(1-5)					
22 Artemisia tilesii Ledeb.							II .7(2-3)	IV 1.5(1-7)	IV 1.8(+-6)					
23 Aster pygmaeus Lindl.	#													
24 Astragalus australis (L.)Lam.		I .5(3-4)												
25 Astragalus umbellatus Bunge		II .4(1-4)		#										
26 Betula glandulosa Michx.		IV 1.3(+-5)	V 4.6(1-7)	V 5.5(2-9)	V 5.8(4-8)	V 3.1(1-5)	III 1.6(1-4)	I .2(+-1)		IV 2.7(3-5)	II 2.5(3-7)	II .2(2-3)	III .9(1-3)	
27 Bupleurum americanum Coult.& Rose	#	III .7(+-2)												
28 Calamagrostis canadensis (Michx.)Beauv.				I .1(+)	I .4(+-3)							I .1(1-2)	#	
29 Calamagrostis lapponica (Wahlenb.)Hartm.			#											
30 Calamagrostis purpurascens R.Br.	#													
31 Campanula uniflora L.		II .3(1-2)												
32 Cardamine bellidiflora L.							#							
33 Cardamine digitata Richards				I .2(+)				#						
34 Cardamine microphylla Adams		#												
35 Cardamine pratensis L.								#			#			III .8(1-2)
36 Carex aquatilis Wahlenb.					I .2(+)	#	II 1.0(1-5)	II .4(+-4)		#		V 6.7(3-9)	II .3(1-2)	#
37 Carex capillaris L.		II .3(+-1)												
38 Carex chordorrhiza Ehrh.											#	II .2(+-7)	#	
39 Carex lachenalii Schkur.							II .3(+-2)	IV 2.3(1-4)	V 3.2(+-6)					
40 Carex lugens Holm		I .1(+-1)	II .5(+-4)	V 3.0(1-7)	III 1.4(+-5)	IV 2.2(1-5)	II .7(1-7)	#					II .4(+-2)	
41 Carex montanensis L.H.Bailey							I .1(+-1)	IV 3.6(1-8)	#					
42 Carex podocarpa R.Br.	IV 1.2(1-3)	IV 1.0(1-4)	IV 1.2(1-3)	#					II 1.8(3-6)					
43 Carex rariflora (Wahlenb.)Sm.						#				V 7.3(7-8)		II .6(1-5)		
44 Carex rotundata Wahlenb.					#	I .3(1-3)				V 3.0(2-7)	V 2.5(2-4)		#	
45 Carex scirpoidea Michx.		III .7(1-3)												
46 Carex vaginata Tausch					#			#						
47 Carex williamsii Britt.		#												
48 Cassiope tetragona (L.)D.Don.		II .9(3-4)	IV 3.2(2-8)	I .3(1-3)	#									
49 Castilleja pallida (L.)Knuth				#										
50 Castilleja raupii Pennell		II .4(+-3)		I .1(1)				#	#					
51 Cerastium beeringianum Cham.& Schlecht.		II .3(+-2)						#						
52 Chrysosplenium tetrandrum (Lund)Fries								#			#			
53 Diapensia lapponica L.	#	I .2(1-3)	II .5(1-3)											
54 Dodecatheon frigidum Cham.& Schlecht.							II 1.0(1-4)	IV 2.2(+-6)	IV 1.4(1-3)					
55 Douglasia arctica Hook.	IV 1.0(1-2)	III .5(+-1)	II .3(+-1)											
56 Draba nivalis Liljebl.	#					I .1(+)								
57 Dryas octopetala L. ssp. alaskensis (Porsild)Hult.	IV 1.6(1-4)	V 6.6(4-9)	I .3(1-3)	II .6(1-3)		I .3(1-2)								
58 Empetrum hermaphroditum (Lng.)Hagerup.			IV 2.3(1-6)	III 1.3(1-6)	V 4.5(2-8)	V 1.8(1-4)	II .3(+-2)	I .1(1)					#	
59 Epilobium anagallidifolium Lam.									II .8(1)					
60 Epilobium angustifolium L.							I .1(1)	II .7(2-4)						
61 Epilobium palustre L.														III 2.8(5-6)
62 Equisetum arvense L.			I .2(1-3)	I .3(1-5)	I .2(+-1)	I .1(+-1)	V 4.7(1-8)	V 5.2(1-8)	II 1.0(2-3)		#			
63 Equisetum scirpoides Michx.				#										
64 Eriophorum angustifolium Honck.						#	II .8(3-4)	#		#	#	II 1.2(1-6)	V 7.7(7-10)	
65 Eriophorum chamissonis Cham.											#			
66 Eriophorum scheuchzeri Hoppe.										IV 1.3(2)	V 7.5(6-9)	II .6(1-5)	#	
67 Eriophorum vaginatum L.				I 1.0(3-6)	III .7(1-2)	V 7.0(5-8)							I .2(1)	
68 Eritrichium splendens Kearney		#												
69 Eutrema edwardsii R.Br.						I .1(1)								
70 Festuca altaica Trin.								II 1.3(+-7)	#					
71 Festuca baffinensis Polunin	#													
72 Festuca brachyphylla Schult.	#	II .3(+-2)												
73 Gentiana glauca Pall.								I .3(2-3)	#					
74 Gentiana propinqua Richards.		#												
75 Geum glaciale Adams			#											
76 Hierochloe alpina (Sw.)R.& S.	V 1.4(1-2)	V 1.6(1-4)	V 1.7(1-3)	IV 1.1(+-4)	#	I .2(1)			#					
77 Hippuris vulgaris L.														V 3.2(1-7)
78 Juncus biglumis L.						I .1(+)								
79 Kobresia hyperborea A.E.Porsild		I .1(1)												
80 Kobresia myosuroides (Vill.)F.& P.	#	III .8(1-3)		I .2(+-1)										
81 Koeleria cairnesiana Hult.		#												
82 Lagotis glauca Gaertn.		I .1(1)				I .3(2)								
83 Ledum decumbens Ait.	#		V 3.6(1-6)	V 2.3(1-6)	V 4.0(2-6)	V 3.0(+-5)	I .4(1-4)			IV 1.7(2-3)	#	I .1(+-1)	III .5(1)	
84 Linnaea borealis L.			#		I .5(2-3)		II 1.0(1-6)	#						
85 Loiseleuria procumbens (L.)Desv.			III 1.0(1-7)						#					
86 Lupinus arcticus S.Wats.	#	V 2.6(1-5)	I .2(+-2)	III .8(1-4)		#								
87 Luzula confusa Lindb.	II .4(+-1)	IV 1.0(+-3)	II .7(+-3)	III .6(1-3)		I .1(+-1)		#						
88 Luzula nivalis (Laest.)Beurl.		III .5(+-2)		I .1(1)										
89 Luzula rufescens Fisch.ex.E.Mey.					#									
90 Luzula wahlenbergii Rupr.			#		I .5(2-3)			I .6(4-5)						
91 Lycopodium annotinum L.			#		III 1.8(1-6)									
92 Lycopodium selago L.			#											
93 Melandrium apetalum L.		#												
94 Myosotis alpestris F.W.Schmidt							I .1(+)	II .7(2-5)		II 1.0(1-4)				
95 Oxycoccus microcarpus Turcz.ex.Rupr.					#						IV 2.3(3-4)	#		
96 Oxyria digyna (L.)Hill								#	IV 2.4(2-5)					
97 Oxytropis maydelliana Trautv.		IV .9(+-3)		I .3(1-2)		I .2(+-1)								
98 Oxytropis nigrescens (Pall.)Fisch.	IV 1.8(+-3)	IV 1.3(+-4)	II .4(1-2)											
99 Papaver macounii Greene		II .4(1-3)												
100 Parnassia kotzebuei Cham.& Schlecht.								I .3(1-4)						
101 Parrya nudicaulis (L.)Regel.		I .2(1)												
102 Pedicularis arctica R.Br.		II .3(+-1)	I .1(+-1)	II .4(1-2)		#								
103 Pedicularis capitata Adams.		II .5(+-2)	I .2(+-2)	II .3(+-1)		#								
104 Pedicularis labradorica Panzer.			II .3(+-1)	II .4(+-1)	III .5(+-1)	I .1(+)				#				
105 Pedicularis lapponica L.			I .1(+-1)	I .2(+-1)	V 1.3(+-4)	IV 1.0(+-3)				IV 1.0(1-2)		I .1(+-1)	#	
106 Pedicularis lanata Willd.		II .3(+-1)	II .2(+-1)	II .4(1-2)		I .2(+-1)								
107 Pedicularis sudetica Willd.							III 1.0(1-2)	III 1.1(+-3)	#			II .3(1-2)	#	
108 Petasites arcticus Porsild												#		
109 Petasites frigidus (L.)Fries.		I .1(+-1)	I .3(+-3)	III .6(+-3)	IV 1.3(+-5)	I .4(2)	V 4.4(1-8)	IV 2.6(1-6)	II .6(1-2)					
110 Phlox richardsonii Hook.		#												
111 Pinguicula villosa L.					I .2(+-1)	II .4(1-2)				#				
112 Poa arctica R.Br.	#	III 1.0(+-3)	III .5(+-3)	III .9(+-3)	II .8(+-3)	II .4(+-3)	IV 1.2(+-3)	IV 1.6(1-4)	IV 1.2(1-2)					
113 Poa glauca Vahl.	#	III .5(+-1)	I .1(1)	#										
114 Polemonium acutiflorum Willd.							IV 1.4(1-4)	IV 1.4(1-3)	#					
115 Polygonum alaskanum (Small)Wight.			I .1(1)	#	#									
116 Polygonum bistorta L.		II .3(+-1)	IV 1.1(+-4)	IV 1.3(+-3)	IV 1.2(1-3)	III .8(1-2)		III .9(+-3)	III 1.0(+-2)					
117 Polygonum viviparum L.		V .9(+-2)	II .3(1)	II .4(+-3)		I .1(1)	I .2(1-2)	II .6(+-3)	#				#	
118 Potentilla fruticosa L.		#												
119 Potentilla nivea L.	#	I .3(+-2)												
120 Potentilla palustris (L.)Scop.												III 2.0(3-5)		
121 Potentilla vahliana Lehm.	#													
122 Pyrola grandiflora Radius.			I .2(2)	I .4(1-4)		I .2(1-2)	II .3(1-2)							
123 Pyrola secunda L.				I .1(1)	#	#	II .4(+-2)							
124 Ranunculus gmelinii DC.											#			III .8(1-2)
125 Ranunculus lapponicus L.							I .5(2-4)							
126 Ranunculus nivalis L.						#	I .4(1-4)	IV 1.1(1-3)	III 1.2(2)					
127 Ranunculus pallasii Schlecht.												II .2(+-1)		#
128 Ranunculus pedatifidus Sm.							#	#						
129 Ranunculus pygmaeus Wall.								#	III 3.2(4-7)					
130 Ranunculus turneri Greene								#						

Table I (cont.)

	S.p.	L.- D.a.	B.- L.d.	V.- B.g.	B.- C.	B.- E.v.	S.pul.	S.c.	S.ps.	C.r.	E.s.	C.a.	E.a.	A.f.
131 Rhododendron lapponicum (L.)Willd.		II .7(2-3)												
132 Rosa acicularis Lindl.							#							
133 Rubus chamaemorus L.				#	V 5.2(2-8)	IV 1.6(1-4)	III 1.7(1-4)	I .2(+-1)		#	#		III .5(1-2)	
134 Rumex arcticus Trautv.								II .3(1-2)						
135 Salix arbutifolia Pallas						#				V 2.3(+-3)		IV 2.1(1-7)	II .9(1-5)	
136 Salix arctica Pallas		II .4(1-2)												
137 Salix brachycarpa Nutt.	#	I .2(1-2)	#	I .1(2-5)										
138 Salix chamissonis Anders.			#					IV 4.7(1-8)	II 1.8(+-8)					
139 Salix farrae Ball							#							
140 Salix glauca L.		II 1.0(1-6)	I .2(1-2)	III 1.1(1-5)	II .8(1-5)	I .2(1-2)						#		
141 Salix phlebophylla Anders.	V 4.5(4-6)	IV 2.0(+-5)	III 1.1(+-4)	III 1.2(1-4)		I .1(1-2)								
142 Salix pseudopolaris (Flod.)Hult.									V 5.0(2-8)					
143 Salix pulchra Cham.			II .7(1-4)	IV 2.5(2-7)	IV 3.4(3-6)	III 1.6(1-5)	V 8.4(7-9)	III 1.3(1-8)				II .5(1-4)	II 2.0(2-8)	
144 Salix reticulata L.		III 1.5(+-5)		I .1(1)		II .7(1-4)		II 1.2(1-7)	#				#	
145 Salix richardsonii Hook.			#				#							
146 Saussurea angustifolia (Willd.)DC.		II .3(+-1)	II .4(1-4)	II .3(+-2)		#			#					
147 Saxifraga bronchialis L.		II .5(1-2)	I .2(1-3)	#										
148 Saxifraga cernua L.											#			
149 Saxifraga davurica Willd.		I .1(+-1)												
150 Saxifraga flagellaris Willd.		II .4(1-3)												
151 Saxifraga hieracifolia Wallst.& Kit.		II .4(+-2)				I .1(+-1)								
152 Saxifraga hirculus L.		II .4(1-3)												
153 Saxifraga oppositifolia L.		#												
154 Saxifraga punctata L.		III .6(+-2)	I .2(1-4)	I .2(1)		I .1(1)	IV 1.4(1-4)	IV 1.8(1-4)	III 1.0(1-2)					
155 Saxifraga radiata Small.							I .2(1-2)	#						
156 Saxifraga reflexa Hook.	#	III .7(+-2)												
157 Saxifraga rivularis L.									II .8(1-3)					
158 Saxifraga tricuspidata Retz.	#	III 1.3(+-3)	#	I .2(1-2)										
159 Sedum roseum (L.)Scop.		#												
160 Selaginella sibirica (Milde)Hieron.	IV .8(+-1)	I .2(+-1)	I .2(+-1)	#	#									
161 Senecio atropurpureus (Ledeb.)B.Feditsch.		I .2(+-1)	I .1(+-1)	II .4(1-2)	#	I .2(1)								
162 Senecio congestus (R.Br.)DC.														IV .8(1)
163 Senecio fuscatus (Jord.& Fourr.)Hayek.		IV .8(+-2)	#	I .3(+-2)										
164 Senecio lugens Rich.							I .3(2)	II .8(1-4)	#					
165 Senecio resedifolius Less.		I .3(1-2)												
166 Senecio yukonensis Porsild			#	#										
167 Sibbaldia procumbens L.								#	IV 1.8(1-4)					
168 Silene acaulis L.		II .5(1-2)												
169 Smelowskia calycina (Stephan)C.A.Meyer	II .4(+-1)	#	#											
170 Spiraea beauverdiana Schneid.			II .4(1-2)		III 1.8(1-5)	#	II 1.6(2-7)	II 1.7(1-6)						
171 Stellaria ciliatosepala Trautv.		II .3(1-2)	#	III .6(+-2)	I .4(2)	I .2(+-1)	II .3(1-2)	I .3(+-2)	#					
172 Stellaria longipes Goldie.		II .3(+-1)	#	I .2(+-1)			II .3(1-2)	I .3(1-3)						
173 Stellaria monantha Hult.		#					II .7(+-3)	#						
174 Taraxacum sp.	#								#					
175 Tofieldia coccinea Richards.	#	III .7(1-2)	I .2(+-1)	II .4(+-2)										
176 Tofieldia pusilla (Michx.)Pers.		#												
177 Trisetum spicatum (L.)Richt.s.l.		II .3(+-1)						IV 1.6(1-5)	II .8(2)					
178 Vaccinium uliginosum L.		IV 2.4(1-7)	V 2.5(1-6)	V 4.0(1-7)	V 4.4(3-6)	V 2.1(1-3)	III 1.4(1-7)	II .3(+-2)		IV 1.0(+-2)	#	I .3(1-4)	II .7(+-3)	
179 Vaccinium vitis-idaea L.	#	I .2(1-2)	V 3.5(1-6)	V 2.3(1-6)	V 3.3(1-6)	V 4.1(1-5)	II .7(+-2)	II .4(1-3)				#	II .3(+-1)	
180 Valeriana capitata Pall.				#		#	III 1.0(1-4)	III .5(+-3)						
181 Viola epipsila Ledeb.ssp.repens (Turcz.)W.Bcker.					#	#	I .2(1-2)	I .6(2-4)						
182 Woodsia alpina (Bolton)S.F.Gray		#												
183 Woodsia glabella R.Br.		#												
Bryophytes														
184 Abietinella abietina (Hedw.)Fleisch.		II .5(+-3)		#										
185 Amblystegium juratzkanum Schimp.				#				#						
186 Andreaea rupestris Hedw.									#					
187 Atrichum sp.													#	
188 Aulacomnium palustre (Hedw.)Schwaegr.		I .3(1-3)	I .4(2-4)	III 1.0(+-5)	III 1.5(2-5)	I .4(+-5)	III 2.3(+-7)	II 1.5(+-5)				II .6(1-4)	II 1.1(+-5)	
189 Aulacomnium turgidum (Wahlenb.)Schwaegr.		III 1.8(1-6)	IV 1.5(1-5)	V 3.7(+-7)	IV 1.2(+-5)	V 2.5(1-4)	#			IV 1.3(+-3)	III .8(1-2)	II .2(+-4)	#	
190 Barbilophozia barbata Dum								#						
191 Bartramia ithyphylla Brid.				#										
191 Blepharostoma trichophyllum (L.)Dum.		I .2(+-1)	#	I .1(+)			#		II .4(1)					
192 Brachythecium albicans (Hedw.)B.S.G.							#	#	II 1.2(3)					
193 Brachythecium turgidum (C.J.Hartm.)Kindb.						#	II 1.2(1-8)	II .5(+-3)						
194 Bryoerythrophyllum recurvirostrum (Hedw.)Chen.				#										
195 Bryum pseudotriquetrum (Hedw.)Gaertn., Meyer & Scherb.		I .2(1-2)					II 1.2(1-5)	III 1.8(+-6)	II .4(+-1)			#	I .2(+-1)	
196 Bryum sp.		II .4(+-2)	#	II .3(+-1)				#	II .4(+)					III 1.2(2-3)
197 Calliergon cordifolium (Hedw.)Kindb.					#		I .5(1-5)					I .4(2-4)	#	
198 Calliergon stramineum (Brid.)Kindb.					II .5(+-2)		II .4(+-1)		#			#	II .7(1-5)	III .8(1-2)
199 Calliergon trifarium (Web.& Mohr)Kindb.													#	
200 Calypogeia trichomanis (L.)Corda			I .1(+-1)	I .2(+-1)	II .5(1-3)	II .4(+-3)						#		
201 Campylium chrysophyllum (Brid.) J.Lange		#												
202 Campylium polygamum (B.S.G.)C.Jens.				#									#	
203 Campylium stellatum (Hedw.)C.Jens.		#												
204 Cephalozia bicuspidata (L.)Dum.					#									
205 Cephalozia leucantha Spruce					#									
206 Cephalozia stellulifera (Tayl.M.S.)Schiffn.								#						
207 Cephaloziella subdentata Warnstf.		#	#											
208 Ceratodon purpureus (Hedw.)Brid.		II .5(+-4)	I .2(+-1)	#	#	#	I .2(+-1)							
209 Chandonanthus setiformis (Ehrh.)Lindb.			I .1(+)											
210 Cinclidium arcticum Schimp.							#							
211 Cinclidium stygium Sw.							#							
212 Cinclidium subrotundum Lindb.												I .1(1)	#	
213 Conostomum tetragonum (Hedw.)Lindb.				#										
214 Cynodontium polycarpon (Hedw.)Schimp.			#	#										
215 Cynodontium schistii (Wahlenb.)Lindb.			#											
216 Cynodontium strumiferum (Hedw.)Lindb.				#										
217 Cynodontium tenellum (B.S.G.)Limpr.				#										
218 Dicranella subulata (Hedw.)Schimp.						#								
219 Dicranoweissia crispula (Hedw.)Lindb.ex Milde			#	#										
220 Dicranum angustum Lindb.		I .3(1-3)	I .3(1-3)	II .8(1-5)	II .5(+-3)	IV 1.7(+-5)							#	
221 Dicranum elongatum Schleich.ex Schwaegr.		II .7(+-5)	V 2.7(1-4)	IV 2.2(1-5)	#	III .9(1-3)	#						#	
222 Dicranum fuscescens Turn.		III 1.3(+-4)	III .9(+-3)	II .8(2-5)	#	II .6(1-3)	#	I .1(+-1)						
223 Dicranum groenlandicum Brid.		I .2(1)	I .4(1-4)	II .8(1-5)		I .5(1-4)								
224 Dicranum mühlenbeckii B.S.G.		II .5(+-2)	#	I .4(1-3)	#	I .1(1)	#	I .3(+-3)	#					
225 Dicranum scoparium Hedw.			II .5(2-3)	I .5(1-4)	III 1.1(1-3)	II .8(+-5)	II .8(1-6)	I .7(1-5)						
226 Distichium capillaceum (Hedw.)B.S.G.		III .7(+-2)		I .2(+-2)					#					
227 Distichium inclinatum (Hedw.)B.S.G.			#	#										
228 Drepanocladus aduncus (Hedw.)Warnst.										#	#	I .6(2-6)	II .7(2-3)	III 3.5(5-9)
229 Drepanocladus exannulatus (B.S.G.)Warnst.											II 2.5(+-9)	#	#	
230 Drepanocladus fluitans (Hedw.)Warnst.								#						
231 Drepanocladus revolvens (Sw.)Warnst.													#	
232 Drepanocladus uncinatus (Hedw.)Warnst.			I .2(+-1)	I .2(+-1)	II .4(1-2)	I .1(+-1)	V 4.0(+-7)	V 4.7(+-7)	III .6(+-1)				#	
233 Drepanocladus vernicosus (Lindb.ex C.Hartm.) Warnst.													#	
234 Encalypta rhaptocarpa Schwaegr.	#	I .2(+-1)					#							
235 Encalypta vulgaris Hedw.			#											
236 Eurhynchium pulchellum (Hedw.)Jenn.		I .2(+)	I .1(1)	I .1(+)										
237 Funaria hygrometrica Hedw.									#					
238 Gymnocolea inflata (Huds.)Dum.					#	#					#			
239 Gymnomitrion corallioides Nees	IV 1.6(+-4)	#	I .2(+-2)											
240 Harpanthus scutatus (Web.& Mohr)Spruce						#								
241 Hylocomium splendens (Hedw.)B.S.G. var.alaskanum (Lesq.& James)Limpr.		I .8(3-5)	III 1.8(1-8)	IV 2.8(+-7)	III 1.4(1-6)	III 1.6(1-5)	III 2.7(3-8)	#						
242 Hypnum callichroum Funck ex Brid.			I .1(1)	I .4(+-4)		I .1(+-1)								
243 Hypnum cupressiforme (Hedw.)	#													
244 Hypnum hamulosum B.S.G.			#											
245 Hypnum plicatulum (Lindb.)Jaeg.& Sauerb.			#											
246 Hypnum revolutum (Mitt.)Lindb.				#										
247 Lescuraea patens (Lindb.)H.Arnell & C.Jens.		#												
248 Lophozia alpestris (Schliech.)Evans		#	I .1(+)	I .1(+-1)		#		#	#					
249 Lophozia attenuata (Mart.)Dum.				#		#								
250 Lophozia badensis (Gottsche)Schiffn.			#											
251 Lophozia bicuspidata (L.)Dum.							#							
252 Lophozia excisa (Dicks.)Dum.		#		#	#		#					#		
253 Lophozia hatcheri (Evans)Steph.								#						
254 Lophozia kunzeana (Hüb)Evans				I .1(+-1)	III .6(+-1)		I .1(+)	#			#	#		
255 Lophozia latifolia Schuster								#						
256 Lophozia obtusa (Lindb.)Evs.				#		#	#							
257 Lophozia porphyroleuca (Nees)Schiffn.				#				#						
258 Lophozia quadriloba (Lindb.)Evans		#		#		I .1(1)		I .1(+-1)						
259 Lophozia quinquedentata (Huds.)Cogn.				I .3(1-4)		#								
260 Lophozia ventricosa (Dicks.)Dum.			I .1(+-1)		#	I .1(+-1)	I .3(1-3)							
261 Marchantia polymorpha L.							#							#
262 Marsupella varians (Lindb.)K.M.			#											
263 Mnium cinclidioides Hüb.							I .3(+-3)					#		
264 Mnium hymenophyllum B.S.G.							#	#						
265 Mnium orthorrhynchum Brid.		I .2(+)												
266 Mnium punctatum Hedw.							#	#	#			I .2(1-2)	#	#
267 Mnium rostratum Schrad.							#							
268 Mnium rugicum Bland.			#				II 1.2(+-7)							
269 Mylia anomala (Hook.)Gray					#									
270 Myurella julacea (Schwaegr.)B.S.G.		I .2(+)												

Table I (cont.)

	S.p.	L.- D.a.	B.- L.d.	V.- B.g.	B.- C.	B.- E.v.	S.pul.	S.c.	S.ps.	C.r.	E.s.	C.a.	E.a.	A.f.
271 Nardia compressa (Hook.)Gray			#	#										
272 Nardia scalaris Gray					#		#							
273 Philonotis fontana (Hedw.)Brid.						#							#	
274 Plagiothecium curvifolium Schleiph.ex Limpr.							#							
275 Plagiothecium roseanum B.S.G.							I .8(1-4)	#						
276 Pleurozium schreberi (Brid.)Mitt.			#	II .3(+-1)			#	#						
277 Pogonatum alpinum (Hedw.)Röhl.						#	II 1.0(1-5)	II 1.8(1-6)	II 1.6(1-7)			#		
278 Pogonatum capillare (Michx.)Brid.	#													
279 Pogonatum urnigerum (Hedw.)P.Beauv.		#												
280 Pohlia drummondii (C.Müll.)Andr.									IV 2.8(3-5)					
281 Pohlia nutans (Hedw.)Lindb.	#		I .1(+)	#	#	#	I .1(+)	I .4(1-4)					#	
282 Pohlia sp.		I .2(1)	I .1(+)											
283 Polytrichum commune Hedw.					II 1.1(2-4)	I .2(1-2)	#	#	III 1.4(1-4)	IV 1.0(1-2)	V 3.0(1-4)	III 1.0(1-4)	II 1.0(2-4)	#
284 Polytrichum juniperinum Hedw.	II 1.2(1-5)	III 1.0(+-4)	IV 2.1(+-6)	V 2.0(1-5)	IV 2.3(1-5)	IV .9(+-3)	I .3(1-2)	II .9(+-5)			#		I .5(1-4)	
285 Polytrichum norvegicum Hedw.								#	IV 2.8(1-6)					
286 Polytrichum piliferum Hedw.	III 1.0(+-2)	II .4(+-3)	I .3(2)			#								
287 Polytrichum swartzii C.J.Hartm.													#	
288 Ptilidium ciliare (L.)Hampe		#	II .7(+-5)	I .5(3-6)		II .5(1-3)		#						
289 Ptilium crista-castrensis (Hedw.)De Not.			#	#										
290 Rhacomitrium lanuginosum (Hedw.)Brid.	II .6(1-2)	I .1(1)	II .5(+-3)			II .3(1-2)			#					
291 Rhytidium rugosum (Hedw.)Kindb.		IV 1.5(+-5)	II .7(+-5)	III 1.7(1-6)		I .3(+-2)								
292 Scapania hyperborea Jørg.								#	#					
293 Scapania irrigua (Nees)Dum.				#			#	#			#			
294 Scapania lingulata Buck								I .1(+-1)						
295 Sphagnum aongstroemii C.Hartm.					#	#				#			#	
296 Sphagnum balticum Russ.ex C.Jens.				#	#	II .6(+-3)				V 4.3(6-7)	V 6.5(2-9)	#	II 1.2(1-5)	
297 Sphagnum compactum Lam.& DC.										IV .7(1)			#	
298 Sphagnum contortum Schultz										#		I .6(2-6)		
299 Sphagnum dusenii C.Jens.ex Russ.														#
300 Sphagnum girgensohnii Russ.			II .5(1-3)	III 1.5(1-7)	IV 5.6(4-9)	II 1.0(2-5)	II 1.4(1-6)					#	II 2.6(4-8)	
301 Sphagnum imbricatum Hornsch.ex Russ.										#				
302 Sphagnum inundatum Russ.							#							
303 Sphagnum lenense H.Lindb.ex Sav.-Lub.			I .2(1-2)		I .5(1-4)	IV 4.4(1-9)	I .4(1-4)			IV 2.7(+-7)		I .1(3-5)	II 1.1(1-5)	
304 Sphagnum lindbergii Schimp.					#						#	#		
305 Sphagnum obtusum Warnst.						#				#		#		
306 Sphagnum platyphyllum (Lindb.)Warnstf.										#		II .9(2-4)	I .4(1-3)	
307 Sphagnum recurvum P.Beauv.				#	IV 3.5(+-7)	III 1.8(1-6)	I .4(1-4)			#		II .2(6-8)		
308 Sphagnum riparium Angstr.					#									
309 Sphagnum rubellum Wils.			I .2(1-4)	I .3(1-3)	IV 1.6(1-5)	IV 1.9(2-6)	I .5(1-4)			#		II .3(1-3)	I .3(1-2)	
310 Sphagnum squarrosum Sw.ex Crome							I .8(1-5)					III 2.1(1-8)		
311 Sphagnum teres (Schimp.)Angstr.ex C.Hartm.				#			I .5(2-4)					I .9(5)		
312 Sphenolobus minutus (Crantz)Steph.			IV 1.0(+-5)	III .7(1-2)	I .3(1-2)	IV 1.0(+-4)							#	
313 Tetraplodon mnioides (Hedw.)B.S.G.				#										
314 Tetraplodon paradoxus (R.Br.)Hag.			I .1(+)	I .1(1)	#	#								
315 Tetraplodon urceolatus (Hedw.)B.S.G.		I .1(+-1)												
316 Timmia austrica Hedw.		#												
317 Tomenthypnum nitens (Hedw.)Loeske.			#	I .2(+-1)	II .4(1-2)	I .2(3-5)	I .4(+-2)	I .8(2-5)						
318 Tortula ruralis (Hedw.)Gaertn.,Meyer & Scherb.			#	#										
319 Trichodon cylindricus (Hedw.)Schimp.								#						
Lichenes														
320 Alectoria miniscula Nyl.	V 1.4(+-2)	II .3(1-2)	II .4(1)											
321 Alectoria nigricans (Ach.)Nyl.	III 1.8(#)	II .3(1)	II .7(1-6)	I .2(1)		I .1(+-1)								
323 Alectoria nitidula (Th.Fr.)Vain.		II .7(1-4)		I .1(+-1)		I .1(+-1)								
324 Alectoria ochroleuca (Hoffm.)Mass.	IV 1.0(+-2)	II .5(+-2)	III 1.0(+-6)	I .3(1-2)		I .2(+-1)								
325 Arctomia delicatula Th.Fr.		I .1(+)												
326 Buellia atrata (Sm.)Anzi.	#													
327 Caloplaca festiva (Ach.)Zw.		#												
328 Cetraria chrysantha Tuck.	IV 1.0(+-2)	IV 1.2(1-5)	II .3(+-1)	I .1(1)		#								
329 Cetraria cucullata (Bell.)Ach.	III .8(+-2)	V 1.9(1-5)	V 2.0(+-6)	V 2.5(+-6)	II .4(+-1)	V 1.8(+-6)		#						
330 Cetraria hepatizon (Ach.)Vain.	#		I .2(1)											
331 Cetraria islandica (L.)Ach.		III .5(+-2)	V 1.4(+-5)	V 1.6(1-4)	I .4(+-3)	IV .8(+-1)		I .4(1-3)	#					
332 Cetraria kamczatica Savicz.			I .2(1)											
333 Cetraria laevigata Rass.			#			#								
334 Cetraria nigricans (Retz.)Nyl.			#											
335 Cetraria nigricascens (Nyl.)Elenk.	III 1.0(1-2)	I .2(+-1)	III .4(+-1)	#										
336 Cetraria nivalis (L.)Ach.	IV 1.2(1-2)	V 1.3(+-3)	IV 1.5(+-4)	IV .7(+-2)		II .3(+-1)	#							
337 Cetraria pinastri (Scop.)S.Gray		#		#	II .4(1-2)	#	III .7(1-2)							
338 Cetraria richardsonii Hook.		III .7(+-3)	IV .9(+-2)	II .4(+-1)	#	I .2(+-1)								
339 Cetraria scholanderi Llano	II .4(1)		#											
340 Cetraria sepincola (Ehrh.)Ach.				#	#	#	#							
341 Cetraria tilesii Ach.	#	II .6(+-3)												
342 Cladonia amaurocraea (Flörke)Schaer.		I .2(+-1)	I .1(1)	III .8(+-4)	II .5(+-3)	III .9(+-4)								
343 Cladonia cariosa (Ach.)Spreng.				#										
344 Cladonia chlorophaea (Flörke)Spreng.	#	I .1(1)	I .2(+)			I .2(+-1)			III .6(+-1)					
345 Cladonia coccifera (L.)Willd.		#	I .1(+)			#								
346 Cladonia coniocraea (Flörke)Spreng.			#											
347 Cladonia fimbriata (L.)Fr.		#			#			#						
348 Cladonia furcata (Huds.)Schrad.			#	#		I .2(+)								
349 Cladonia gonecha (Ach.)Asah.			#	I .1(+-1)		I .1(+)								
350 Cladonia gracilis (L.)Willd.		II .3(+-2)	III .5(+-1)	III .6(1-2)		II .3(+-1)		I .2(1-2)						
351 Cladonia mitis Sandst.	#	#	V 2.0(+-6)	IV 1.4(+-4)	#	IV .9(+-4)								
352 Cladonia pleurota (Flörke)Schaer.	#		#											
353 Cladonia pyxidata (L.)Hoffm.		#												
354 Cladonia rangiferina Wigg.			IV 1.3(+-5)	III 1.2(+-4)	II .4(+-2)	III 1.0(+-4)								
355 Cladonia squamosa (Scop.)Hoffm.								#						
356 Cladonia uncialis (L.)Wigg.		I .1(+-1)	II .4(+-2)	II .4(+-2)		#								
357 Cladonia verticillata (Hoffm.)Schaer.			#											
358 Collema tenax (Sw.)Ach.					#									
359 Cornicularia aculeata (Schreb.)Ach.		II .3(1)												
360 Cornicularia divergens Ach.	V 2.8(2-4)	III .8(1-2)	III 1.1(+-5)	I .3(1-2)		#								
361 Dactylina arctica (Hook.)Nyl.		II .3(+-2)	IV .8(+-2)	III .6(1-3)		III .7(+-2)								
362 Dactylina madreporiformis (Wuff.)Tuck.			I .1(+-1)											
363 Haematomma lapponicum Räs	IV 1.8(1-4)		II .2(+-1)											
364 Hypogymnia physodes (L.)Nyl.			#											
365 Hypogymnia subobscura (Vain.)Poelt	III .6(+-1)	III .8(+-3)	#	I .2(+-1)										
366 Icmadophila ericetorum (L.)Zahlbr.			I .1(+-1)			#								
367 Lecanora anseris Lynge		II .3(1-3)												
368 Lecanora atrosulphurea (Wahlenb.)Ach.		#	I .1(1)											
369 Lecanora castanea (Hepp)Th.Fr.				#										
370 Lecanora epibryon (Ach.)Ach.		II .7(+-5)	I .1(+-1)											
371 Lecanora polytropa (Ehrh.)Rabenh.	#	I .1(+)	#											
372 Lecanora rupicola (L.)Zahlbr.			#											
373 Lecidea atromarginata Magn.	#	I .3(+-3)	I .1(1-2)											
374 Lecidea flavocaerulescens Hornem.	II .4(1)		I .1(+-1)						#					
375 Lecidea lapicida (Ach.)Ach.	#		I .2(+-2)						#					
376 Lecidea granulosa (Hoffm.)Ach.									II .4(+-1)					
377 Leptogium saturninum (Dicks.)Nyl.		II .4(+-1)												
378 Lobaria linita (Ach.)Rabenh.			II .3(+-1)	II .3(1-2)				#						
379 Nephroma arcticum (L.)Torss.			I .1(+-1)											
380 Nephroma expallidum (Nyl.)Nyl.		III .6(+-2)	II .5(+-2)	III .6(+-2)		I .1(+-2)	#	#						
381 Ochrolechia frigida (Sw.)Lynge	III 1.2(+-3)	II .3(+-3)	III .8(+-3)	I .1(+)		#								
382 Ochrolechia inaequatala (Nyl.)Zahlbr.			#	#		#								
383 Ochrolechia upsaliensis (L.)Mass.		II .9(+-4)		#										
384 Pannaria leucostricta (Tuck.)Tuck.ex Nyl.		#												
385 Parmelia almquisti Vain.	#		#											
386 Parmelia alpicola Th.Fr.	II 1.0(1-4)	#	#											
387 Parmelia fraudans Nyl.			#											
388 Parmelia omphalodes (L.)Ach.	V 1.0(+-1)	II .4(+-2)	II .4(+-1)	I .1(1)										
389 Parmelia separata Th.Fr.	V 1.4(1-2)	I .1(1)	II .3(+-2)											
390 Parmelia stygia (L.)Ach.	II .6(+-1)	#	II .5(+-4)	#										
391 Parmeliopsis ambigua (Wulf.)Nyl.		#			#		I .1(+)							
392 Peltigera aphthosa (L.)Willd.		II .4(+-2)	II .8(+-4)	V 1.3(+-3)	#	III .9(1-2)	III .8(+-3)	II .5(1-2)	#					
393 Peltigera canina (L.)Willd.		III .5(+-1)	I .2(+-1)	III .6(+-2)	#	II .3(1)	III 1.0(1-4)	II .7(+-5)	III .8(1-2)					
394 Peltigera malacea (Ach.)Funck		#	I .1(+-2)	#	#		#							
395 Peltigera polydactyla (Neck.)Hoffm.			I .1(+-1)	I .3(+-2)	#	II .3(+-1)	#							
396 Peltigera scabrosa Th.Fr.		#	II .5(1-4)	III .6(1-2)	II .5(+-2)	III .5(+-1)	II .5(1-2)	II .3(1-2)					#	
397 Peltigera spuria (Ach.)DC.		#	I .7(+-3)	I .2(+-2)			III .5(+-1)	II .3(+-1)	II .4(1)					
398 Peltigera venosa (L.)Baumg.									#					
399 Pertusaria coriacea (Th.Fr.)Th.Fr.	III 1.0(+-3)	II 1.0(+-6)	II .3(+-3)											
400 Pertusaria dactylina (Ach.)Nyl.		I .1(+-1)	II .4(+-3)			#								
401 Pertusaria panyrga (Ach.)Mass.	#	III 1.3(+-6)	II .3(+-3)	#		#								
402 Pertusaria subobducens Nyl.			#											
403 Physcia aipolia (Ehrh.)Hampe							#							
404 Physcia muscigena (Ach.)Nyl.		III .7(+-2)												
405 Psoroma hypnorum (Vahl.)S.Gray		II .3(+-1)	I .2(+-1)	I .2(+)			#		#					
406 Rhizocarpon geographicum (L.)DC.	IV 2.0(1-4)	II .7(1-4)	III .6(+-3)	#					II .6(1-2)					
407 Rinodina mniaraea (Ach.)Körb.									#					
408 Solorina crocea (L.)Ach.	#		I .1(1)	#					II .4(1)					
409 Solorina saccata (L.)Ach.		I .2(+-1)		#										
410 Sphaerophorus globosus (Huds.)Vain.	V 1.0(+-1)	II .3(1)	III .8(+-5)	II .5(+-2)		#								
411 Stereocaulon alpinum Laur.		II .5(+-2)	III 1.5(+-7)	IV .9(+-3)	II .4(+-2)	II .3(1)		#						
412 Stereocaulon rivulorum Magn.	#		I .1(1-2)			I .2(+)								
413 Stereocaulon tomentosum Fr.		#	I .5(1-4)	I .1(1)										
414 Tonina cumulata (Somm.)Th.Fr.	#													
415 Thamnolia vermicularis (Sw.)Ach.ex Schaer.	IV .8(+-1)	IV 1.0(+-2)	IV .9(+-4)	IV 1.0(1-3)	#	II .5(+-2)								
416 Umbilicaria cylindrica (L.)Del.		#		#										
417 Umbilicaria hyperborea (Ach.)Ach.	III 1.4(1-4)	II .3(+-2)	II .5(+-3)											
418 Umbilicaria proboscidea (L.)Schrad.	III 2.0(+-5)	I .1(+-1)	II .5(+-4)											
419 Xanthoria elegans (Link)Th.Fr.		#												