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THE UNIVERSITY OF ALBERTA

VEGETATION OF THE HEART LAKE AREA, SOUTHERN DISTRICT OF MACKENZIE

BY

© STEPHEN SNOW TALBOT

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE

OF DOCTOR OF PHILOSOPHY

IN PLANT ECOLOGY

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled "Vegetation of the Heart Lake area, southern District of Mackenzie" submitted by Stephen Snow Talbot in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Plant Ecology.

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Date 14 October 1982

This thesis is dedicated to the memory of
my parents, Olyphant Mills Talbot and
Valdis Wessell Talbot.

ABSTRACT

A phytosociological study of the middle boreal subzone in the southern District of Mackenzie documented the floristic composition and structure of the vegetation in order to determine the variety of plant communities and their relationships to soils and sites. Ten major vegetation classes and their subclasses were distinguished and reflected a complex gradient of increasing moisture: bryoid-dominated talus, *Arctostaphylos uva-ursi* steppe scrub, *Pinus banksiana* woodland, *Populus tremuloides* forest, *Picea glauca* feathermoss forest, *Picea mariana* raised ombrotrophic bog, *Picea mariana* fen, *Salix pedicellaris* dwarf shrub peatland, *Carex aquatilis* fen, and *Eleocharis pauciflora* marl fen.

The methodology employed a three-phase process - inventory, analysis, and synthesis - to refine the comprehensive method of Küchler - and culminated in a large scale vegetation map representative of distinctive, regional community patterns. During inventory, the structure and dominant species of all stands within a 30-km^2 area of a small watershed surrounding Heart Lake were enumerated, mapped, and stratified into formation classes. Representative stands from each class were then selected along a topographic gradient for detailed

quantitative description of structure, dominant life-forms, and floristic composition. The analytic phase involved classification and comparison based on multivariate techniques and a computer-assisted version of the Braun-Blanquet method. The process was concluded by synthesizing information into a final map produced by a fusion of classifications developed in the inventory and analytic phases.

Phytogeographic analysis of the Heart Lake area supported previous analyses of floristic affinities in adjacent regions and the concept of a middle boreal subzone in central Canada. Classification using differential species groups based on the presence or absence of species agreed well with classification based on quantitative floristic and life-form criteria. Successional sequence and return interval following fire were well correlated with the presence or absence of poorly drained soils.

ACKNOWLEDGEMENTS

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J. MacDonald, Topographic and Mapping Surveys, Department of Energy, Mines and Resources, Ottawa, provided a 5 m contour for the vegetation map and UTM grid. J. Day, Soils Research Institute, Agriculture Canada, Ottawa, critically reviewed the soils section and provided valuable insight in the classification of some profiles. L. Knapik, Alberta Soil Survey, Edmonton, also offered suggestions in classifying certain profiles. Field assistance was provided by R. Hagen, J. Hushagen, and W. Reed.

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INTRODUCTION

Climatic zonation provides a means for comparing plant communities from widely separated areas. One procedure for accomplishing comparisons within the boreal zone (Hämet-Ahti et al. 1974) distinguishes four thermally defined subzones: northern boreal, middle boreal, southern boreal, and hemiboreal. In Canada the application of this approach is limited to Ontario and British Columbia (Ahti 1964, Hämet-Ahti 1965) and points to the need for greater understanding of vegetation/zone relationships.

An examination of the vegetation literature from locations in west central Canada indicates that accounts focus almost entirely on the northern and southern boreal, while investigations within the middle boreal are rare. In particular there is a paucity of quantitative studies from the middle boreal of northern Alberta and the adjacent southern District of Mackenzie. What is known of this portion of the middle boreal comes primarily from general overviews. For example, Rowe (1972a:37) broadly characterizes the upland forests of the "Hay River Section, B. 18b" (which includes parts of both the middle and southern boreal) as "the northern extension of the mixedwood forest, somewhat modified by a more rigorous climate (colder and drier)."

Most published descriptions of the middle boreal are too broad to convey much information on community characteristics and are made without regard to subzonation. Thus, studies either span more than one subzone or are concentrated in the southern boreal subzone. In addition, lichens and mosses, despite their high importance in the vegetation, either are not included or are given brief attention.

Other accounts are floristic or based on partial species lists. These include the botanical investigations of the Wood Buffalo, Athabasca-Great Slave, and southwestern Mackenzie regions (Raup 1935, 1946, 1947; the bogs and forests of northwestern Alberta (Moss 1953a, 1953b, 1955); the flora and vegetation adjacent to the Enterprise-Yellowknife section of the Mackenzie Highway (Thieret 1963a, 1963b, 1964); the vegetation of ancient beach ridges of Glacial Lake McConnell (Lindsey 1952); and the large-scale study of the North American taiga (La Roi 1967). Because the amounts of information in these studies are so varied, a subzone-based synthesis is difficult. However, for central-most Canada, Larsen (1972), using zonal subdivisions similar to those of Hämet-Ahti et al. (1974), but utilizing a complex of nine environmental factors, correlates zonal changes with plant distribution. The close coincidence between the subzones of Larsen (1972) and Hämet-Ahti et al. (1974) suggests that a direct comparison of species-zone relationships is possible for areas adjacent but outside the region studied by Larsen (1972).

One method basic to an understanding of the geography of plant communities is vegetation mapping, but there are few vegetation maps for the continental Northwest Territories. Those published are restricted to small scale vegetation maps, which convey broad physiognomic information, e.g., Raup (1946:62), Rowe (1972a), and the Forest Management Institute (1974), and forest cover maps which distinguish types like hardwood, softwood, and mixtures thereof (Hirvonen 1968, Wallace 1969). Large scale vegetation maps, detailing structural and compositional attributes, are unavailable. In addition, there are no attempts to ascertain if a mapping method like that of Küchler (1967), successful in temperate and tropical regions, is meaningful at northern latitudes.

Fire is known to be an integral component of boreal ecosystems (Rowe and Scotter 1973). Because fire recovery sequences are often different from region to region, an examination of each region is warranted (Black and Bliss 1978). Similarly, the concepts of succession and climax must always be related to specific terrain (Rowe 1961). For the Hay River Section of Rowe (1972a), no quantitative studies of succession exist.

One purpose of this phytosociological study was to obtain vegetational evidence of the middle boreal subzone in the southern District of Mackenzie by documenting the terrestrial and wetland plant communities occurring in a small but representative watershed.

The Heart Lake watershed was selected as the study area because its vegetation and landforms present a relatively diverse but representative pattern of boreal plant communities within a small area. Because the study is restricted, genetic and climatic variations are minimized. Furthermore, since the Heart Lake area lies adjacent to the region studied by Larsen (1972), a direct comparison of zonal characteristics is possible. Other reasons for selecting this study area are that it is easily accessible by road, lacks major disturbance, and had a research station within it.

The main objectives of the study were as follows:

1. record the floristic composition and structure of the vegetation in order to determine the variety of plant communities and their relationships to soils and sites;
2. determine if phytogeographical analysis of the vegetation supports previous analyses of floristic affinities in adjacent regions;
3. ascertain if classification of the boreal vegetation of this area based on dominant life-forms provides a scheme which

corresponds with the floristic phytosociological classification;

4. determine the pattern of the succession in relation to the landscape by analyzing tree diameter-classes;
5. refine the comprehensive mapping method proposed by Küchler (1967) to produce a vegetation map which emphasizes the distinctive features important for a portion of the middle boreal subzone;
6. compare classification techniques to see if the use of differential species groups based on the presence or absence of species was consistent with classification based on quantitative criteria; and
7. obtain detailed descriptions of the vegetation, flora, and soils.

The method of investigation employs a three-phase process: inventory, analysis, and synthesis. During the inventory, the structure and dominant species of all stands within a 30-km^2 area are completely enumerated, mapped, and stratified into formation-classes. Representative stands from each class are then selected along a topographic gradient for a detailed quantitative description. The analysis process involves classification and comparison based on a number of multivariate techniques. Concluding the process is a synthesis of the information into a final map produced by a fusion of several classifications using structure and dominant species, life forms, and floristic composition.

I will show that within the Heart Lake study area:

1. the vegetation supports the existence of a middle boreal subzone in central Canada;

2. a classification scheme employing differential species groups is mainly consistent with analyses based on dominance or frequency while exhibiting increased sensitivity to edaphic factors;

3. classification using dominant life-form spectra closely resembles the floristic phytosociological classification;

4. the kind of succession that occurs and return interval following fire are closely related to the presence or absence of poorly drained soils; and

5. modification of Küchler's vegetation mapping method results in a map that is meaningful at boreal latitudes.

STUDY AREA

Location

The study area is located southwest of Great Slave Lake in the southern District of Mackenzie, Northwest Territories, Canada (Figs. 1 and 2). It is bounded approximately by the geographical coordinates of 60°48′ and 60°53′ N lat. and of 116°37′ and 116°43′ W long. The study area surrounds Heart Lake, is irregular in shape, and is approximately 30 km^2 in size. The Mackenzie Highway crosses the study area and serves as a rough topographic boundary between its two major physiographic units: (1) the western lowlands and (2) the eastern uplands. From Heart Lake at an elevation of 249 m ASL in the southwestern part, the land rises slowly to 270-275 m in the east where it drops suddenly to

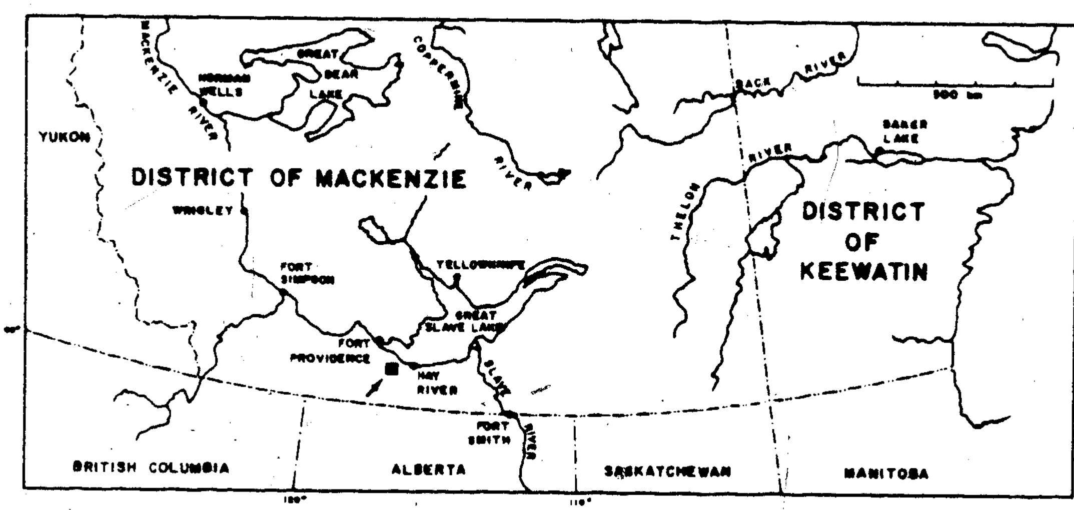
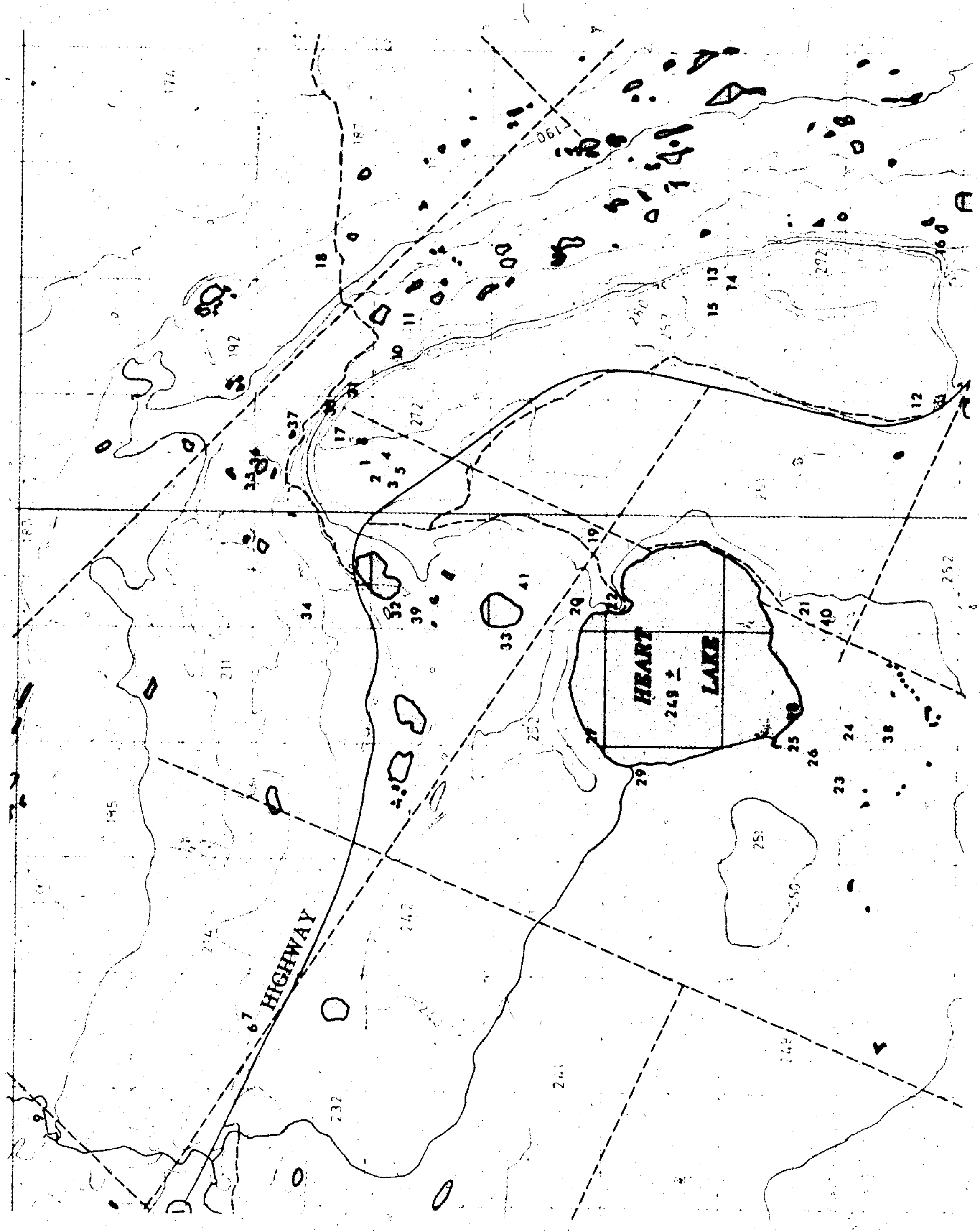


Figure 1. Location of the Heart Lake study area.

Figure 2. Map of the Heart Lake area study sites (modified from the Heart Lake map sheet, 85C/15; scale 1:50,000; courtesy of Surveys and Mapping Branch, Dept. of Energy, Mines and Resources, Ottawa, 1975). Contour interval is 10 m (light gray). Dashed lines indicate abandoned roads and seismic lines; study sites are shown (1-41).


HEART
LAKE
HIGHWAY

220 m along a steep limestone escarpment. From the top of this escarpment, Great Slave Lake is clearly visible some 18 km to the northeast at 154 m.

Physiographically the study area lies in the southern portion of the Great Slave Plain of the Interior Plains Region (Bostock 1970). It is distinctly bounded by the Cameron Hills of the Alberta Plateau to the south and the Cartridge Mountains escarpment of Great Bear Plain to the north. In the west the plain merges with the Mackenzie Mountain area of the Cordilleran Region, while the Shield of the Kazan Region defines the eastern boundary. Great Slave Plain is predominately low-lying, almost flat ground, usually below 300 m in elevation. It is characterized by low scarps of resistant carbonate strata, small shallow lakes, and organic terrain. In the central portion, however, an outlier of the Alberta Plateau, the Horn Plateau, rises to an elevation of 750 m (Bostock 1970).

Geology

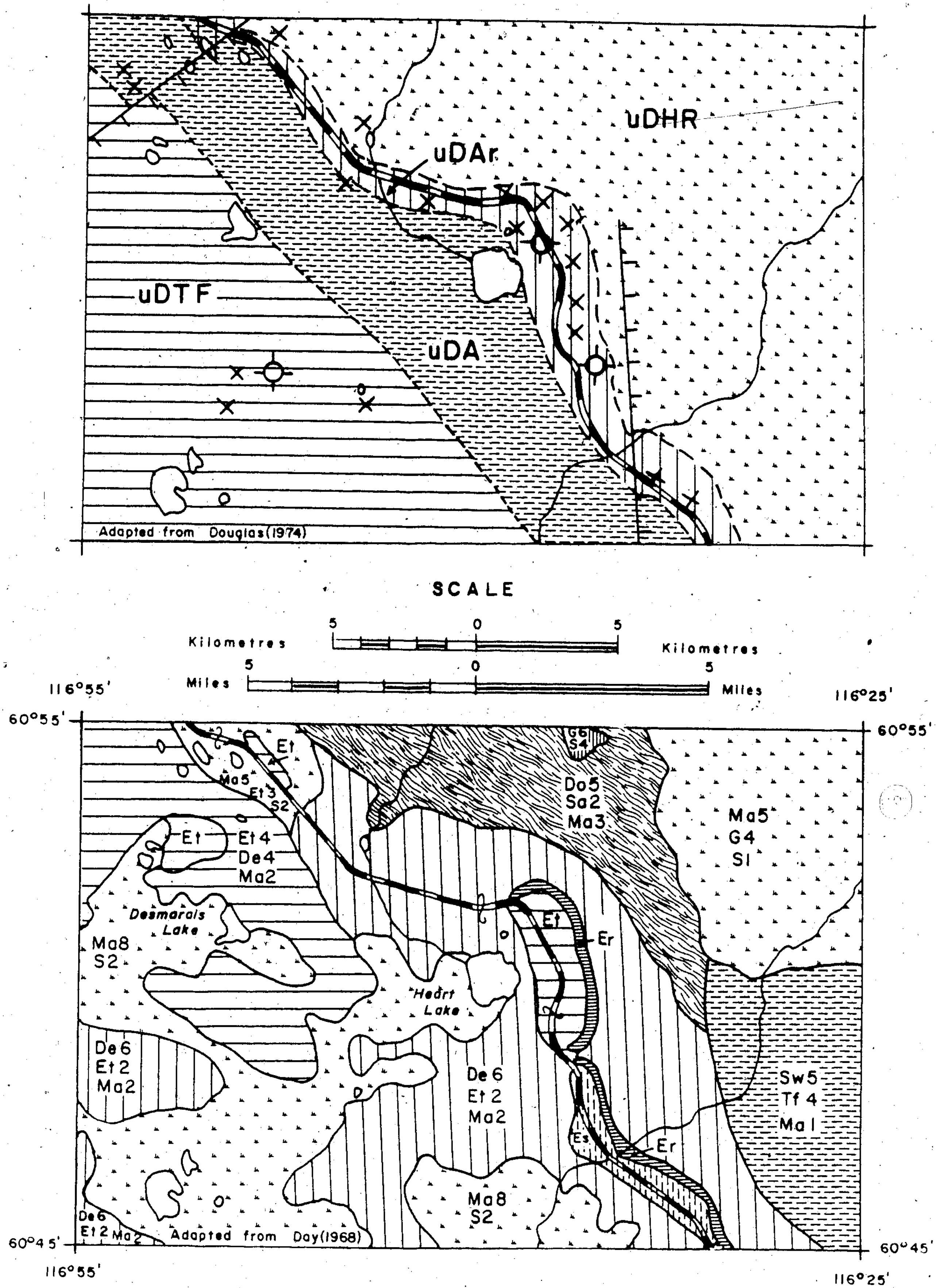
The major reports examining the surficial geology and geological formations of the southern Mackenzie are those of Craig (1965) and Douglas (1974), respectively, whose conclusions are adopted here.

The entire western basin of Great Slave Lake is underlain by Upper Devonian bedrock, while the hills of the Alberta and Horn Plateaus are of Cretaceous origin (Douglas 1974). Along the escarpment at Heart Lake, massive bioclastic limestone and reefy limestone beds outcrop as the Alexandra Member of the Twin Falls Formation (Fig. 3). A second component of this member bordering it to the west underlies Heart Lake and is composed of aphanitic limestone and shale. Farther west the Twin Falls Formation consists of varicolored limestone and shale. Below the escarpment to the east, the Hay River Formation, composed of greenish gray shale limestone and siltstone, stretches to Great Slave Lake (Douglas 1974).

During Wisconsin time, glacial ice, whose center was in the Keewatin District, covered the Interior Plains and penetrated to the eastern ranges of the Franklin and Mackenzie Mountains (Craig 1965). Although the main elements of physiography were probably well-developed prior to glaciation, the effect of glaciation was to lessen the apparent relief (Craig 1965). Immediately following the retreat of the continental ice sheet, an immense lake, Glacial Lake McConnell, was formed resulting from differential isostatic rebound toward the east (Craig 1965). The glacial lake's former limits extended from Great Bear Lake through Great Slave Lake to Lake Athabasca. During the isostatic re-adjustment that followed, water levels lowered until Glacial Lake McConnell separated into three

Figure 3. Geology of the area encompassing Heart Lake (Legend - uDTF = Twin Falls Formation: vari-colored limestone and shale; uDA = Alexandra Member, Twin Falls Formation: aphanitic lime-stone, shale; UDAr = Alexandra Member, Twin Falls Formation: bioclastic limestone and reefy limestone beds; uDHR = Hay River Formation: greenish gray shale, limestone, silt- stone; ⊥⊥⊥⊥ = normal fault (hatchures on downthrow side); X = rock outcrop; ⌖ = abandoned well).

Figure 4. Soils map of the area encompassing Heart Lake (Legend - De = Desmarais series; Do = Dory series; Et = Enterprise series; Er = Escarpment land type; Es = Escarpment complex; G = Grainger series; Ma - Matou series; S = Slough and Marsh land type; Sw = Swede series; Tf = Twin Falls complex. The number following each symbol is the decile portion of the series component in each unit of the complex).



uDHR
uDAr
uDTF
uDA
Adapted from Douglas(1974)
SCALE
Kilometres
5
0
5
Kilometres
Miles
5
0
5
Miles
116°55'
116°25'
60°55'
60°55'
Et
Ma5
Et 3
S2
G6
S4
Do5
Sa2
Ma3
Ma5
G4
S1
Et
Et 4
De4
Ma2
Desmarais
Lake
Ma8
S2
Et
Er
Heart
Lake
De6
Et2
Ma2
De 6
Et 2
Ma2
Sw5
Tf 4
Ma1
Es
Er
Ma8
S2
De6
Et2 Ma2
Adapted from Day(1968)
60°45'
60°45'
116°55'
116°25'

smaller lakes, one of which was ancestral to Great Slave Lake.

As a result of glaciation nearly the entire study area is covered by glacial drift with strandline features and bottom deposits from Glacial Lake McConnell dominating the landscape (Craig 1965). In many parts of the Heart Lake uplands, limestone bedrock is exposed. Although the drift is generally less that one meter thick, it occasionally reaches depths of several meters.

Paleovegetational investigations in the southern Mackenzie have been few. A broad outline of climatic and vegetational change in late Wisconsin and Holocene times as deduced from the pollen record for the northernmost forest line of Canada was presented by Nichols (1974, 1975). He demonstrated a synchrony and parallelism in movement of the northern forest-tundra ecotone over the past 6000 years and tentatively suggested similar movements for the southern tree line. His preliminary evidence indicated the greatest ecotonal displacement, perhaps 400 km, occurred in the continental interior of the Mackenzie and Keewatin. Conceivably, this may have had a significant effect on the study area.

Following deglaciation the climate ameliorated and entered a hypsithermal warm period with spruce forests ranging north of their present limit. A cooling period began about 4800 BP and lasted until 4000 BP during which time tundra expanded southward approaching its modern limit. Around 4000 BP temperatures peaked followed by generally decreasing temperatures and massive forest retreat. From 4000-3000 BP frequent fires swept through the northern forest presumably caused by summer expansion of cold dry arctic air masses (cf. Bryson 1966). Recovery from severe cooling occurred about 2000 BP followed by a brief cooling at 1400 BP. A minor warming around 1200-1000 BP apparently allowed a woodland advance followed by major cooling after 800-600 BP which resulted in a large-scale forest retreat. Within the last 150 years a slight warming may have occurred (Nichols 1974, 1975).

Soils

Soil development is generally weak throughout the study area. This may be attributed to three factors: (1) youth of the soils material with Laurentide glaciation ending at approximately 8500 BP (Bryson et al. 1969); (2) high base concentration of the parent material; and (3) a climate with low precipitation, long cold winters, and consequently low soil temperatures. According to Ives (1974) the study area lies within the sporadic permafrost zone.

In an extensive survey Day (1968) described and mapped the soils of the upper Mackenzie region which includes the Heart Lake area. These soils can be conveniently classified into great groups having generally similar profile characteristics which reflect similar genetic processes. If each great group is compared as to the percentage of the total area occupied, the mineral soils of the upper Mackenzie may be arranged according to decreasing abundance: Eutric Brunisols (32%), Gleysols (22), Regosols (4), Gray Luvisols (3), and Humic Gleysols (1). Eutric Brunisols are regarded as the zonal type (Department of Energy, Mines, and Resources 1974). Organic soils comprise 24%. Their zonal relations are considered by Tarnocai (1973) whose conclusions may be extended to the study area. He considers the organic soils in the southern Mackenzie to be dominantly Mesisols and Cryic Fibrisols. "Land types" (Day 1968) and water represent an additional 5 and 10%, respectively. Soils included within and adjacent to the Heart Lake study area are shown in Fig. 4 and their characteristics are summarized in Table 1.

Climate

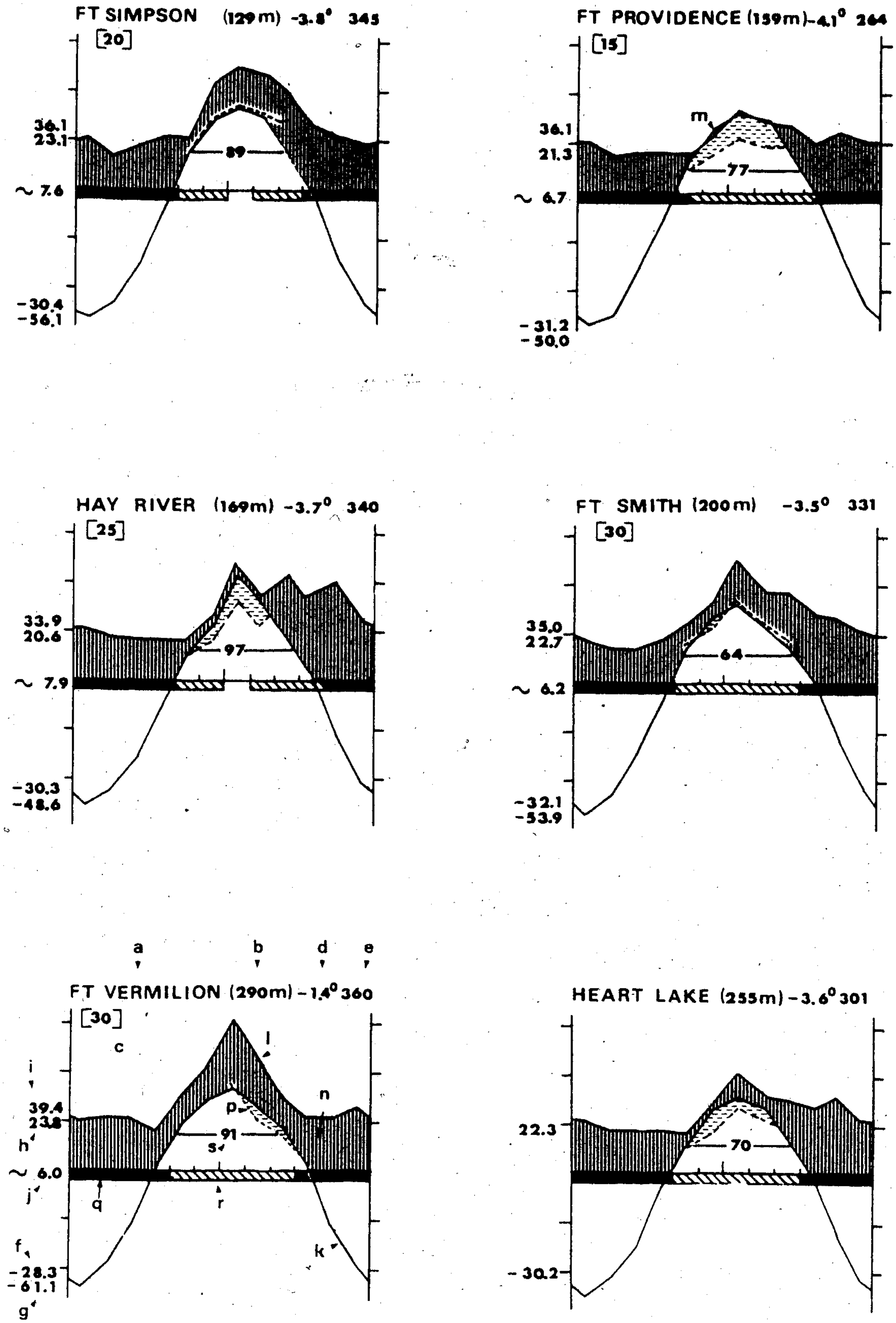
The climate of the Mackenzie Plain is cold, continental. In winter and spring the weather patterns are dominated by Arctic airstreams which are generally replaced in summer and fall by westerly currents originating in the Pacific (Hare and Thomas 1974).

Table 1. Characteristics of the soils of the Heart Lake area adapted from Day (1968).

Series	Subgroup[a]	*Distinctive Features*
Escarpment	Eutric Brunisols (Lithic family) Orthic Eutric Brunisols	Thin L-H over brown gravelly loam or sandy loam underlain by sandstone; well drained.
Enterprise	Orthic Eutric Brunisols	L-H thicker than above; brown stony, gravelly loam or sandy loam over stony, gravelly loam which often grades into sandstone, well drained.
Twin Falls	Orthic Eutric Brunisols Eluviated Eutric Brunisols Brunisolic Gray Luvisols	Coarse textured beach deposits of sand and gravel with occasional layers of medium textured deposits at elevations of 180-270 m; rapidly drained.
Granger	Fibric Organic Cryosols	Poorly decomposed, strongly acidic, reddish brown peat often with a cryic layer below 45 cm.
Matou	Mesisols	Well disintegrated peat over mineral soil, usually with a cryic layer.
Swede	Rego Gleysols (peaty phase)	Peaty organic material (8-30 cm) overlaying mottled, calcareous loamy sand or sand; occur on coarse upper beach deposits above elevations of 180 m; poorly drained.
Dory	Rego Gleysols	Brown strong, gravely loam over mottled grayish lacustrine silty loam; occur on medium to moderately fine beach deposits at elevations below 180 m; poorly drained.
Desmarais	Orthic Regosols	Peaty surface layer over moderately coarse to medium textured beach deposits.

[a]Nomenclature follows Canada Soil Survey Committee (1978).

Figure 5. Climatic diagrams (after Walter and Lieth 1967) of six stations located in northern Alberta and the southern District of Mackenzie. Data from Environment Canada (1973a and 1973b). For Heart Lake precipitation was estimated by averaging values from Fort Providence and Hay River, and temperature was calculated using the regression formulas of Hopkins (1968). Key: abscissa = months of year, January to December; ordinate = one unit equals 10°C or 20 mm precipitation; a - station name; b - altitude (m); c = number of years of observation; d = mean annual temperature (°C); e = mean annual precipitation (mm); f = mean daily minimum temperature in coldest month; g = absolute minimum temperature; h = mean daily maximum temperature; i = absolute maximum temperature; j = mean daily temperature range; k = curve of mean monthly temperature; l = curve of mean monthly precipitation; m = drought period (dotted); n = humid period (hatchures); p = reduced supplementary precipitation curve (10°C = 30 mm) and above it dashes in dry period; q = months with mean daily minimum below 0°C (black), cold period; r = months with absolute minimum below 0°C (diagonal shading), late or early frosts occur; s = mean duration of frost-dree period (days).


FT SIMPSON (129m) -3.8° 345
[20]
36.1
23.1
89
~ 7.6
-30.4
-56.1
FT PROVIDENCE (159m)-4.1° 264
[15]
m
36.1
21.3
77
~ 6.7
-31.2
-50.0
HAY RIVER (169m) -3.7° 340
[25]
33.9
20.6
97
~ 7.9
-30.3
-48.6
FT SMITH (200m) -3.5° 331
[30]
35.0
22.7
64
~ 6.2
-32.1
-53.9
a
b
d
e
FT VERMILION (290m) -1.4° 360
[30]
c
l
i
n
p
39.4
23.8
91
h
s
~ 6.0
j
q
r
f
k
-28.3
-61.1
g
HEART LAKE (255m) -3.6° 301
22.3
70
-30.2

The regional climate (Fig. 5) may be characterized and classified on the basis of long-term normals from several stations that encircle the Hay River Section of Rowe (1972a). In assessing the representativeness of these records, care is needed because many of the weather stations are located adjacent to large lakes and rivers. It is possible to interpolate climates of other locations within the section, given latitude, longitude, and elevation, and using the regression formulas of Hopkins (1968). For Heart Lake, these formulas were used to calculate temperature values such as the monthly and annual mean daily maximum, mean daily minimum, and mean temperatures (Williams 1975, personal communication).

Climatic classification is a geographic technique for synthesizing large quantities of climatic data into a manageable number of climatic types that can be characterized and mapped. Some climatic classification systems (Troll and Paffen 1964) are broad in scope, characterizing vast areas of central Canada including the study area as belonging to one climatic type, the Cold Temperate Boreal Zone. Others systems are more discriminatory and recognize subclasses (Walter and Lieth 1967, Hare and Thomas 1974, and Hämet-Ahti et al. 1974).

To compare climatic details of widely separated geographic localities whose vegetation might be very similar, Walter and Lieth (1967) developed a technique for constructing climatic diagrams for meteorological stations that record temperature and precipitation. The climatic diagrams (Fig. 5) representative of the southern District of Mackenzie and northern Alberta were classified into two types whose joint boundary passes approximately through Heart Lake. Using this approach the Fort Simpson, Hay River, and Fort Vermilion stations, were "Boreal"; whereas Fort Providence, Fort Smith, and tentatively Heart Lake were "Arctic".

Hare and Thomas (1974) related annual net radiation to vegetation zonation. Typical values (kly yr^{-1}) for the boreal zone are: forest tundra and woodland (20-25), northern forest line (30), and boreal forest (30-35). The study area, with an interpolated annual net radiation of 28 (Hare and Thomas 1974:30, Fig. 3.3), bridges the woodland and main boreal divisions.

Hämet-Ahti et al. (1974) proposed a method to determine the bioclimatic zones and subzones of the world based on "biotemperature". The mean annual biotemperature is calculated by summing all the mean months temperatures above 0^oC, mean temperatures above 30^oC being counted as 30^oC, and dividing by 12. The approximate biotemperature ranges are: northern (3.5 - 4.5^oC), middle 4.5 - 5.5), southern (5.5 - 6.5), and hemiboreal (6.5 - 7.5).

If compared on the criterion of biotemperature, the following stations are middle boreal: Hay River

(5.1°C), Fort Simpson (5.1°C), Fort Smith (4.9°C), Fort Providence (4.8°C), and Heart Lake (4.6°C); whereas Yellowknife (4.4°C) is northern boreal; and Fort Vermilion (5.5°C) is marginally southern boreal (cf. Hämet-Ahti 1976:58).

These narrowly-defined climatic classification systems show clearly that the climate of the study area is transitional. In contrast to the classifications of Walter and Lieth (1967) and Hare and Thomas (1974), whose boundaries go across Heart Lake, the system of Hämet-Ahti et al. (1974) recognizes an intermediate subzone, middle boreal. As climate is one of the main determinants of plant distribution, the nature of the Heart Lake vegetation should likewise be transitional and exhibit characteristics intermediate between southern and northern boreal.

Fire is a natural phenomenon in boreal ecosystems (Rowe and Scotter 1973). In the Mackenzie Valley, Rowe et al. (1974) concluded that climate exerts a significant effect on fire frequency with lightning as the primary ignition agent. Since boreal vegetation pattern is so strongly related to fire history, the vegetation mosaic of the study area should similarly reflect the influence of fire. From an examination of Mackenzie Forest Service fire records in Fort Smith, N.W.T., it is apparent that fires are a frequent phenomenon through the District of Mackenzie. After plotting these reported fire records on the Tathlina Lake (85C) map sheet (60-61N, 116-118W) which includes the study area, I estimate 15-20 percent of the land surface was burned over from 1950 to 1971.

METHODS

Vegetation

In this study the term "phytocoenose" (Westhoff and Maarel 1973:625) refers to a concrete plant community or compartment of the vegetation which was sampled. The abstract "phytocoenon" (Westhoff and Maarel 1973:625) was a "type of phytocoenose derived from the characterization of a group of phytocoenoses corresponding with each other in all characters that were considered typologically relevant". Phytocoena therefore included vegetation units defined on criteria such as physiognomy, life-forms, dominance, floristics, multivariate analysis, or combinations of these.

The methodology employed to describe and classify the vegetation was developed in a stepwise manner which involved inventory, analysis, and synthesis, and culminated in a vegetation map of the study area.

Inventory

In order to form a sound basis for characterizing a representative area within the middle boreal subzone, a 30-km^2 portion of a small watershed surrounding Heart Lake was selected to encompass a topographic gradient which included a catena of sites from wet to dry.

Prior to initiating the field investigation, all 571 phytocoenoses within the study area were interpreted from aerial photographs, scale 1:13,200, and delineated into physiognomically homogeneous units on a preliminary map. These phytocoenoses later served as the framework for a phytosociological study of the plant communities selected to represent the spectrum of environmental and vegetational variation within the area.

Following a ground reconnaissance of the Heart Lake region, a field survey of all 571 phytocoenoses was conducted to record physiognomy, structure, and dominant woody species. Concomitantly, the boundaries between phytocoenoses were reinterpreted and modified when necessary. Each phytocoenose was described in the field according to Küchler's (1967) physiognomic-structural system with a minor modification of his height classes, which were altered as follows: class 1, <0.1 m; 2, 0.1-0.3 m; 3, 0.3- 1.5 m, 4, 1.5-4.5 m; 5, 4.5-9 m; 6, 9-15 m; 7, 15-18 m; 8, >18 m. Estimation of height was refined through the use of a meter stick and clinometer in each phytocoenose. Life-form categories and their definitions follow Küchler (1967) with the exception of the "bryoid" category which was subdivided into mosses, lichens, and sphagna, to better express boreal characteristics. The basic woody categories were: broadleaf evergreen, broadleaf deciduous, needleleaf evergreen, needleleaf deciduous, and mixed (at least 25%

broadleaf deciduous and 25% needleleaf evergreen). Herbaceous vegetation categories included graminoids and forbs. Cover, using the cover classes of Küchler (1967), was estimated for each height class of each life-form category. To obtain some indication of floristic composition the dominant species of major woody vegetation and forb categories were enumerated and assigned cover values.

In the next major step, all phytocoenose field descriptions were hand sorted and classified into seven formation classes according to the Fosberg (1967) structural-formation system. These classes were delimited on the preliminary map and served to stratify the vegetation for more intensive sampling. Forty-one representative phytocoenoses within these seven classes were then selected for future quantitative study along an elevational gradient which originated in xeric plateau-like uplands and terminated in wet peatlands. Sampling intensity was thus roughly proportional to the commonness of a particular formation class. Examples of rare phytocoenoses not found along the gradient but occurring elsewhere in the study area were also included. As suggested by Ramensky (1953:35): "a rare experiment in nature sometimes gives a key to understanding a wide range of phenomena".

Vegetation description was therefore accomplished at two levels: general and detailed. At the general level the physiognomy, structure, and dominant woody species of all map phytocoenoses were investigated. At the detailed level, quantitative investigations were undertaken to record the floristic composition, structure, life-form, and major edaphic and site features of the selected phytocoenoses. To be acceptable for sampling, a phytocoenose had to meet two requirements: (1) homogeneous; and (2) area occupied by phytocoenose not less than 0.5 ha.

A stratified-random sampling procedure was employed using ten centrally nested quadrats of the following dimensions: 1 x 1 m, 5 x 5 m, and 10 x 10 m to measure the composition and structure of the herb, moss, lichen; shrub; and tree strata, respectively, of 41 phytocoenoses. Stratal subdivisions of the above follow La Roi (1967): (1) Tree, specimens whose stem dbh exceeds 7.5 cm; (2) Low Tree - sapling, specimens ranging from 2.5-7.5 cm dbh; (3) Tall Shrub - transgressive, plants from 150 cm tall to 2.5 cm dbh. The 150 cm limit represents a minor modification of La Roi's (1967) system where 135 cm was used; (4) Medium and Low Shrub - transgressive, specimens from 30-150 cm tall; (5) Herb-Dwarf Shrub - seedling, woody plants less than 30 cm tall and all herbaceous plants; and (6) Bryoid - bryophytes and lichens.

Sampling adequacy was assessed using a modification of Cain's (1938:577) minimal area criterion.

The modification used the stratified-random procedure above to develop species-area curves of plants of different stature rather than by assessing all species within contiguous quadrats. Sampled areas were larger than those indicated by species-area curves for each stratum. Homogeneity degree was calculated for each phytocoenose using the homogeneity-coefficient (bH) of Moravec (1971):

$$bH = \frac{1}{d} \sum_{j}^{\ell} C_j$$

where Cj = quadrat frequency percentage of species j (=species with frequency ≥61%), d = mean species number per sample plot, l = number of species with frequency ≥61%. The highest value possible was 100 indicating perfect homogeneity, and the lowest, zero.

Canopy coverage was evaluated as the sum of shadows (Daubenmire 1968:42) for all species. Bryoids on decaying stumps and logs were included but not crustose lichens, epilithic bryoids, or certain Lophoziaceae due to difficulties in critical identification.

Cover values were estimated by strata in each quadrat for eight cover-abundance classes: +, <1%; 1, 1-5%; 2, 6-15%; 3, 16-25%; 4, 26-50% 5, 51-75% 6, 76-95%; and 7, 96-100%. In an additional category, r, rare species occurring outside the quadrats but within each phytocoenose were listed. Mean cover was calculated using the midpoints of the cover-abundance classes. Categories r and + were arbitrarily assigned a value of 1%.

In addition to the plant collections made within each phytocoenose, a concomitant survey was conducted which sought to catalog all vascular plants and bryoids in the study area excluding the exceptions previously noted.

Classification of vascular life-forms followed the Emberger and Sauvage (1968) revision of Raunkiaer (1934). In this study the traditional qualitative classification was used, and a second approach was introduced which sought to establish a quantitative description based on dominant life-forms of component vascular strata. The method described structure at the phytocoenose level by indicating the percentages of total cover of the life-forms in the different strata.

Identification of life-forms according to Emberger and Sauvage (1968) were made in both the field and from voucher specimens. In cases where more than one interpretation was possible for a particular species, I was guided by the categorizations of Scoggan (1978), Thieret (1963), and Ennis (1928) to maintain inter-study consistency.

Tree age was assessed in several size classes by taking increment cores, or discs at 30 cm above-ground for the tree or sapling nearest quadrat center in each of the ten 10 x 10 m quadrats and also the largest tree (dbh and height) in the quadrat.

Potential climax was predicted from tree stand structure. As discussed by Harper (1977) tree size distribution represents some measure of a population's future. Thus, to determine successional trends toward the climax, all living and dead-standing trees were tallied by species and by 2.5 cm (1-inch) diameter classes within ten 10 x 10 m quadrats for each of the 41 phytocoenoses. The resulting data were also used to calculate density and basal area. Assessment of reproduction success was based on whether ten or more individuals per acre (.4047 ha) occupied or would occupy the site (Pfister et al. 1977). In this study an arbitrary lower diameter limit of 2.5 cm was set to determine if a species might occupy the site at the climax. Thus, tree species less than 2.5 cm dbh were excluded from analysis. The dead standing trees were assumed to represent the known mortality of the population since few fallen dead trees were observed and decay was inhibited under the dry, cold-continental climate.

Analysis

Phytocoenoses were classified by a combination of methods including two fundamental approaches: clustering and ordination. In clustering, similar phytocoenoses are grouped into classes, while in ordination each phytocoenose is ordered on one or more axes as an individual. Although different philosophies underlay each method, these were considered complementary. Their primary purposes were data reduction, efficient communication, and interpretation. Accordingly, their objective was to produce a quantitative description or display of some of the relations between the objects being classified. These procedures were used to improve objectivity and judgement in defining phytocoena and vegetation map units.

In this study a polythetic, agglomerative clustering method, described in detail by Orloci (1967), was used. The technique was defined by a metric (distance) function and utilized within-group sum of squares as the agglomeration criterion (Orloci 1975). Successive cycles of agglomeration were carried out to minimize within-group sum of squares which, consequently, maximized the differences between groups at each clustering cycle (Orloci 1967).

Similarity relationships were displayed geometrically using the polar ordination technique of Bray and Curtis (1957) as modified by Beals (1960) for positioning the phytocoenoses along ordination axes and employed Sørensen's (1948) index of similarity (IS) = 2 $w/(a+b)$ where w = the number of species shared by two phytocoenoses, a = the total number of species in one phytocoenose, and b = the total number of species in the second phytocoenose.

Since ordinations are only a geometric approximation for displaying similarity values, it was necessary to test for their efficiency. Statistical tests were performed to assess the validity of the ordinations using randomly selected phytocoenose pairs. Following standard phytosociological practice inter-stand ordination distances were compared with inter-stand similarity values and the ordinations were evaluated by the correlation coefficient *r* (Bray and Curtis 1957, Mueller-Dombois and Ellenberg 1974).

In evaluating clustering results it was desirable to know the degree to which two classifications of the same set of phytocoenoses were independent. Thus, classes established on a criterion like species cover-abundance could be used to compare classes based on other properties, e.g., life-form. To determine how reliably a given classification might be used for prediction, the method of Orloci (1975:134-136) was adopted. He calculates a "mutual information" statistic (I) and tests for independence in a contingency table:

$$2I = 2 \sum_h \sum_i f_{hi} \ln \frac{f_{hi} f_{..}}{f_{h.} f_{.i}}$$

where h - label for row; i = label for column; $\ln$ - natural logarithm; f_{hi} = element in hi cell; f_h - hth row total; $f_{.i}$ = ith column total; and $f_{..}$ =

grand total for table. The calculated value was then referred to the chi-square distribution table to test for significance and if less than $2I$, the hypothesis for independence was rejected. In order to make a more quantitative statement in terms of relating scale, a coherence coefficient, r (Orloci 1975) may be calculated using Rajski's (d) metric defined by

$$d = 1 - \frac{\sum_h \sum_i f_{hi} \ln f_{hi} f_{..} / (f_{h.} f_{.i})}{-\sum_h \sum_i f_{hi} \ln f_{hi} \ln f_{hi} / f_{..}}$$

with summations $h = 1, \ldots, n$; $i = 1, \ldots, c$, where n and c indicate the number of rows and columns, respectively, in the contingency table. From the d value Orloci (1975) computes the coherence coefficient, r, whose limits are one and zero where a value of one indicates the highest affinity:

$$r = \sqrt{(1 - d^2)}$$

Orloci's procedure ostensibly resembles other tests of independence and like them only indicates whether two classifications are related. But, because he first incorporates an information statistic into the test, it is possible through the use of the coherence coefficient to offer a unique quantitative measure of the strength of the relationship.

In all quantitative analyses, cover data computations were based on an ordinal cover transformation. The transformed value scale follows: 1, <1%; 2, 1-1.9%; 3, 2-2.9%; 4, 3-4.9%; 5, 5-12.9%; 6, 13-25.9%; 7, 26-50.9%; 8, 51-75.9%; and 9, 76-100% (Westhoff and Maarel 1973). This transformation, while recognizing overall dominance, allowed for the representation of small values and maintained the relative order of species importance.

An analysis of several data sets based on actual percent cover was also carried out, but the results, although similar to those where transformed values were used, were not adopted because of the flooding of small data values by the larger.

One other classificatory technique was used. It employed a computer program based on the Braun-Blanquet method for identifying species-phytocoenose groups (Ceska and Roemer 1971) and used species presence-absence data. The aim of this process was to group those phytocoenoses together which were typified by particular groups of species and, conversely, to group those species together which typified particular groups of phytocoenoses. According to Ceska and Roemer (1971:256-257), the species-phytocoenose groups, or "blocks", in a vegetation table "show the extent, precision, and validity of these species-phytocoenose groups, and distinguish the vegetation types from each other." Once identified those species phytocoenose groups which "optimally differentiate" corresponding groups of phytocoenoses were extracted from the table. Both species groups and phytocoenoses are then ordered using Hill's (1973) method of reciprocal averaging to follow the main underlying factor (Ceska and Roemer 1973:1).

Classification of the 41 phytocoenoses was thus the combined result of several formulative numerical procedures. Phytocoenoses were first classified using the agglomerative clustering method (Orloci 1967) based on species quadrat frequency classes, giving the "F" classification. Although frequency is a non-absolute measure (Greig-Smith 1964) and varies with quadrat size and shape, it has the advantage of integrating density and pattern.

A second cluster analysis was performed on transformed species cover values, giving the "C" classification. Cover is usually attributed greater ecological significance than is density or frequency (Mueller-Dombois and Ellenberg 1974).

Coincidence between the "F" and "C" classifications was compared using the mutual information statistic and coherence coefficient (Orloci 1975). Inconsistencies were resolved using the species-phytocoenose group method (Ceska and Roemer 1973), species-number curve method (Böttcher 1968), and ordination (Bray and Curtis 1957). Using ordination it was possible to "demonstrate similarity relations geometrically" (Mueller-Dombois and Ellenberg 1974:277) and relate the phytocoenoses to edaphic trends.

Classification of 41 phytocoenoses based on the dominance of 32 vascular life-forms was accomplished using the Orloci (1967) clustering method and the ordinal transformation of percent cover given previously.

Synthesis

The final stage integrated the classifications produced in the analytic phase through the process of successive approximation (Poore 1962), i.e., those based on structure, dominant life-forms, floristic composition, and succession, into a hierarchical system of vegetation units which formed the framework of the map legend. This was accomplished using characteristics of the plant communities identified as significant in the analytic phase. Since not all significant features can be fully reflected in a hierarchical system, a coordination scheme was developed for the map and text which sought to emphasize distinctive vegetation features.

An important consideration in the development of the entire map was that the names of the vegetation classes follow a relatively consistent system of nomenclature. Thus, the map units were defined primarily within the framework of the Fosberg (1967) classification system. This system, based strictly on characteristics of the vegetation, was modified according to the Ellenberg and Mueller-Dombois (1967a) structural-ecological system to incorporate terms referring to soils and landforms where they aided in the identification of units. Like the preliminary map, the final map utilized the "formation class" as the broadest level of division, e.g. forest, woodland, dwarf scrub. The next separation of units, "formation group", recognized whether or not the dominant community layer was evergreen or deciduous. At the next succeeding level, "formation", characterization was by growth-form with emphasis on leaf texture, e.g., resinous evergreen narrow sclerophyll forest. Further subdivisions separated the actual map units. These were distinguished by compositional criteria, the evergreen or deciduous nature of the understory, and bryoid dominance.

Average percent cover values determined for the map units were based on midpoints of Kuchler coverage classes. The numerical value 0.5% was arbitrarily selected for the a class, <1%.

Taxonomic considerations

Species nomenclature follows Porsild and Cody (1968) for all vascular plants except *Salix* which follows Argus (1973), Crum et al. (1973) for all mosses except Mniaceae and *Sphagnum* which follow Koponen (1974) and

Isoviita (1966), respectively; Bird and Hong (1975) for hepatics; and Hale and Culberson (1970) for lichens except Cladina which generally follows the European treatment as Cladonia (Appendix I).

The treatment of the Peltigera canina complex included P. rufescens (Weiss) Humb. in the phytocoenose descriptions. Although both were present, they were often difficult to distinguish in the field.

Information on species distribution was obtained from Bird et al. (1977), Bird and Hong (1975), Brodo (1968), Porsild and Cody (1981), Kurokawa (1962), Llano (1950), National Herbarium of Canada, Porsild (1955), Thomson (1963, 1967), and Welch (1960).

A nearly complete set of voucher specimens is deposited at the University of Alberta Herbarium (ALTA). Partial sets have been placed on file at the National Herbarium of Canada, Ottawa (CAN), New York Botanical Garden, Bronx, (NY), Canada Department of Agriculture, Ottawa (DOA), U.S. Forest Service, Ft. Collins (FS), and University of Helsinki (H) herbaria.

Soils

Within each phytocoenose two soil profiles were described at least to the subgroup level according to the Canada Soil Survey Committee, Subcommittee on Soil Classification (1978). Soil pit location was established using the center of the first and tenth nested vegetation quadrats in each phytocoenose. Soil color determination was based on the Munsell color designations. In some instances the presence of permafrost or high water tables did not permit complete descriptions of the lower horizons. Composite samples were collected from each horizon for laboratory analysis.

After screening the <2 mm fraction was subjected to textural analysis following the hydrometer method (Bouyoucos 1951). Percentages of sand (2.0 - 0.05 mm), silt (0.05 - 0.002 mm), and clay (<0.002 mm) were determined, but organic matter was not removed prior to the analysis. Soil horizon acidity was determined using a Beckman pH meter according to the soil paste method (Doughty 1941).

Drainage conditions were estimated in the field based on factors such as water table depth, molting, texture, soil depth to bedrock, and topographic position.

RESULTS

Flora

An enumeration of the vascular flora revealed 316 species (317 taxa) representing 162 genera distributed in 60 families (Appendix I). The largest families were: Cyperaceae (42 species), Compositae (29), Gramineae (23), Salicaceae (17), Rosaceae (16), Cruciferae (13), Caryophyllaceae (12), Orchidaceae (11), and Ranunculaceae (10). The two genera with the highest number of species were: Carex (31) and Salix (15).

In geographical distribution the vascular species are composed of several floristic elements:

1. North American. This group is composed of species endemic to North America. It contains nearly half, or 49.3% (156 species) of the Heart Lake flora. They are primarily wide-ranging, boreal species such as *Glyceria striata*, *Listera borealis*, *Larix laricina*, *Muhlenbergia glomerata*, *Orzyopsis asperifolia*, *Picea mariana*, and *Primula mistassinica*. Nine species within the North American element are endemic to the west: *Antennaria campestris*, *Astragalus yukonis*, *Dodecatheon pauciflorum*, *Erigeron glabellus*, *Melandrium ostenfeldii*, *Oxytropis varians*, *Salix athabascensis*, *Senecio lugens*, and *Solidago decumbens*.

2. Circumpolar. This second major group is composed of 135 species, or 42.7% of the flora. Although the majority are wide-ranging species like Allium schoenoprasum, Andromeda polifolia, Androsace septentrionalis, Arctostaphylos uva-ursi, Corallorhiza trifida, Equisetum fluviatile, and Moneses unifora, there are species groups of more restricted distribution (sensu Porsild 1955): widespread arctic-alpine (Arnica alpina, Campanula rotundifolia, Draba glabella, Empetrum nigrum, Poa glauca, Polygonum viviparum, Salix reticulata, and Woodsia glabella); low arctic (Carex chordorrhiza, C. gynocrates, Deschampsia caespitosa, Eriophorum brachyantherum, Lycopodium annotinum, and Tofieldia pusilla); and non-arctic (Carex diandra, Eleocharis palustris, Oxycoccus quadripetalus, Potamogeton natans, Potentilla norvegica, Stellaria calycantha, and Typha latifolia).

3. Amphi-Beringian. This element is centered in eastern Asia and northwestern America. Three species, or 1.0% of the flora, belong to this category: Arctagrostis arundinacea, Aster sibiricus and Cypripedium guttatum.

4. Cosmopolitan. This group contains species which are either introduced aliens, including those native Canadian species transported north by man, or species with a nearly world-wide distribution. It accounts for 5.7% of the flora with 18 species. Examples are: Capsella bursa-

pastoris, Crepis tectorum, Descurainia sophia, Melilotus alba, Phleum pratense, Poa pratensis, and Plantago major.

5. Cordilleran. There are only four species or 1.3% of the flora in this group whose center of distribution is in the Cordillera: Draba oligosperma, Plantago septata, Senecio cymbalarioides, and Silene menziesii.

The Heart Lake mosses were represented by 136 species from 61 genera and 33 families (Appendix I). Families with 10 or more species are Amblystegiaceae (18 species), Dicranaceae (15), Hypnaceae (12), Mniaceae (12), Bryaceae (10), and Sphagnaceae (10). The largest genera are Dicranum (12 species), Sphagnum (10), Hypnum (8), and Drepanocladus (6).

Four phytogeographic elements are represented:

1. Circumpolar. This dominant group comprised 79.4% of the mosses, or 108 species. Examples included Dicranum polysetum, Mnium orthorrhynchum, Sphagnum riparium, Tetraphis pellucida, Thuidium recognitum, and Tortula ruralis.

2. Cosmopolitan. This group accounted for 16.9% of the mosses, or 23 species. It contained the "weedy" species Ceratodon purpureus, Funaria hygrometrica, Leptobryum pyriforme, and Bryum argenteum as well as nearly world-wide species like Grimmia apocarpa,

Rhacomitrium heterostichum, *Pohlia cruda*, *Drepanocladus uncinatus*, and *Hypnum cupressiforme*.

3. North American. A minor element composed of 5 species, or 3.7% of the mosses: *Fissidens arcticus*, *Orthotrichum jamesianum*, *Plagiomnium ciliare*, *Fontinalis daecarlica*, and possibly *Seligeria tristichoides*.

All 16 species (Appendix I) of the hepatic flora collected at Heart Lake were circumboreal.

Eighty-five lichen species were collected (Appendix I) but the number of species in the flora may be higher. The flora contains a major circumpolar element, 95.2%, or 81 species. Two species, 2.3%, might be amphi-Beringian: *Evernia perfragilis* and *Umbilicaria muhlenbergii*; one (1.1%) is nearly cosmopolitan, *Cladonia gracilis*; and the other (1.1%) is primarily North American, *Alectoria glabra*.

Presence

A number of species were widespread throughout the Heart Lake area. Those with a presence in phytocoenoses of 50% or greater were: *Cetraria pinastri*, *Cladonia arbuscula*, *C. mitis*, *Galium boreale*, *Hylocomium splendens*, *Juniperus communis*, and *Rosa acicularis*; while those occurring from 40-49% were *Campylium hispidulum*, *Cladonia cornuta*, *C. gracilis*, *C. pyxidata*, *C.*

rangiferina, Dicranum undulatum, Ditrichum flexicaule, Drepanocladus uncinatus, Elymus innovatus, Linnaea borealis, Peltigera aphthosa, Picea glauca, P. mariana, Pinus banksiana, Ptilidium ciliare, Pyrola secunda, and Tomenthypnum nitens.

A different pattern emerged if presence was considered separately within two major topographic groups: uplands (21 phytocoenoses) and lowlands (20). For inclusion in a given group a species must not have a presence of more than 15% in the other group. Accordingly, "upland species" with presence 70% or greater were: Drepanocladus uncinatus, Elymus innovatus, Eurhynchium pulchellum, Juniperus communis, Linnaea borealis, Picea glauca, Populus tremuloides, Pyrola secunda, and Rosa acicularis; 60-69%: Arctostaphylos uva-ursi, Brachythechium salebrosum, Cetraria ericetorum, Cladonia pyxidata, and Peltigera canina; and 50-59%: Amelanchier alnifolia, Cetraria nivalis, Cladonia multiformis, Cornus canadensis, Ptilidium pulcherrimum, and Salix bebbiana. Predominantly "lowland species" with presence 70% or greater were: Betula glandulosa and Bryum pseudotriquetrum; 60-69%: Campylium stellatum; and 50-59%: Carex aquatilis, Drepanocladus revolvens, Larix laricina, Salix candida, and Scorpidium scorpioides.

Life-form composition of the vascular flora

The vascular species collected at Heart Lake are referable to 34 classes in the life-form classification system of Emberger and Sauvage (1968; Appendix II). In Table 2 the life-form spectra are compared for the study area. When vascular cryptogams were included (Emberger and Sauvage 1968), the percentages of chamaephytes and cryptophytes increased only slightly, 0.5 and 2.1% respectively, while other groups correspondingly decreased. Therefore, the inclusion of 14 vascular cryptogamic species, which form an important floristic element, did not seem to modify the spectrum appreciably. The vascular flora was made up of 83% herbaceous and 17% woody species.

Hemicryptophytes clearly represent the most abundant life-form, constituting 46% of the flora, while cryptophytes (including hydrophytes) comprise 25%. Thus 71% of the Heart Lake species have their perennating bud protected by the substratum. The remaining 29% of the flora consists of phanerophytes, 13%, chamaephytes, 12%, and therophytes, 4%.

In comparison with the "normal spectrum" (Raunkiaer 1934), the flora at Heart Lake was lower in phanerophytes and therophytes, higher in chamaephytes, and much higher in hemicryptophytes and cryptophytes. This departure from the "normal spectrum" demonstrated

Table 2. Life-form spectra of the Heart Lake flora and the "normal spectrum" of Raunkiaer (1934).

	No. Species	Life-form percentages				
		P	Ch	H	C	Th
Heart Lake						
Without vascular cryptogams	303	13.9	11.2	47.5	23.1	4.0
With vascular cryptogams	317	13.4	11.7	46.1	25.2	3.8
"Normal spectrum"	1000	46.0	9.0	26.0	6.0	13.0

differences which Raunkiaer considers characteristic of thermally unfavorable climates (Raunkiaer 1934).

The numbers of species in subclasses of the life-form classes are presented in Table 3. In the phanerophyte class the greatest proportion of species is in the nanophanerophyte subclass. There are approximately twice as many herbaceous as woody species represented in the chamaephyte class. In the hemicryptophytes the semi-rosette subclass has 66 species, or 46% of the class. When the hemicryptophyte data were reassessed using the three traditional subclasses (Raunkiaer 1934), most biennial and caespitose species (Appendix II) fell into the semi-rosette subclass which then accounted for 64% of the hemicryptophyte class. Hemicryptophyte species are also classed as stoloniferous, 46%, and non-stoloniferous, 54% (Appendix II). Rhizomatous species make up 81% of all terrestrial cryptophytes. Cryptophytes without rosettes are more abundant that those with rosettes: 61% and 39% of all terrestrial cryptophytes, respectively. If hydrophytes were considered as a cryptophyte subclass, they would comprise 31% of all cryptophytes and 8% of the flora.

In Table 4 woody species are classified into three leaf types: broadleaf evergreen, needleleaf evergreen, and deciduous. Broadleaf evergreen angiosperms were most species rich in the chamaephyte subclass (18%), decreased markedly in the nanophanerophytes (5%), and were

Table 3. Life-form distribution of the Heart Lake flora. Vascular cryptogams are included.

LIFE-FORM CLASS Subclass	Total Species		Percent of Flora	
PHANEROPHYTES (P)	41		13.0	
Mesophanerophytes		7		2.2
Michrophanerophytes		11		3.5
Nanophanerophytes		23		7.3
CHAMAEPHYTES (Ch)	38		12.0	
Herbaceous chamaephytes		24		7.6
Woody chamaephytes		14		4.4
HEMICRYPTOPHYTES (H)	146		46.0	
Protohemicryptophytes		29		9.1
Caespitose hemicryptophytes		16		5.0
Semi-rosette hemicryptophytes		66		20.8
Biennial hemicryptophytes		11		3.5
CRYPTOPHYTES (C)	54		17.0	
Bulb or tuber cryptophytes				
with rosettes		3		0.9
without rosettes		6		1.9
Rhizome cryptophytes				
with rosettes		18		5.7
without rosettes		26		8.2
Root cryptophytes		1		0.1
HYDROPHYTES (Hy)	26		8.2	
THEROPHYTES (Th)	12		3.8	
	317		100.0	

Table 4. Percentage distribution of Heart Lake woody species of four life-form classes in three leaf types. Number of species in parentheses.

Life-form	No. Species	Broadleaf Evergreem Angiosperm	Needleleaf Evergreen Gymnosperm	Deciduous Angiosperm and Gymnosperm
Meso-phanerophyte	7	-	5.4 (3)	7.2 (4)
Micro-phanerophyte	12	-	-	21.8 (12)
Nano-phanerophyte	23	5.4 (3)	1.8 (1)	34.5 (19)
Chamaephyte	13	18.0 (10)	1.8 (1)	3.6 (2)

absent as micro- and mesophanerophytes. Needleleaf evergreen gymnosperms were represented almost entirely as mesophanerophytes. Deciduous gymnosperms and angiosperms peaked in the nanophanerophyte class (34%), decreased in richness with height to 7% in the mesophanerophyte class and were rare as chamaephytes.

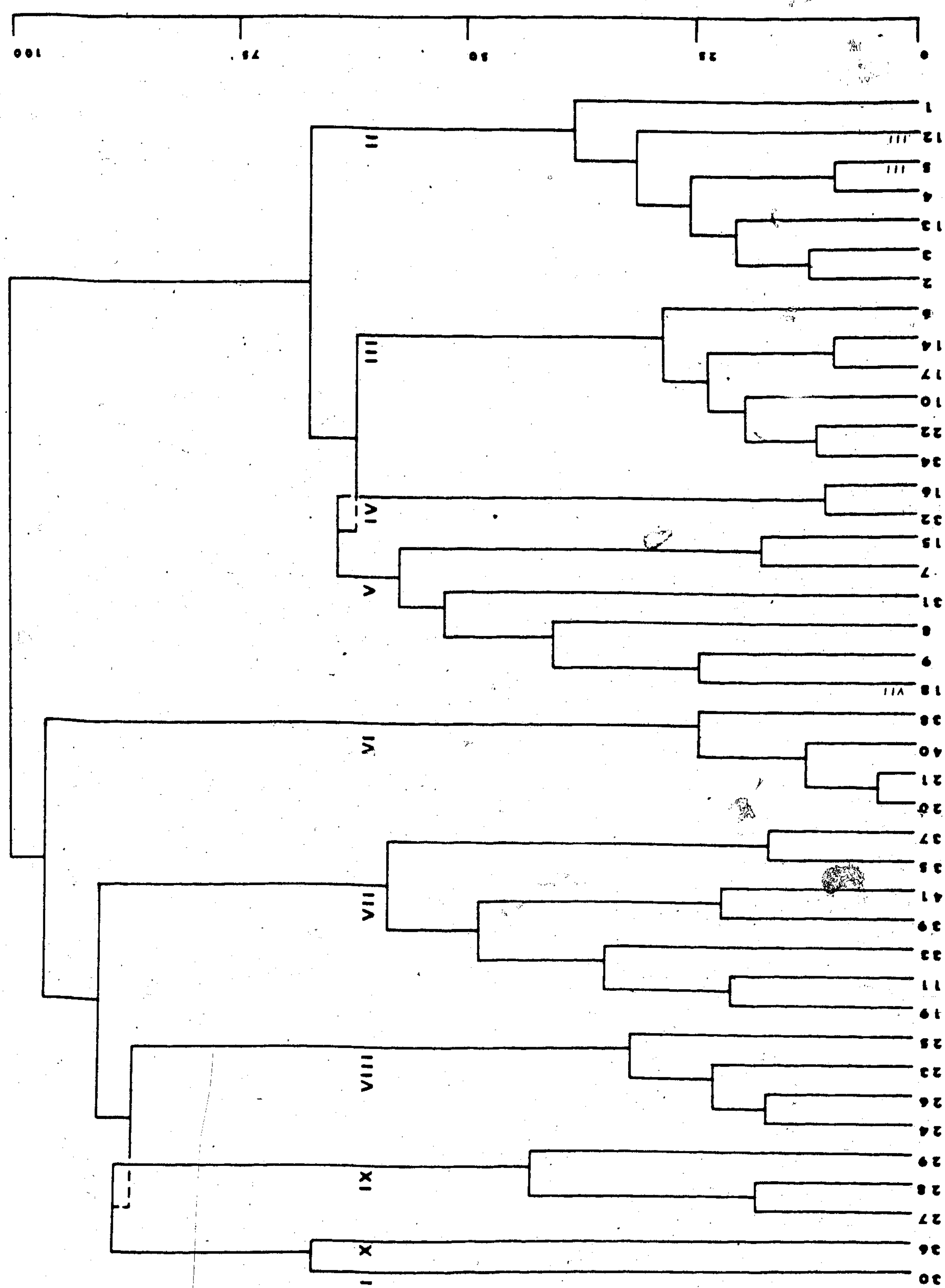
Classification of phytocoenoses based on species composition and abundance

Interpretation of classifications

Phytocoenose classification based on species composition and abundance involved a series of steps (see Methods). First, phytocoenoses were clustered (Orloci 1967) based on species frequency classes ("F" classification). This was followed by clustering the phytocoenoses based on species cover ("C" classification). Ten major phytocoena were recognized in the "F" classification (Fig. 6) at the 60% dissimilarity level, where within-cluster mean squares were expressed as a percent of total mean squares. Eleven clusters are delimited in the "C" classification at approximately the 45% dissimilarity level (Fig. 7).

Coincidence between the two classifications was high at the specified clustering thresholds as measured with the mutual information statistic (Orloci 1975:134-136). Because chi-square (P <0.01, 90 df) = 124.1 was less than $2I$ (= 156.4), the two classifications were not independent, and the coherence coefficient r = indicated high similarity. Only four phytocoenoses were problematical. These were summarized as four exceptions: (1) phytocoenoses 35 and 37 were clustered in phytocoenon VII of "F", while in "C"

Figure 6. The "F" classification, a hierarchy of 41 phytocoenoses based on quadrat frequency values and using absolute distance (Orloci 1967). Vertical scale indicates within-group mean squares (Q/k) expressed as percentages of sample mean square (Q/n). Ten major phytocoena (I-X) are recognized at the 60% threshold.


100
75
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25
0
II
III
IV
V
VI
VII
VIII
IX
X
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12
5
4
13
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21
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37
35
41
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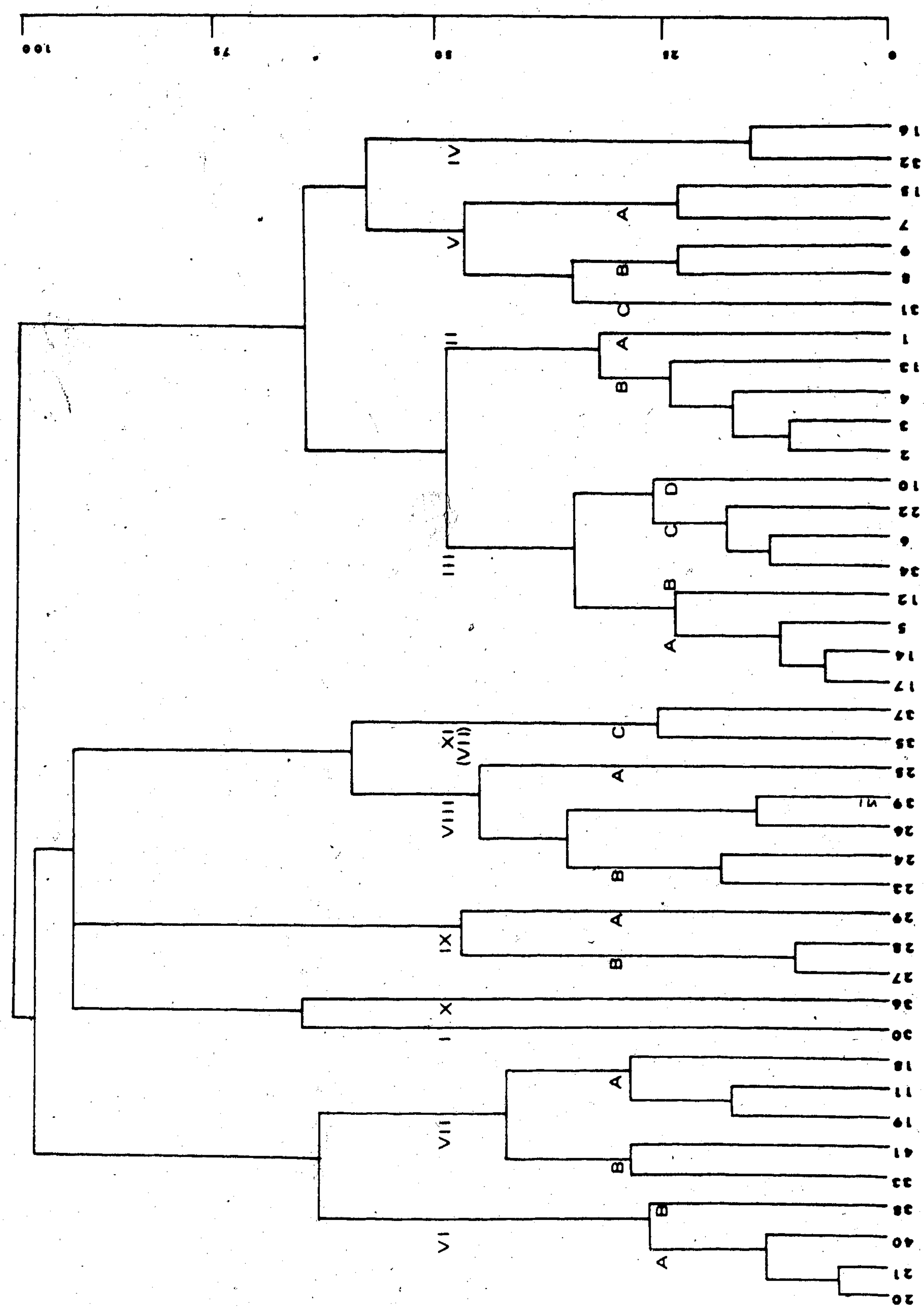
29
28
27
36
30

Figure 7. The "C" classification, a hierarchy of 41 phytocoenoses based on mean percent cover values and using absolute distance (Orloci 1967). Vertical scale indicated within-group mean squares (Q/k) expressed as percentages of sample mean square (Q/n). Eleven major phytocoena (I-XI) are recognized at the 47% threshold. Subclasses (A, B, C, D) are recognized at approximately the 30% threshold.


0
25
50
75
100
IV
V
II
III
XI (VII)
VIII
IX
X
VII
VI
16
32
15
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9
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38
40
21
20

they formed a separate cluster, XI, linked at the 60% threshold to phytocoenon VIII; (2) phytocoenose 39 was clustered in phytocoenon VII in "F", but in phytocoenon VIII in "C"; (3) phytocoenoses 5 and 12 were clustered in phytocoenon II in "F", but with phytocoenon III in "C"; and (4) phytocoenose 18 was assigned to phytocoenon V in "F", but with phytocoenon VII in "C".

Classification "C"	Classification "F"		
	VII	II	V
IX	35, 37	-	-
VIII	39	-	-
III	-	5, 12	-
VII	-	-	18

These exceptions were investigated critically using computer programs based on the Braun-Blanquet method (Ceska-Roemer 1973), ordination (Bray and Curtis 1957), and species-number curves (Böttcher 1968) relationships.

The four exceptions were then evaluated and assigned classes according to the Ceska-Roemer (1973) program for identifying species-phytocoenose groups. Although the species phytocoenose groups were based on presence-absence values, they exhibited high similarity to the quantitative classifications "F" and "C" (Appendi[illegible]

Exceptions 1 (Nos. 35 and 37), 2 (39), and 4 (18) were placed in phytocoenon VII (Table 5) while exception 3 (Nos. 5 and 12) was assigned to phytocoenon III. Allocation of phytocoenose 18, however, was not clearly resolved because it exhibited transitional tendencies. To resolve the problem Böttcher's (1968) species-number curve was employed and served as an indicator of homogeneity. Phytocoenose 18 was relatively species-rich compared to the member phytocoenoses in phytocoenon V, and was therefore allocated to phytocoenon VII (Table 5), confirming the selection of Ceska and Roemer's (1973) program.

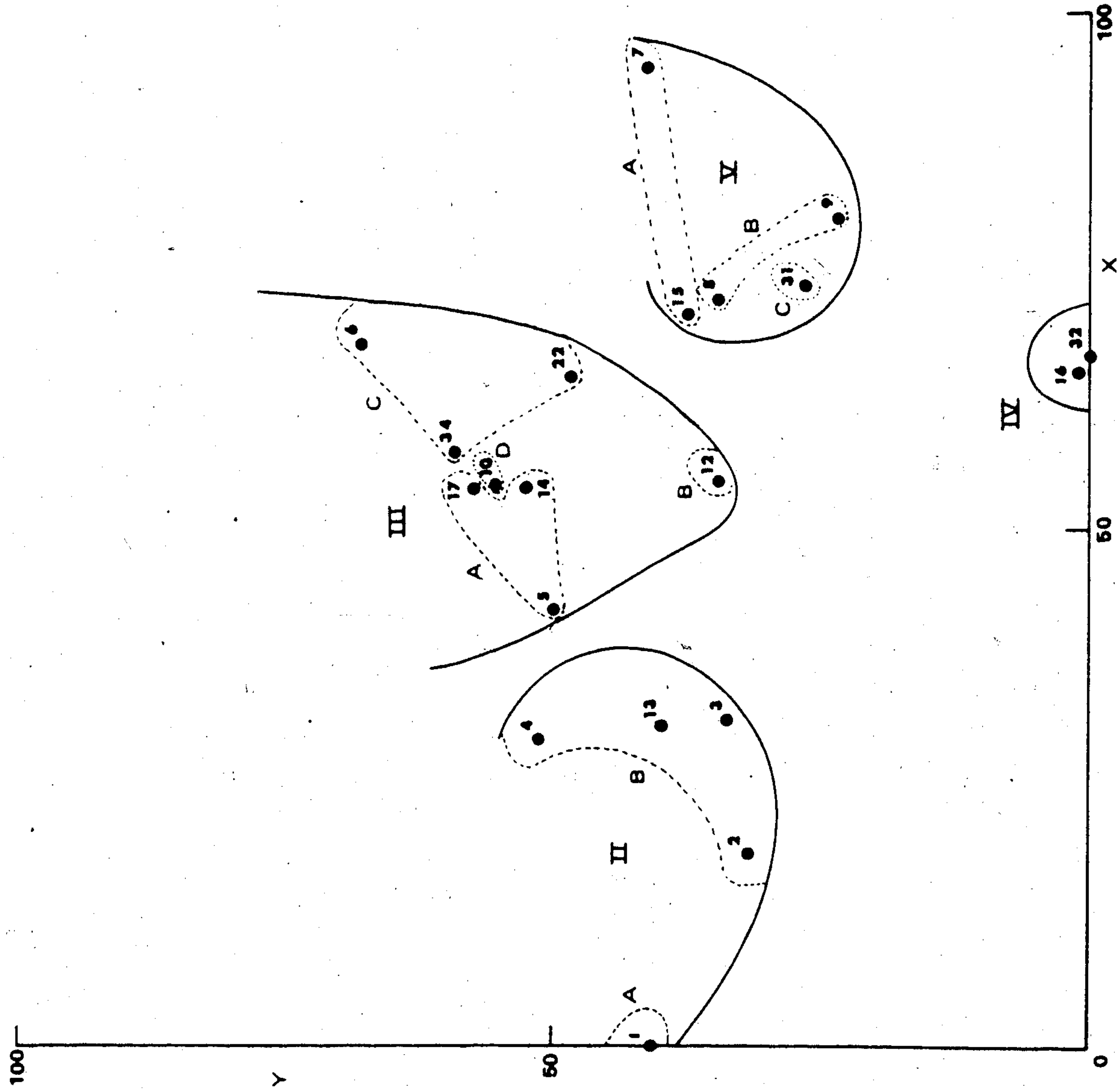
A second classification technique utilized stand ordination (Bray and Curtis 1957, Beals 1960). It yielded an independent assessment of similarity relations and represented a complex moisture gradient. To reduce beta diversity and its distortion effects on ordination the phytocoenoses were divided into two classes for ordination: uplands (phytocoena I-V) and lowlands (VI-X). Selection of phytocoena for these two classes was based on the two largest clusters agglomerated in Figures 6 and 7. It should be noted that phytocoenon I (no. 36), an upland type, was apparently misclassified and linked directly to phytocoenon X (No. 30), a lowland type in the cluster analyses at about the 70% dissimilarity level. This may be due to the low information content of each type. In the preliminary ordinations considerable distortion was introduced by phytocoenoses 36 (I) and 30 (X) since both formed single-member satellite groups; in subsequent ordinations phytocoenoses 36 and 30 were removed, considerably reducing distortion (Figs. 8 and 9). Inter-stand similarity values are given in Appendices III and IV.

Statistical tests of ordination efficiency using 20 randomly selected phytocoenose pairs from each ordination demonstrated reasonably consistent quantitative representations of phytocoenose relations. For upland phytocoenoses (Fig. 8) $r = 0.71$ (significant at $p<0.01$), and for lowland phytocoenoses (Fig. 9) $r = 0.71$ (significant at $p<0.01$).

Finally, a linear ordination of phytocoena and their subclasses was prepared as a differentiated table (Table 5) based on the reciprocal averaging technique of Ceska and Roemer (1973). Statistically defined species releve-groups (Ceska and Roemer 1971) served as nuclei for further table differentiation (Appendix V).

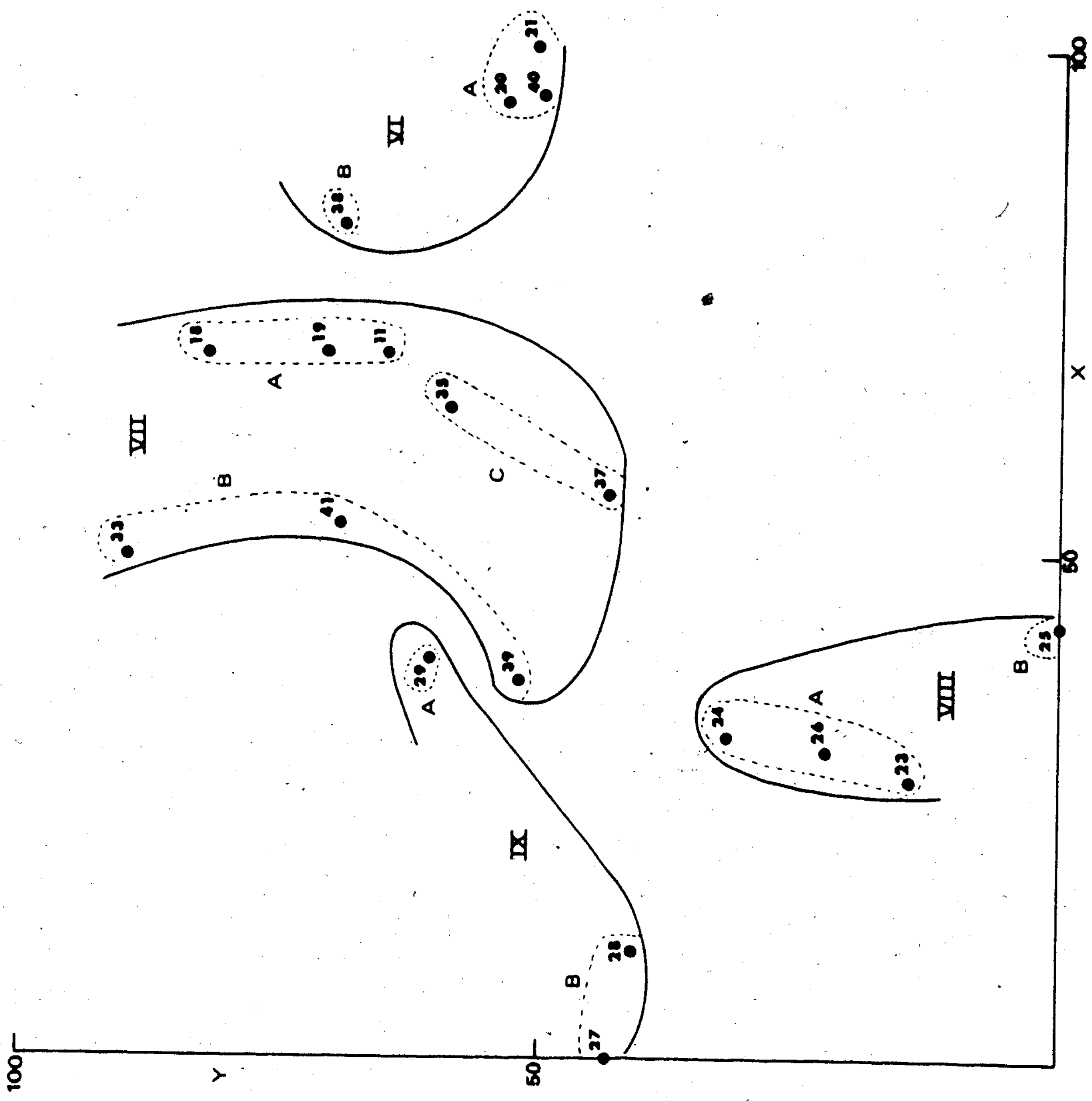
Values of the homogeneity-coefficient (Moravec 1971) for quadrat frequency within phytocoenoses ranged from 20 to 82. The mean value for all phytocoenoses was 55.5. These values were expected since small plots could only record fragments of the phytocoenoses being investigated (Moravec 1973). The coefficient would, therefore, vary with quadrat size. Microclimatic effect on bryoids was also recognized in influencing homogeneity

Figure 8. Bray-Curtis ordination of 20 upland phytocoenoses in the Heart Lake study area in relation to a moisture gradient. Phytocoena II-V, delimited by solid lines and their subclasses circumscribed by dashed lines, were recognized after an analysis of all formulative classifications.



100
50
0
Y
X
II
III
IV
V
A
B
C
D

Figure 9. Bray-Curtis ordination of 19 lowland phytocoenoses in the Heart Lake study area in relation to a moisture gradient. Phytocoena VI-IX delimited by solid lines and their subclasses circumscribed by dashed lines, were recognized after an analysis of all formulative classifications.


VI
VII
VIII
IX
A
B
C
X
Y
50
100

values (Barkman 1968). When coefficients were determined separately for vascular and bryoid species, mean homogeneity values for vascular plants reached 63.4 and for bryoids 45.1.

Description of Phytocoena

Ten phytocoena and their subclasses were included in the following descriptions. Species groups which optimally differentiated phytocoena were delimited with solid lines, while weakly defined groups were indicated by dashed lines (Table 5). The average number of species per quadrat was abbreviated as NSQ, and species richness or the total number of species within each phytocoenose was abbreviated as SR. Total plant cover and stratum cover were expressed as sums of cover values of member species. The similarity of phytocoenoses within a phytocoenon was indicated as percentage based on Figure 7. The original sequence of phytocoena I-X, although established entirely on species composition, represented a gradient of increasing wetness.

I. *Hypnum cupressiforme* - *Grimmia apocarpa* phytocoenon (No. 30).

This bryoid-dominated phytocoenon occurred below the escarpment on a 30° N-facing talus slope composed of semi-stabilized, extremely well-drained, limestone debris ranging from 30-60 cm in diameter. On some level blocks fine material accumulated and provided a rhizosphere for higher plants. Of all phytocoena it was the second lowest both in NSQ and SR.

Total plant cover was 17% (Table 6). In the

Table 6. Mean percent cover by stratum of phytocoenon and phytocoenose.

UPLAND: PHYTOCOENON AND PHYTOCOENOSE

	I	II					III								IV		V				
		A	B				A			B	C			D			A		B		C
	30	1	2	3	4	13	17	14	5	12	22	6	34	10	32	16	7	15	8	9	31
Tree			1.2	8.6	15.7	2.6	24.0	21.8	20.5		17.6	19.1	2.6	15.8	50.8	37.5	28.1	25.3	27.5	36.7	15.7
Low tree			7.6	17.2	7.2	2.8	6.2	6.4	4.2	10.7	2.3	2.5	0.9	6.9	1.4	4.0	13.6	29.4	36.7	7.1	7.0
Tall shrub			12.3	4.4	1.1	2.5	1.5		0.4	28.0	0.2	1.0	4.3	1.3	1.4	2.6	14.9	71.3	1.5	0.4	1.2
Low shrub		2.2	10.1	24.3	17.0	10.5	16.0	12.6	12.9	22.7	8.3	6.8	7.4	7.9	12.8	27.0	11.1	5.3	1.4	5.4	6.4
Herb-Dwarf shrub	0.2	37.5	36.8	39.1	34.5	39.6	31.0	26.0	21.4	18.0	79.3	23.8	57.5	16.0	32.1	21.3	16.6	10.8	9.9	43.6	17.5
Bryoid	17.1	55.9	20.2	10.2	28.2	13.3	43.7	30.7	16.3	13.5	52.6	35.7	43.5	59.2	2.2	2.3	31.9	12.7	73.4	42.9	91.3
Moss	13.3	12.2	5.1	5.8	15.6	3.4	28.0	18.3	8.2	8.7	45.2	12.7	22.3	48.5	1.6	1.7	31.2	9.6	72.1	42.9	80.7
Lichen	3.8	43.7	15.1	4.4	12.6	9.9	15.7	12.4	8.1	4.8	7.4	23.0	21.2	10.7	0.6	0.6	0.7	3.1	1.3		10.6
Σ Total phytocoenose	17.3	95.6	88.2	103.8	103.7	71.3	122.4	97.5	75.7	90.9	160.3	88.9	116.2	107.7	100.7	94.7	116.2	154.8	152.4	138.1	139.1
$\bar{X}$ Total subclass	17.3	95.6	91.8				98.5			90.9	121.8			107.7	97.7		136.5		144.2		139.1
$\bar{X}$ Total phytocoena	17.3	92.5					107.4								97.7		139.7				

LOWLAND: PHYTOCOENON AND PHYTOCOENOSE

	VI				VII								VIII				IX			X
	A			B	A			B			C		A			B	A	B		
	20	21	40	38	18	19	11	33	41	39	35	37	26	24	23	25	29	28	27	36
Tree	4.4	0.5	4.8	1.1	16.4	14.9	5.5	25.0	1.0											
Low tree	9.4	7.2	5.8	3.1	21.4	8.7	12.2	4.7	4.0	0.9	0.3									
Tall shrub	1.8	2.4	1.1	2.3	1.6	0.4	2.2	2.2	2.8	0.6	0.4						8.7			
Low shrub	7.1	15.2	32.8	8.6	14.5	12.9	21.3	5.8	16.7	8.2	3.3	0.4	9.7	4.2	2.7	1.8	36.8	2.0	4.3	
Herb-Dwarf shrub	18.4	22.9	15.1	27.9	26.6	26.2	24.5	66.3	38.2	43.8	70.6	83.1	41.8	70.9	33.3	39.2	11.2	74.6	89.4	5.0
Bryoid	93.8	90.3	91.1	82.8	91.5	62.8	49.4	37.4	87.4	41.8	26.9	79.5	49.1	63.4	42.7	80.2	50.2	3.4		0.6
Moss	33.2	63.1	1.7	74.8	79.6	51.6	28.3	37.2	87.1	41.8	19.5	79.4	49.1	63.4	42.7	80.2	48.7	3.4		0.6
Lichen	60.6	27.2	89.4	8.0	11.9	11.2	21.1	0.2	0.3		7.4	0.1					1.5			
Σ Total phytocoenose	134.9	138.5	150.7	125.8	172.0	125.9	115.1	141.4	150.1	95.3	101.5	183.0	100.6	138.5	78.7	101.2	106.9	80.0	93.7	5.6
$\bar{X}$ Total subclass	141.3			125.8	141.2			128.9			132.2		105.9			101.2	106.9	86.8		5.6
$\bar{X}$ Total phytocoena	137.5				133.0								104.7				93.5			5.6

bryoid layer mosses (cover 13%) were three times as abundant as lichens (4%). Important mosses with 100% frequency were: Hypnum cupressiforme (average cover 4%), Grimmia apocarpa (2%), Ditrichum flexicaule (2%), Tortella fragilis (1%), and Orthotrichum anomalum (1%). The most abundant lichens, Cladonia pyxidata (cover 2%), and Collema tunaeforme (<1%), were slightly less frequent (80-90%). Saxifraga tricuspidata, the only vascular plant species, was infrequent (20%), and very low in cover (<1%).

II. Arctostaphylos uva-ursi - Anemone multifida - Senecio cymbalarioides phytocoenon (Nos. 1, 2, 3, 4, 13).

This widespread Arctostaphylos uva-ursi steppe scrub phytocoenon was found in the plateau-like uplands on shallow, very rapidly drained soils over calcareous bedrock. Typically, the soils were silt loams and are classed as Eutric Brunisols (Lithic family; Nos. 2, 3, 4, and 13) but Lithic phase Regosols (1) also occurred.

The five phytocoenoses making up the type were 68% similar (Fig. 7), their average SR = 30 and NSQ = 19.6.

Member phytocoenoses might differ in structure but in general they were xeric, open-shrublands and often contained scattered coniferous trees. Identification of the phytocoenon was based largely on the combination of 13 diagnostic species: Achillea lanulosa, Aster alpinus, Brachythecium albicans, Bryum argenteum, Cerastium arvense, Draba lanceolata, Encalypta vulgaris, Festuca saximontana, Geum triflorum, Poa glauca, Prunus pensylvanica, Saxifraga tricuspidata, and Solidago decumbens (Table 5). A second group of species reached their optimum development in phytocoenon II but were also occasionally found in phytocoenon III: Campanula rotundifolia, Carex richardsonii, Cladonia cariosa, Fragaria virginiana, Senecio cymbalarioides, and Tortella fragilis. The last attained its peak abundance in phytocoenon I.

Several other species had a slightly broader distribution and occurred in both phytocoenon II and III, thus linking them at a broader taxonomic level: Arctostaphylos uva-ursi, Anenome multifida, Cetraria ericetorum, and Peltigera canina.

Wider-ranging species having 100% constancy within this type were: Cetraria pinastri, Cladonia mitis, Cladonia pyxidata, Ditrichum flexicaule, Eurhynchium pulchellum, Galium boreale, Juniperus communis and Rosa acicularis, while those having 80% constancy were: Campylium hispidulum, Cetraria nivalis, Cladonia arbuscula, Drepanocladus uncinatus, Elymus innovatus, Juniperus horizontalis, Picea glauca, Populus tremuloides, and Shepherdia canadensis.

Although member phytocoenoses were difficult to age precisely (e.g., due to rot), some indication was obtained by combining evidence from shrubs (Juniperus communis) and tree age. On this basis, the age of oldest plants was 80-90 years.

IIA. Juniperus horizontalis - Arctostaphylos uva-ursi - cladonia pyxidata phytocoenon (No. 1).

This subclass (Plate 1) occurred on an open, subarctic heath of evergreen dwarf shrubs on a Lithic phase Regosol.

Total plant cover was 96%. Although there was no shrub stratum as such, three species (Juniperus communis, Potentilla fruticosa, and Rosa acicularis) occasionally became low shrubs (cover 2%).

The herb-dwarf shrub stratum was well developed (cover 38%) and mainly composed of Juniperus horizontalis (23%), and Arctostaphylos uva-ursi (5%). Other frequently encountered species with lower cover (1-2%) were: Carex richardsonii, Cerastium arvense, Festuca saximontana, Potentilla nivea, Saxifraga tricuspidata, and Senecio cymbalarioides.

In the bryoid stratum (cover 56%), lichens (44%) were more abundant than mosses, 12%. The stratum was dominated by Cladonia pyxidata (34%), Ditrichum flexicaule (7%), and Peltigera canina (5%), all with 100% frequency.

Plate 1. Juniperus horizontalis - Arctostaphylos uva-ursi - Cladonia pyxidata phytocoenon (IIA: phytocoenose 1).

Plate 2. Populus tremuloides - Juniperus communis - Ditrichum flexicaule phytocoenon (IIB: phytocoenose 13).

IIB. Populus tremuloides - Juniperus communis - Ditrichum flexicaule phytocoenon (Nos. 2, 3, 4, 13).

Typically found on shallow soils, Eutric Brunisols (Lithic family) over calcareous bedrock, this phytocoenon occurred as xeric, open shrublands (Plate 2). In some instances, the bedrock was exposed.

Total plant cover was 92% (Table 6). The tree stratum was poorly developed with trees averaging 7% cover and low trees (6%), while in the shrub stratum, low shrubs (16%), predominated with tall shrubs averaging 5% cover.

Mean tree basal area, 6 m^2/ha, and density, 882 stems/ha, were relatively low (Tables 7 and 8).

Although there was considerable structural variation in the upper strata, tree species predominated as shrubs or saplings. Populus tremuloides was dominant, (cover 13%), while Picea glauca ranked second (7%). Pinus banksiana represented a minor but conspicuous component (3%).

In the herb-dwarf shrub stratum (cover 38%), Arctostaphylos uva-ursi (18%), and Juniperus communis (10%), were clearly the most important species, both with 95% frequency. Rosa acicularis and Shepherdia canadensis, averaging 2-3%, cover were less important but conspicuous and evenly distributed, frequency 88% and 75%, respectively. Notably absent was the suffrutescent dwarf-shrub, Linnaea borealis. The most abundant herb was Carex richardsonii (<2% cover). Several noteworthy herbs

Table 7. Basal area (m^2/ha) of species 2.5 cm dbh or greater by phytocoenon and phytocoenose.

PHYTOCOENON AND PHYTOCOENOSE

SPECIES	II				III								IV		V					VI				VII					
	B				A			B	C			D			A		B		C	A			B	A			B		
	2	3	4	13	17	14	5	12	22	6	34	10	32	16	7	15	8	9	31	20	21	40	38	18	19	11	33	41	39
Populus tremuloides	0.5	3.5	0.8	0.1		<0.1			<0.1	0.2	2.1		34.7	13.6	12.7	14.5	0.4												
Live	0.3	2.7	0.7	0.1		<0.1			<0.1	0.2	2.0		32.4	13.2	12.0	13.7	0.4												
Dead	0.2	0.8	0.1								0.1		2.3	0.4	0.7	0.8	<0.1												
Picea glauca	0.3	3.0	8.8		3.8		5.0		0.6		0.5	13.6	0.3	<0.1	0.7	1.1	19.4	46.8	14.4					8.4	5.9		25.4		
Live	0.3	2.6	8.4		3.8		4.8		0.6		0.5	12.7	0.3	<0.1	0.7	1.1	18.6	43.9	13.8					7.4	5.2		24.5		
Dead		0.4	0.4				0.2					0.9					0.8	2.9	0.6					1.0	0.7		0.9		
Pinus banksiana		1.2	3.2	1.8	20.1	23.2	15.4	1.5	27.2	17.7	8.2	4.2		1.2	7.5	9.8	21.1			<0.1						3.7			
Live		1.1	3.1	1.8	17.8	20.4	13.4	1.5	25.2	16.8	8.2	1.0		1.2	7.3	9.1	14.9			<0.1						1.8			
Dead		0.1	0.1	<0.1	2.3	2.8	2.0		2.0	0.9		3.2			0.2	0.7	6.2			<0.1						1.9			
Betula papyrifera						0.1						0.7			2.2				0.4										
Live						0.1						0.5			2.2				0.4										
Dead												0.2							<0.1										
Populus balsamifera											0.1		7.9	11.9				0.3											
Live											<0.1		6.9	11.7															
Dead											0.1		1.0	0.2				0.3											
Salix spp.														0.4	0.3	0.4			<0.1										
Live														0.4	0.3	0.3			<0.1										
Dead														<0.1	<0.1	0.1													
Picea mariana											0.1	2.1	<0.1		2.5			3.2	0.5	5.1	3.0	7.1	1.0	17.3	6.6	7.3	1.8	5.0	
Live											0.1	2.0	<0.1		2.3			2.6	0.5	5.0	2.7	6.8	1.0	12.5	6.2	7.2	1.4	4.9	
Dead												0.1			0.2			0.6		0.1	0.3	0.3	<0.1	4.8	0.4	0.1	0.4	0.1	
Larix laricina																							0.2	0.9	2.3	0.1	3.1	10.5	0.5
Live																							0.2	0.4	1.4	0.1	1.9	9.1	0.5
Dead																								0.5	0.9		1.2	1.4	
Σ Total	0.8	7.7	12.8	1.9	23.9	23.3	20.4	1.5	[illegible]	17.9	11.0	20.6	42.9	27.1	25.9	25.8	40.9	50.3	15.3	5.1	3.0	7.1	1.2	26.6	14.8	11.1	30.3	15.5	0.5
Σ Live	0.6	6.4	12.2	1.8	21.6	20.5	[illegible]	[illegible]	[illegible]	17.0	10.8	16.2	39.6	26.5	24.8	24.2	33.9	46.5	14.7	5.0	2.7	6.8	1.0	20.3	12.8	9.1	27.8	14.0	0.5
Σ Dead	0.2	1.3	0.6	0.1	2.3	2.8	[illegible]		[illegible]	0.9	0.2	4.4	3.3	0.6	1.1	1.6	7.0	3.8	0.6	0.1	0.3	0.3	0.2	6.3	2.0	2.0	2.5	1.5	
Mean total (subclasses)	5.8				22.5			1.5	18.9			20.6	35.0		25.8		45.6		15.3	5.1			1.2	17.5			15.4		
Live	5.2				20.1			1.5	17.9			16.2	33.0		24.5		40.2		14.7	4.8			1.0	14.1			14.1		
Dead	0.6				2.4				1.0			4.4	2.0		1.4		5.4		0.6	0.2			0.2	3.4			1.3		
Mean total (major phytocoena)	4.6				18.3								35.0		31.6					4.1				12.3					
Live	4.2				16.4								33.0		28.8					3.9				10.5					
Dead	0.4				1.8								2.0		2.8					0.2				1.8					

Table 8. Density per ha of species 2.5 cm dbh or greater by phytocoenon and phytocoenose.

PHYTOCOENON AND PHYTOCOENOSE

SPECIES	II				III								IV		V					VI				VII					
	B				A			B	C			D			A		B		C	A			B	A			B		
	2	3	4	13	17	14	5	32	22	6	34	10	32	16	7	15	8	9	31	20	21	40	38	18	19	11	33	41	39
Populus tremuloides	270	1260	230	60		10			10	20	160		1670	890	1500	1860													
Live	190	1020	150	60		10			10	20	120		1420	700	1330	1620													
Dead	80	240	80								40		250	190	170	240													
Picea glauca	100	430	730		530		440		80		160	1520	40	20	50	100	7050	1980	1030					1190	750		1850		
Live	100	430	700		530		400		80		160	1310	40	20	50	100	6510	1730	960					1000	730		1610		
Dead		30	30				40					210					540	260	70					190	20		240		
Pinus banksiana		50	180	220	3210	4110	1370	2080	2170	1720	200	590			570	380	4130			40						670			
Live		40	160	210	2260	3080	1010	2080	1760	1380	200	70			490	340	1930			10						260			
Dead		10	20	10	950	1050	380		410	340		520			80	50	2200			30						410			
Betula papyrifera						20						140		140					170										
Live						20						110		140					160										
Dead												30							10										
Populus balsamifera													350	440				20											
Live													290	410															
Dead													60	30				20											
Salix spp.														110	210	210			10										
Live														100	190	110			10										
Dead														10	20	100													
Picea mariana												330	10		790			300	60	2210	1920	2460	490	5930	1440	2820	290	370	
Live												310	10		750			240	60	2180	1710	2340	470	3860	1260	2720	200	350	
Dead												20			40			60		30	210	120	20	2070	180	100	90	20	
Larix laricina																							70	130	580	20	150	530	30
Live																							70	60	290	20	80	450	30
Dead																								70	300		70	80	
Σ Total	370	1740	1140	280	3740	4140	1810	2080	2260	1740	620	2580	2070	1630	3120	2560	11180	2290	1270	2250	1920	2460	560	7250	2780	3510	2290	900	30
Σ Live	290	1460	1010	270	2790	3090	1410	2080	1850	1400	580	1800	1760	1400	2810	2170	8440	1970	1190	2190	1710	2340	540	4920	2280	3000	1890	800	30
Σ Dead	80	280	130	10	950	1050	400		410	340	40	780	310	230	310	390	2740	320	80	60	210	120	20	2330	500	510	400	100	
Mean total (subclasses)	882				3230			2080	1540			2580	1850		2840		6735		1270	2210			560	4513			1073		
X̄ Live	758				2430			2080	1277			1800	1580		2490		5206		1190	2080			540	3400			907		
X̄ Dead	123				800				263			780	270		350		1520		80	130			20	1113			167		
Mean total (major phytocoena)	706				2369								1850		4084					1798				2096					
X̄ Live	606				1872								1580		3316					1695				1615					
X̄ Dead	100				492								270		768					102				480					

occurred in at least one-third of the quadrats but with an average cover <1%: Achillea lanulosa, Anemone multifida, Campanula rotundifolia, Elymus innovatus, Fragaria virginiana, Galium boreale, Saxifraga tricuspidata, and Senecio cymbalarioides.

The bryoid layer, cover 18%, with 8% moss and 10% lichen cover, was dominated by Ditrichum flexicaule and Cladonia pyxidata, each averaging 4% cover. Other minor (<1% cover) less frequently (20-40%) occurring bryoids were: Cladonia mitis, Eurhynchium pulchellum, and Tortella fragilis.

III. Pinus banksiana - Arctostaphylos uva-ursi - Cladonia phytocoenon (Nos. 5, 6, 10, 12, 14, 17, 22, 34).

This phytocoenon of pine woodlands usually occurred on deep, rapidly to well drained soils and was by far the best represented phytocoenon. It was composed of eight phytocoenoses whose similarity is 72% (Fig. 7.). The NSQ of 21.1 and mean SR of 56 species make this the richest upland phytocoenon.

Community structure was remarkably similar throughout the type except phytocoenose 12 (III B) which was excluded from consideration because of it successional status (Table 6). In the tree stratum trees averaged 17% cover and low trees 3%, while in the shrub stratum tall shrubs represented only 1% with low shrubs reaching 10%. The herb-dwarf shrub stratum (36%) was well developed as was the bryoid stratum (40%) where mosses (26%) were about twice as abundant as lichens (14%). Total plant cover was 107%.

Mean basal area, 21 m^2/ha, and mean density, 2413 stems/ha, showed a marked increase over phytocoenon II (Tables 7 and 8).

Typically phytocoenon III shared four characteristic species with phytocoenon II, i.e. *Anemone multifida*, *Arctostaphylos uva-ursi*, *Cetraria ericetorum*, and *Peltigera canina*, but lacked the diagonostic species of II (Table 5).

Wider ranging species (100% constancy) within the type were: *Cetraria pinastri*, *Cladonia cornuta*, *Elymus innovatus*, *Linnaea borealis*, *Peltigera aphthosa*, *Pinus banksiana*, *Pyrola secunda*, *Rosa acicularis*, and *Shepherdia canadensis*; slightly less constant (88%) species were: *Cladonia arbuscula*, *C. gracilis*, *C. mitis*, *C. rangiferina*, *Galium boreale*, *Hylocomium splendens*, *Juniperus communis*, *Pleurozium schreberi*, *Ptilidium ciliare*, *Viburnum edule*, and *Zygadenus elegans*.

Four subclasses were recognized.

IIIA. *Pinus bansiana* - *Juniperus communis* - *Arctostaphylos uva-ursi* phytocoenon (Nos. 5, 14, 17).

This subclass was found in the plateau-like uplands on rapidly drained soils over calcareous bedrock (Plate 3). Soils were Orthic Eutric Brunisols and thus deeper than the Eutric Brunisols (Lithic family) of phytocoenon II.

Total plant cover was 98% (Table 6). The tree stratum was relatively well developed with trees averaging 22% cover and low trees 6% cover. In the shrub stratum tall shrubs were almost absent (<1%) but low shrubs averaged 14%. Herb-dwarf shrub cover (26%) was only slightly less than bryoid stratum cover (30%) with 18% moss cover and 12% lichen cover.

The overstory was dominated by mature Pinus banksiana (cover 22%) with Picea glauca subdominant (6%). Phytocoenon age was 83 years.

The mean basal area, 22 m^2/ha, and density, 3230 stems/ha, of this subclass were the highest within phytocoenon III (Table 7 and 8).

The distinct shrub stratum was characterized by three constant species: Juniperus communis (cover 11%), Rosa acicularis (3%), and Shepherdia canadensis (3%).

In the herb-dwarf shrub stratum (cover 26%), the most prominent species was Arctostaphylos uva-ursi (12%). Next in importance were Linnaea borealis (7%) and Carex richardsonii (6%). Elymus innovatus and Galium boreale were also typical despite their low average covers (<1%).

Plate 3. *Pinus banksiana* - *Juniperus communis* - *Arctostaphylos uva-ursi* phytocoenon (IIIA: phytocoenose 14). Divisions on scale pole (photograph center) are 30 cm long.

Plate 4. *Populus tremuloides* (*Picea*) - *Alnus crispa* - *Hylocomium splendens* phytocoenon (VA: phytocoenose 15).

Important bryoids were Hylocomium splendens (11%), Cladonia arbuscula (3%), Ptilidium ciliare (2%), Ditrichum flexicaule (1%), and Cetraria ericetorum (1%).

IIIB. Pinus banksiana - Rosa acicularis - Ditrichum flexicaule phytocoenon (No. 12).

This was a seral community recovering from the effects of an extensive fire which occurred in the eastern part of the Heart Lake area about 30 years ago.

Total plant cover was 91% (Table 6). The tree stratum was still immature and only low trees (cover 11%) were present. In the dense shrub stratum, cover was almost equally distributed between tall (26%) and low (22%) shrubs. Average herb-dwarf shrub cover was 10% and bryoid cover, 14%, with mosses comprising 9% and lichens 5%.

Basal area, 2 m^2/ha, was very low despite a density of 2060 stems/ha (Table 7 and 8).

At present Pinus banksiana (cover 51%), occurred as transgressives and saplings. Picea glauca was poorly represented.

The most important species were: Rosa acicularis (cover 6%), Shepherdia canadensis (5%), Elymus innovatus (3%), Cladonia pyxidata (2%), and Ditrichum flexicaule (2%).

Species present in phytocoenon IIIA such as Arctostaphylos uva-ursi, Juniperus communis, and Linnaea borealis were present but had minor representation (<1% cover). With advancing age this phytocoenose might develop into the Pinus banksiana - Juniperus communis - Arctostaphylos uva-ursi phytocoenon.

IIIC. Pinus banksiana - Arctostaphylos uva-ursi - Vaccinium vitis-idaea phytocoenon (Nos. 6, 22, 34).

Phytocoenoses belonging to this subclass were found on well-drained beach deposits from Glacial Lake McConnell. Soils were classed as Orthic and Eluviated Eutric Brunisols. Two were gravelly (Nos. 22, 34) but one was sandy (6).

A total plant cover of 122% was the highest within the phytocoenon (Table 6). However in comparison with III A, the tree stratum was less developed with trees averaging 13% cover and low trees only 2%.

Typically the Pinus banksiana - Arctostaphylos uva-ursi - Vaccinium vitis-idaea phytocoenon had a sparse tree cover of Pinus banksiana (cover 14%) with very minor representation of Picea glauca and Populus tremuloides <1%). Its average age of 84 years closely resembled that of III A (88 years).

Mean basal area, 19 m^2/ha, was slightly less than III A but mean density, 1540 stems/ha, was less than half as much (Tables 7 and 8). Accordingly, dbh's were higher in III C.

The shrub stratum was also less developed than in III A with tall and low shrubs averaging 2% and 8%, respectively. Shrub cover was composed of Rosa acicularis (7%), Shepherdia canadensis (3%), and Viburnum edule (3%); Alnus crispa and Juniperus communis occurred infrequently.

In contrast to the preceding strata, the herb - dwarf shrub stratum (54%) was extremely well developed. Arctostaphylos uva-ursi was clearly the dominant dwarf-shrub (averaging 22% cover), but Vaccinium vitis-idaea was also very prominent (13%) and diagnostic for the type. The only other important species in the stratum, also a dwarf shrub, was Linnaea borealis (4%).

In the bryoid stratum (cover 45%), mosses (28%) were more common. Hylocomium splendens (cover 12%) and Pleurozium schreberi (11%) were codominant. Ptilidium ciliare was evenly distributed and present in lesser amounts (cover 3%). Lichens (17%) were well represented with the three dominant species: Cladonia arbuscula (9%), C. mitis (5%), and C. rangiferina (2%).

Although qualitatively similar to III A, this subclass differed quantitatively in several respects: the cover of Pinus banksiana, Juniperus communis, Linnaea borealis, Carex richardsonii, and Ditrichum flexicaule was much lower. Conversely, several species in III C were more abundant such as Arctostaphylos uva-ursi, Vaccinium vitis-idaea, and Pleurozium schreberi.

IIID. Picea glauca - Betula papyrifera - Hylocomium splendens - Pleurozium schreberi phytocoenon (No. 10).

This phytocoenon was represented on north-facing colluvium below the escarpment. Soils were stony, well- drained, Orthic Humic Regosols.

Total plant cover was 108% (Table 6). Tree cover averaged 16% and low tree cover 7%. Tall and low shrub cover were 1% and 8%, respectively. The bryoid stratum, 60%, was well developed with mosses (48%), dominant over lichens (11%). The herb-dwarf shrub stratum averaged 16% cover. In relation to other subclasses within the phytocoenon, this subclass appeared structurally intermediate.

Basal area, 21 m^2/ha, and density, 2580 stems/ha, were the second highest within the phytocoenon (Tables 7 and 8).

The overstory was dominated by mature Picea glauca (cover 15%), with a scattered admixture of Betula papyrifera, Picea mariana, and Pinus banksiana. Phytocoenon age was 149 years.

This phytocoenose had the highest species richness of the 21 upland phytocoenoses, 8 more than the next richest (no. 34).

Shrub and herb layers were qualitatively similar to other phytocoenoses within the class and differed mainly in being depauperate.

The bryoid layer was dominated by Hylocomium splendens (cover 24%), and Pleurozium schreberi (18%), and Cladonia arbuscula (4%).

IV. Populus tremuloides - Populus balsamifera - Viburnum edule phytocoenon (Nos. 16, 32).

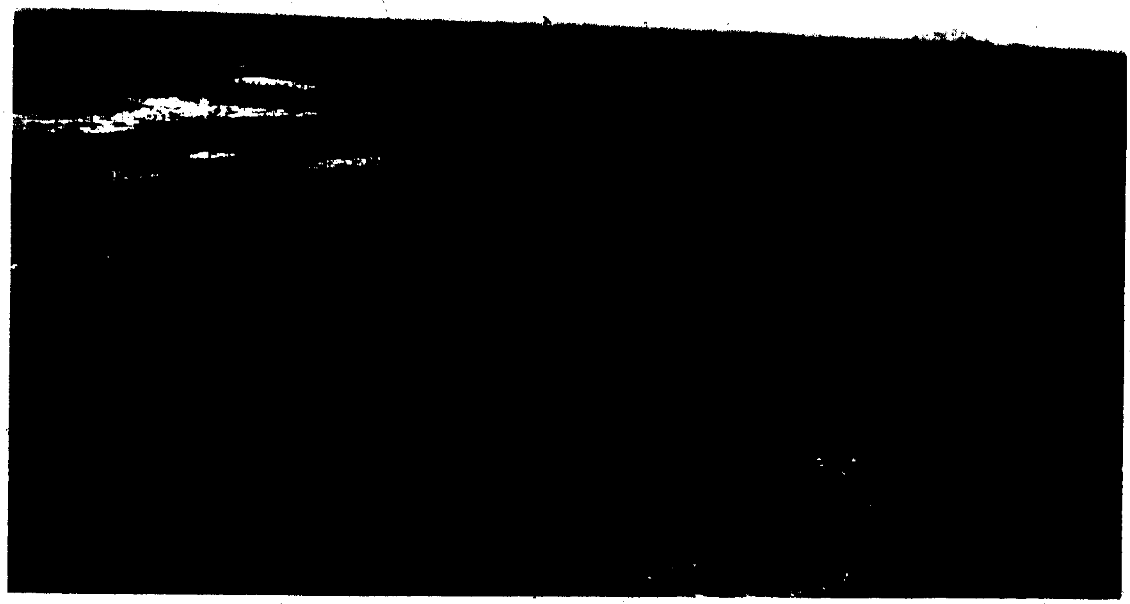
These deciduous forests occurred on stony, moderately well-drained sites of colluvium (No. 16) and ancient beach deposits (No. 32; Plates 5 and 6). Soils were Orthic Humic Regosols and Orthic Eutric Brunisols, respectively. Significantly, they bordered wetlands which might provide access to moisture.

Overall phytocoenon similarity was high, 90% (Fig. 8), mean NSQ = 13.7 and mean SR = 42. This phytocoenon was thus lower in species diversity than all other treed, upland phytocoena in the study area.

Total plant cover was 98% (Table 6). Tree cover was 44%, the maximum recorded, while the low tree cover was only 3%, tall shrub 2%, and bryoid 2% with

Plate 5. Aerial oblique of _Populus tremuloides_ - _Populus balsamifera_ - _Viburnum edule_ phytocoenon (IV: phytocoenose 16) at base of escarpment. To the left the deciduous forest changed to a _Picea_ swamp and then to a marl fen; to the right and above the escarpment on the plateau-like uplands was a _Pinus banksiana_ woodland.

Plate 6. Interior of the deciduous forest shown in Plate 5 (_Populus tremuloides_ - _Populus balsamifera_ - _Viburnum edule_ phytocoenon; IV: phytocoenose 16). Divisions on scale pole (photograph center) are 30 cm long.



mosses 2% and lichens <1%. In contrast the low shrub and herb-dwarf shrub strata averaged 20% and 27% cover, respectively.

Although tree density, 1850 stems/ha, was not relatively high, basal area, 35 m^2/ha, was the highest of any phytocoenon (Tables 7 and 8). However, at the subclass level basal area was higher in phytocoenon V B.

In the tree stratum Populus tremuloides (cover 30%) was more important than Populus balsamifera (10%). Phytocoenon age was 81 years.

The well developed low shrub and herb-dwarf shrub stratum contained several important shrubs: Viburnum edule (cover 16%), Rosa acicularis (8%), Shepherdia canadensis (5%), Amelanchier alnifolia (4%), Cornus stolonifera (4%), and Ribes oxyacanthoides (<1%). The two most abundant herbaceous species were Cornus canadensis (3%) and Rubus pubescens (2%). Other characteristic forbs but with low covers (<1%), were the legumes Lathyrus ochroleucus and Vicia americana.

Bryoids mostly occurred on rotting logs, slightly above the litter and thus not smothered by deciduous leaf fall.

Like phytocoena II and III, this subclass typically contained Cornus canadensis, Ptilidium pulcherrimum, and Viburnum edule. Unlike phytocoenon II, however, it lacked Anemone multifida, Arctostaphylos uva-ursi, and Cetraria ericetorum (Table 5).

Other species present in both phytocoenoses within the type were: Brachythecium salebrosum, Campylium hispidulum, Cetraria pinastri, Drepanocladus uncinatus, Elymus innovatus, Eurhynchium pulchellum, Epilobium angustifolium, Galium boreale, Juniperus communis, Linnaea borealis, Pyrola secunda, Picea glauca, Salix bebbiana, and Thuidium abietinum.

V. Picea glauca (P. mariana) - Hylocomium splendens phytocoenon (Nos. 7, 8, 9, 15, 18, 31).

An overall similarity of 53% (Fig. 7) indicated the heterogeneous nature of this upland Picea glauca feathermoss forest phytocoenon whose members occurred on a variety of mesic sites. They were primarily related through their feather moss understories. The NSQ was 15.5 and mean SR = 47.

Structurally, they ranged from woodlands to forests. The mean total plant cover of 140% was the highest of all phytocoena (Table 6). Because of their structural diversity they are best described at the subclass level.

Mean basal area, 32 m^2/ha, was the second highest of all phytocoena with a range of 15-50 m^2/ha. While the mean density of 4084 stems/ha was the highest of all phytocoena, this value was deceptive because the density in phytocoenose 8 was very high, 11,180 stems/ha, which significantly increased mean density (Tables 7 and 8).

Important member species with 100% constancy were (Table 5): Cornus canadensis, Hylocomium splendens, Linnaea borealis, Picea glauca, Rosa acicularis, Salix bebbiana, Vaccinium vitis-idaea, and Viburnum edule. Other less constant (80%) species were: Brachythecium salebrosum, Campylium chrysophyllum, Drepanocladus uncinatus, Elymus innovatus, Pyrola secunda, and Shepherdia canadensis.

VA. Populus tremuloides (Picea) - Alnus crispa - Hylocomium splendens phytocoenon (Nos. 7, 15).

Two phytocoenoses belonged to this subclass. Phytocoenose 7 was on a north-facing sandy beach ridge, while phytocoenose 15 (Plate 4) occurred on loam in a relatively closed depression located in the plateau-like uplands. Both soils were Eluviated Eutric Brunisols.

Total plant cover was 136% (Table 6). The tree stratum was well developed with trees averaging 27% cover and low trees, 22%. They were dominated by Populus tremuloides (23%) with Picea and Pinus banksiana admixed. Phytocoenon age was 78 years.

Mean basal area was 26 m2/ha and mean density was 2840 stems/ha (Table 7 and 8).

In the shrub stratum tall shrubs were very abundant (43%), while low shrubs were much less abundant (8%). The stratum was dominated by Alnus crispa (42%) with Rosa acicularis the only other important shrub (8%).

Probably due to the dominance of deciduous trees and shrubs, the herb-dwarf shrub stratum (14%) and bryoid stratum (22%) were weakly developed. The most prominent species in these strata were Hylocomium splendens (16%) and Linnaea borealis (1%). Mosses (cover 20%) were more abundant than the primarily fruticose lichens (2%).

VB. Picea glauca - Hylocomium splendens - Thuidium abietinum phytocoenon (Nos. 8, 9).

The phytocoenoses representative of this subclass (Plate 9) were both found on Orthic Eutric Brunisols. One occurred on the plateau-like uplands in a relatively closed depression (No. 8), while the other was below the escarpment on alluvium along Heart Lake Creek (9).

Total plant cover, 144% (Table 6) was the mean maximum value recorded for subclasses at Heart Lake. In the tree stratum, as in phytocoenon V A, the tree (32%)

and low tree (23%) were jointly better developed than all other phytocoenon subclasses. Concomitantly, mean basal area, 46 m^2/ha, was higher than in all phytocoena as was density, 6735 stems/ha (Tables 7 and 8).

The primary overstory species was Picea glauca with an average cover of 40%. In the uplands, however, Pinus banksiana comprised an important portion of the overstory cover (13%), while in the lowlands Picea mariana contributed to the overstory (5%). Age of the oldest trees in the upland phytocoenose averaged 95 years, and in the lowland, 225 years. The latter was the second oldest phytocoenose.

The shrub stratum was depauperate (cover 3%) and only two species appeared with any regularity, Rosa acicularis and Shepherdia canadensis, although both had low cover (1-3%).

In the herb-dwarf shrub stratum, cover 27%, several species were constant with average covers up to 2%: Carex concinna, Cornus canadensis, Elymus innovatus, and Linnaea borealis.

The bryoid layer (58%) was well developed. Dominant species were: Hylocomium splendens (cover 43%) and Thuidium abietinum (6%). Lichens were poorly represented (<1%).

VC. *Picea glauca* - *Mitella nuda* - *Hylocomium splendens* - *Ptilium crista* - *castrensis* phytocoenon (No. 31).

This subclass (Plate 7) occurred in a deep (13 m) escarpment canyon and probably represented the most mesic upland site within the study area. The soil was a Regosolic Static Cryosol.

Total plant cover was 139% (Table 6). In the tree stratum, trees averaged 16% cover and low trees 7%. The site was dominated by very old *Picea glauca* (16%) with *Betula papyrifera* (5%) subdominant. Phytocoenose age was 264 years, the oldest sampled.

Basal area, 15 m^2/ha, and density, 1270 stems/ha, were relatively low (Tables 7 and 8).

The shrub stratum was sparse with tall shrub cover only 1% and low shrub cover 6%. The most prominent shrub, *Ledum groenlandicum*, averaged less than 2% cover.

The bryoid stratum (91%) established the phytocoenon's essential character. Within it mosses attained 81% cover and lichens only 11%. It was dominated by *Hylocomium splendens*. Other common bryoids were: *Ptilium crista-castrensis* (18%), *Peltigera aphthosa* (10%), and *Barbilophozia barbata* (<2%). Considerable importance was ascribed *Ptilium*, because this was the only phytocoenose where it occurred in more than trace amounts. Also, *Peltigera aphthosa*, although it occurred in other phytocoena, reached its optimum development here.

Plate 7. Mesic escarpment canyon with Picea glauca - Hylocomium splendens - Ptilium crista-castrensis phytocoenon (VC: phytocoenose 31).

VI. Picea mariana - Ledum decumbens - Sphagnum fuscum phytocoenon (Nos: 20, 21, 38, 40).

Commonly found in the southern part of the Heart Lake area (Fig. 10), this phytocoenon was restricted to organic terrain rich in Sphagnum peat. This four-member phytocoenon represented a gradient from poor fen (No. 38) in an aapamire strang through raised bogs with shallow peat (1m; No. 20) to deep peat (5m; No. 40).

Overall phytocoenose similarity was 76% (Fig. 7). There was a mean total of 38 species and the NSQ was 18.0.

Total plant cover was 138% (Table 6). In the tree stratum, tree cover was sparse, 3%, as was the low tree stratum comprising 6% cover. The shrub stratum had a minor tall shrub component (2%), while low shrubs averaged 16% cover. Tree and shrub strata were almost entirely composed of Picea mariana (16%).

Mean basal area, 4.1 m^2/ha, was the lowest obtained for treed phytocoena, despite a fairly high mean density of 1798 stems/ha (Tables 7 and 8).

In the herb-dwarf shrub stratum (21%), evergreen dwarf shrubs were particularly prominent: Andromeda polifolia, Chamaedaphne calyculata, Ledum decumbens, L. groenlandicum, Oxycoccus microcarpus, and Vaccinium vitis-idaea.

The bryoid stratum averaged 90% cover and contained three constant and dominant bryoids: Sphagnum fuscum (35%), Cladonia mitis (30%), and Cladonia rangiferina (4%). Three other species, Cladonia arbuscula, C. cornuta, and Dicranum undulatum, were less abundant but constant.

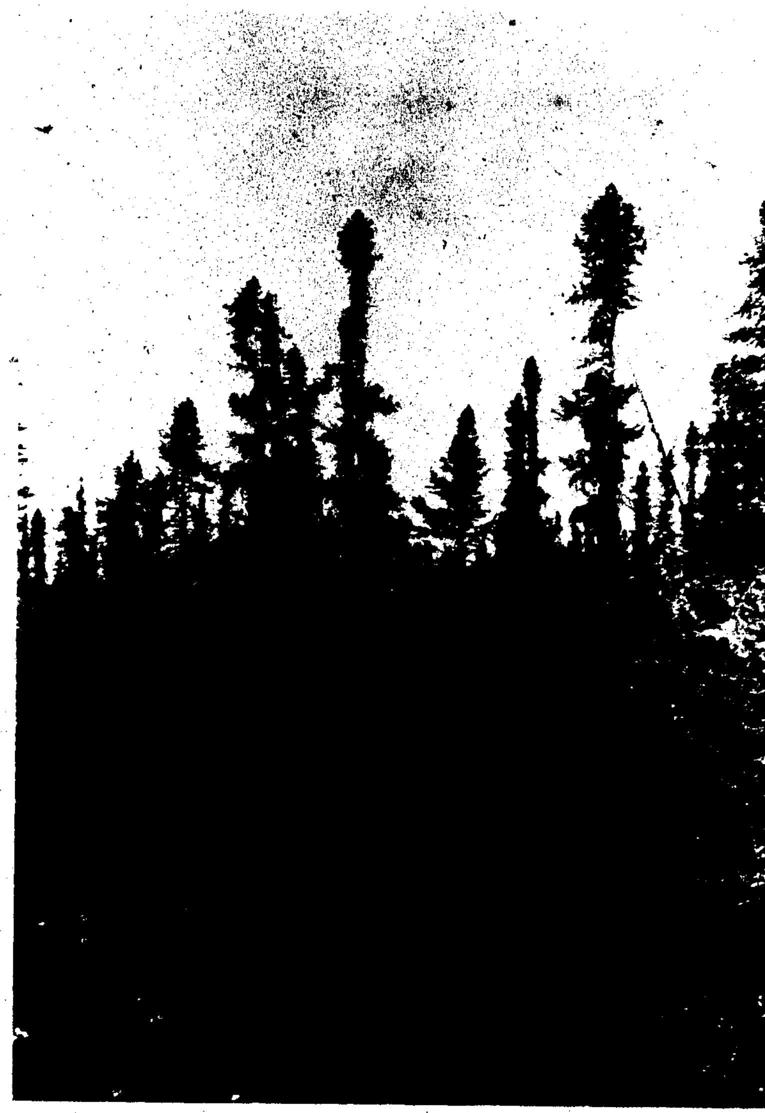
Diagnostic species were: Chamaedaphne calyculata, Cladonia amaurocraea, C. pleurota, Drosera rotundifolia, Icmadophila ericetorum, Ledum decumbens, Mylia anomala, Pinguicula villosa, Pohlia cf. sphagnicola, Polytrichum strictum, Rubus chamaemorus, Sphagnum nemoreum, and S. fuscum.

In the two subclasses, raised bogs (VI A) were distinguished from aapamire strangs (VI B).

VIA. Picea mariana - Ledum decumbens - Sphagnum fuscum phytocoenon (Nos. 20, 21, 40).

This subclass (Plate 8) occurred in raised ombrotrophic peat plateaus at the margin of Heart Lake and in old lake beds at other locations. These organic landforms were frozen, Sphagnum-derived, peat deposits raised one or two meters above the surrounding minerotrophic fen deposits. The raised surface prevented

Plate 8. *Picea mariana* - *Ledum decumbens* - *Sphagnum fuscum* phytocoenon (VI A: phytocoenose 21).



inflow of water from mineral soils and, therefore, these bogs were dependent on precipitation for water and nutrients. Soils were typically Fibric Organic Cryosols. Microrelief was hummocky with individual hummock height about 30 cm.

Total plant cover was 141% (Table 6). The tree stratum was better developed than in VI B; here trees covered 3% and low trees 7%. In the shrub stratum, low shrubs averaged 18% while tall shrubs only 2%. *Picea mariana* was absolutely dominant in all these strata. Phytocoenose age ranged from 82 years (No. 20) to 113 years (40) to 203 years (21). Phytocoenose 21 contained the oldest tree sampled within the Heart Lake area, a 318+ year old black spruce.

The herb-dwarf shrub stratum (cover 19%) and the bryoid stratum (92%) contained the same diagnostic species present at the phytocoenon level (Table 5).

VIB. *Picea mariana* - *Larix laricina* - *Betula glandulosa* - *Sphagnum fuscum* phytocoenon (No. 38).

Occurring on aapamire strangs (Plate 13), this phytocoenon showed a pronounced effect of minerotrophy as evidenced by the presence of *Meesia uliginosa*, *Myrica gale*, *Smilacina trifolia*, *Tomenthypnum nitens*, and several sedges. The organic soil was classed as a Typic Mesisol.

Picea mariana and *Larix laricina* were represented as mainly low trees with average covers of 2%. Only *Picea mariana* was represented in the tree stratum. Phytocoenose age was 72 years.

The bryoid stratum was dominated by *Sphagnum fuscum* (cover 52%). *Tomenthypnum nitens* (11%), was well represented in depressions. *Aulacomnium palustre* and *Dicranum undulatum* were important associates. Lichens (8%) were far less abundant here in comparison with VI A where they attained an average cover of 59%.

In comparison with subclass VI B, this phytocoenon was primarily distinguished by a relatively low NSQ, 16.0, and low SR, 32. In subclass VI B, the NSQ was 23.8 with a total SR of 59.

In addition both basal area and density were greater in subclass VI A than in VI B (Tables 7 and 8). For VI A mean basal area and density were 5.1 m^2/ha and 2210 stems/ha, respectively, while for VI B there were only 1.2 m^2/ha and 560 stems/ha.

Despite the cited differences between the two subclasses the abundances of *Sphagnum fuscum*, evergreen shrubs, and *Picea mariana* were responsible for VI B being clustered with VI A.

VII. Picea mariana - Potentilla fruticosa - Tomenthypnum nitens - Campylium stellatum phytocoenon (Nos. 11, 18, 19, 33, 35, 37, 39, 41).

With a mean NSQ of 21.7 and an SR of 58, this was floristically the richest phytocoenon. It was, however, only slightly richer in species than Pinus banksiana - Arctostaphylos uva-ursi - Viburnum edule phytocoenon (III). Its eight phytocoenoses had the least similarity, 42% (Fig. 7).

This phytocoenon was composed of wooded fens, shrub fens, and rich sedge fens occurring on imperfectly to poorly drained lacustrine deposits. The microrelief was hummocky.

Total plant cover is 133% (Table 6). Because of the great structural diversity within the type, stratal cover is discussed at the subclass level.

A mean basal area of 12 m^2/ha and mean density of 2095 stems/ha are mentioned here for comparative purposes (Table 7 and 8). Because of structural diversity, caution must also be used in assessing mean values at these levels.

Diagnostic species were: Arctostaphylos rubra, Equisetum pratense, Mitella nuda, Salix myrtillifolia, Selaginella selaginoides.

Several species had 100% constancy but occurred in other phytocoena: Tomenthypnum nitens (cover 19%), Campylium stellatum (15%), Picea mariana (9%), Larix laricina (4%), Potentilla fruticosa (4%), and Galium boreale (<1%). Two other species (constancy 76%-88%) were: Aulacomnium palustre (1%) and Equisetum scirpoides (<1%).

Differential species common to both phytocoena VII and VIII were: Betula glandulosa, Campylium stellatum, Drepanocladus revolvens, and Salix candida (Table 9). Several species occurred less frequently but were often characteristic: Cinclidium stygium, Drosera anglica, Scirpus caespitosus, Scorpidium scorpioides, and Triglochin maritima.

Other species had their optimum development in phytocoenon VI and VII: Carex aurea, C. capillaris, C. leptalea, C. vaginata, Catascopium nigritum, Parnassia palustris, Rubus acaulis, and Smilacina trifolia.

The three subclasses presented a complexity gradient from structurally diverse (VII A) to simple (VII C).

VIIA. Picea mariana - Larix laricina - Vaccinium vitis-idaea - Tomenthypnum nitens phytocoenon (Nos. 11, 18, 19).

Occurring as open, wooded-fens, this subclass (Plate 10) was found extensively below the escarpment and south of the Mackenzie Highway. The microrelief was

Plate 9. *Picea glauca* - *Hylocomium splendens* - *Thuidium abietinum* phytocoenon (V B: phytocoenose 9). Divisions on scale pole (right of center) were 10 cm in length.

Plate 10. *Picea mariana* - *Larix laricina* - *Vaccinium vitis-idaea* - *Tomenthypnum nitens* - *Cladonia arbuscula* phytocoenon (VII A: phytocoenose 19).

hummocky and the soils were mainly Rego Gleysols (peaty phase).

Total plant cover was 141% (Table 6). In the tree stratum, cover was almost equally divided between trees (12%) and low trees (14%).

The overstory was dominated by evenly distributed Picea mariana (cover 13%) and scattered Larix laricina (3%). Picea glauca sometimes composed part of the overstory (8-12% cover). Average ages of the oldest trees ranged from 144 to over 200 years.

Mean basal area was 10 m^2/ha and density was 4513 stems/ha (Tables 7 and 8).

Although the tall shrub stratum was essentially absent (1%), the low shrub and herb-dwarf shrub strata accounted for 16% and 26%, respectively. These strata contained several characteristic species: Ledum groenlandicum (cover 6%), Juniperus horizontalis (1%), Salix glauca (1%), Shepherdia canadensis (<1%), Juniperus communis (<1%), Rosa acicularis (2%), and Vaccinium vitis-idaea (<1%). Several other shrubs were common to both phytocoena VII A and VII B: Potentilla fruticosa (2%), Arctostaphylos rubra (2%), Salix myrtillifolia (4%), and Betula glandulosa (1%).

The herb component contained minor amounts (<1%) of Mitella nuda, Galium boreale, Carex vaginata, Equisetum scirpoides, and Carex scirpoidea.

Plate 11. *Lobelia kalmii* - *Scirpus caespitosus* - *Campylium stellatum* phytocoenon VII C: phytocoenose 37).

Plate 12. *Salix pedicellaris* - *Carex lasiocarpa* - *Scorpidium scorpioides* - *Drepanocladus revolvens* phytocoenon (VIII B: phytocoenose 25) along the inlet to Heart Lake.

In the bryoid stratum (68%), the mosses Tomenthypnum nitens (cover 30%), and Hylocomium splendens (7%) were dominant with a significant fruticose lichen component: Cladonia mitis (5%), C. arbuscula (3%), C. rangiferina (3%), and C. alpestris (2%). Altogether, mosses totaled 53% and lichens 15%.

Compared with phytocoenon VII B, which reflected slightly moister conditions, this phytocoenon shared many common species. However, there were several which were distinctly more prominent here: Picea mariana, Salix myrtillifolia, Equisetum scirpoides, Carex vaginata, Rosa acicularis, Hylocomium splendens, and Tomenthypnum nitens.

Several species occurred in both VII A and VII B but attained their optimum development in VII B: Betula glandulosa (cover 6%), Campylium stellatum (13%), Drepanocladus revolvens (9%), Carex aquatilis (3%), Smilacina trifolia (1%), Salix arctophylla (2%), Larix laricina (6%), Carex garberi (<1%), and Parnassia palustris (<1%; Table 5).

VII B. Picea mariana - Larix laricina - Carex capillaris - Campylium stellatum phytocoenon (Nos. 33, 39, 41).

This subclass of very open, wooded-fens was found on wetter sites than the previous subclass. Soils were Terric Humisols.

Total plant cover (129%) was slightly less than in subclass VII A (Table 6) and the average cover of most strata also tended to be lower: tree (9%), low tree (3%), low transgressive (10%), and bryoid (56%), while the tall shrub cover (2%), was essentially the same but the herb-dwarf shrub cover (49%) was nearly twice as much. In the bryoid stratum lichens (<1%) were nearly absent, while mosses accounted for 55%.

While mean basal area, 15 m^2/ha, was only slightly less than VII A, density, 1073 stems/ha, was much lower (Tables 7 and 8).

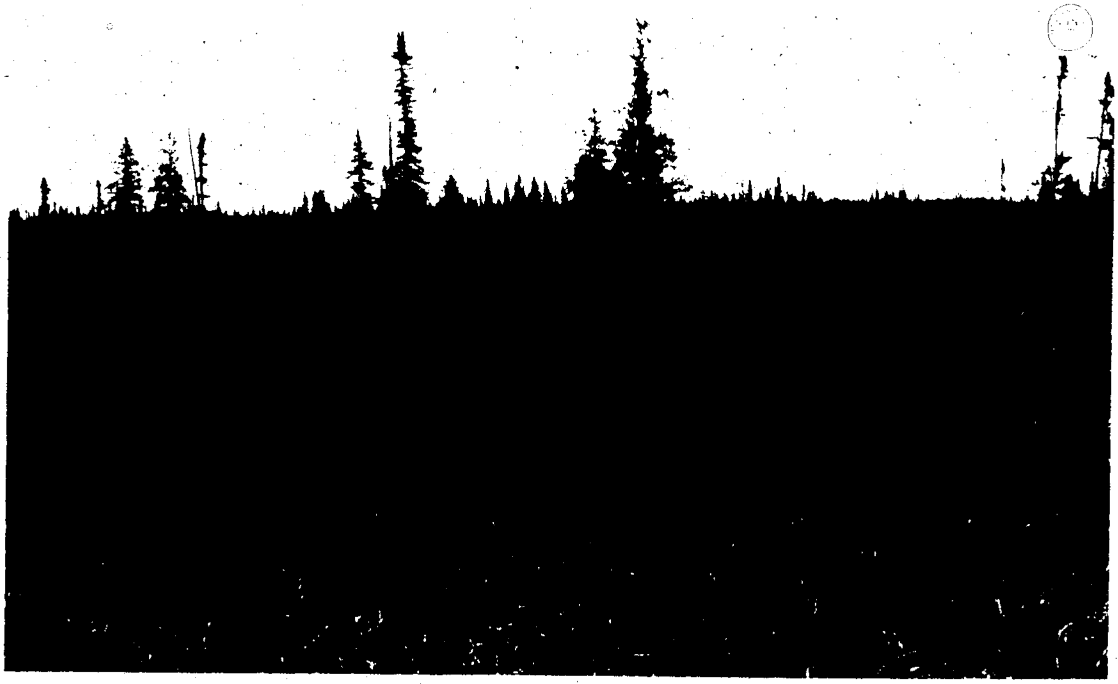
Phytocoenose ages ranged from 142 years (phytocoenose 41) to 158 years (33) in the oldest but only 27 years in phytocoenose 39. The latter must have burned over about the same time as III B (13).

VII C. Lobelia kalmii - Scirpus caespitosus - Campylium stellatum phytocoenon (Nos. 35, 37).

This subclass occurred in patterned string fens (Plate 11) and on islands in marl fens (Plates 15 and 16).

Plate 13. Oblique aerial photograph of aapamire or net fen showing reticulate pattern of strangs, or ridges (cf. phytocoenon VI B) and flarks or hollow (cf. VII A). A raised bog (cf. VI A) appears in the upper right land corner of the photograph.

Plate 14. Salix pedicellaris - Carex aquatilis - Drepanocladus revolvens phytocoenon (VII A: phytocoenose 23) occurring in aapamire flark. Divisions on scale pole (center) are 10 cm in length.



Both were of limited occurrence and were found exclusively below the escarpment. Soils were Rego Gleysols.

Total plant cover was 132% (Table 6). Dominant strata include the herb-dwarf shrub (77%) and bryoid (53%) with mosses (49%) far more abundant than lichens (4%). There was a rather sparse cover of low trees (<1%), tall shrubs (<1%), and low shrubs (2%).

Lobelia kalmii was distinctive but with low cover (<2%). Scirpus caespitosus and Campylium stellatum were dominant (35% and 39%), respectively. Other characteristic species included: Andromeda polifolia, Kobresia simpliciuscula, Moerkia hibernica, Pinguicula vulgaris, Primula mistassinica, Selaginella selaginoides, and Tofieldia glutinosa.

Larix laricina and Picea mariana were primarily present as seedlings and dwarf-shrubs.

VIII. Salix pedicellaris - Menyanthes trifoliata - Drepanocladus revolvens phytocoenon (Nos. 23, 24, 25, 26).

Occurring as deciduous dwarf shrub peatlands, this phytocoenon was found on very poorly drained sites like aapamire flarks or in fens along streams.

The NSQ was 13.6 and the SR 24. The four phytocoenoses making up this phytocoenon had an overall similarity of 73% (Fig. 7), which was relatively high.

Total plant cover was 106% (Table 6). In the shrub stratum only low shrubs (2%) were present. The phytocoenon was dominated by the herb-dwarf shrubs (36%) and bryoids strata (54%). No lichens were present.

Differential species were Salix pedicellaris (cover 2%), Carex limosa (4%), and Menyanthes trifoliata (5%). Several other species reached their optimum development in VIII but also occurred in VII: Myrica gale, Scorpidium scorpioides, Triglochin maritima, and Cinclidium stygium (Table 5).

Scorpidium scorpioides (24%) was usually the dominant bryoid and associated with the less abundant Drepanocladus revolvens (6%).

This phytocoenon was related to phytocoenon VII through the constancy of several characteristic species: Betula glandulosa, Campylium stellatum, Drepanocladus revolvens, Bryum pseudotriquetrum, and Salix candida (Table 9).

Other more wide ranging wetland species with 75% constancy were: Andromeda polifolia, Galium labradoricum, Potentilla palustris, and Aneura pinguis.

VII A. *Salix pedicellaris* - *Carex aquatilis* - *Drepanocladus revolvens* phytocoenon (Nos. 23, 24, 26).

Total plant cover of these fens (Plates 13 and 14) was 104% (Table 6). They were distinguished by a higher average low shrub and dwarf shrub cover (20%), than subclass VIII B (3%). Average cover of the low shrub stratum was 6% and the herb-dwarf shrub stratum, 49%. The bryoid stratum was composed entirely of mosses (52%). The organic soils were Hydric Mesisols.

The subclass was also characterized by the importance of *Carex aquatilis* (10%) and by two frequent bryoids: *Cinclidium stygium* and *Aneura pinguis*. *Andromeda polifolia* was present in all phytocoenoses but usually in very low abundance. Other noteworthy species were: *Drepanocladus fluitans*, *Muhlenbergia glomerata*, and *Scirpus caespitosus*.

Some weak reproduction of *Larix laricina* occurred.

VIII B. *Salix pedicellaris* - *Carex lasiocarpa* - *Scorpidium scorpioides* - *Drepanocladus revolvens* phytocoenon (No. 25).

This subclass (Plate 12) occurred along the clear, slow-moving inlet stream to Heart Lake as a quaking mat of living and dead plant life. It changed with decreasing moisture into a shrub fen and ultimately into a raised bog. The organic soil was a Hydric Mesisol.

Total plant cover was 101% (Table 6). The minor low shrub stratum (2%) was underlain by a herb-dwarf shrub stratum which averaged 39% cover. The bryoid stratum, again comprised entirely of mosses, was well developed (60%).

Species with a quadrat frequency 80% or greater were: Scorpidium scorpioides (cover 37%), Calliergon giganteum (12%), Drepanocladus revolvens (5%), Carex lasiocarpa (12%), Carex limosa (6%), Menyanthes trifoliata (17%), and Utricularia intermedia (1%).

There was no reproduction by tree species.

IX. Carex aquatilis - Galium labradoricum - Calamagrostis canadensis phytocoenon (Nos. 27, 28, 29).

Characterized by a low NSQ of 9.6 and SR of 25, this phytocoenon occurred on poorly drained organic sites. One phytocoenose, 29, introduced considerable heterogeneity and resulted in a rather low overall similarity for the phytocoenon, 58%.

Because of high heterogeneity, low species numbers, and the need for more phytocoenose records, the validity of this phytocoenon as a vegetation unit might be questioned. However, there were several factors which pointed toward considering it as such. First the phytocoenon had three constant species: Carex aquatilis, with a cover of 49%, Calamagrostis canadensis and Galium labradoricum, 1% each. Secondly, five species occurred in at least two member phytocoenoses: Rorippa islandica, Salix planifolia, Carex rostrata, Cicuta mackenziana, and Scutellaria galles iculata. Thirdly, the class lacked several species common to phytocoena VII and VIII: Drepanocladus revolvens, Scorpidium scorpioides, Triglochin maritima, and Cinclidium stygium. Three other species primarily found in phytocoenon VIII, Carex limosa, Salix pedicellaris, and Menyanthes trifoliata, were also absent.

The phytocoenon might be considered as a 3-member gradient from the wettest, phytocoenose 27, without bryoids, through phytocoenose 28 with mosses but without lichens, to the wet-mesic phytocoenose 29 with mosses and a few foliose lichens.

IX A. Salix planifolia - Carex aquatilis - Brachythecium salebrosum phytocoenon (No. 29).

Located at the outlet of Heart Lake, this deciduous thicket was occasionally flooded in the spring. The organic soil was classed as Fibric Mesisol.

The total plant cover was 107% (Table 10). In the shrub stratum, Salix planifolia (37%) occurred with S. bebbiana (8%). Together they formed a nearly continuous layer of tall and low shrubs.

The herb-dwarf shrub layer was sparse (cover 11%) and dominated by the graminoids Carex aquatilis and Calamagrostis canadensis. Reproduction by the tree species Picea mariana and Larix laricina was weak.

The bryoid stratum (50%) was dominated by mosses (49%) especially Brachythecium salebrosum (cover 20%). Other prominent mosses included: Drepanocladus vernicosus, Tomenthypnum nitens, Aulacomnium palustre, and Rhizomnium pseudopunctatum. Lichens (1%) were poorly represented (3 species) and all belonged to the genus Peltigera.

IX B. Carex aquatilis - Carex rostrata - Potentilla palustris phytocoenon (Nos. 27, 28).

This subclass occurred as graminoid-dominated shore fens. These fens were floating mats several meters wide and partially encircled Heart Lake. Typically they formed an ecotone between the open water and raised bogs. Soils were Hydric Humisols (27) and Hydric Mesisols (28).

Total plant cover was 87% with a very predominant herb-dwarf shrub stratum, 82%. The low shrub (3%) and bryoid strata (2%) accounted for only a small percent of the total (Table 6).

Carex aquatilis and C. rostrata were absolutely dominant with combined covers of 73%. Important associates were the forbs, Potentilla palustris (cover 3%), Galium labradoricum (<1%), and Scutellaria gallericulata (1%), and the shrub, Myrica gale (2%).

In the bryoid layer, mosses were poorly represented and were only found in phytocoenose 28. Lichens were absent in both members.

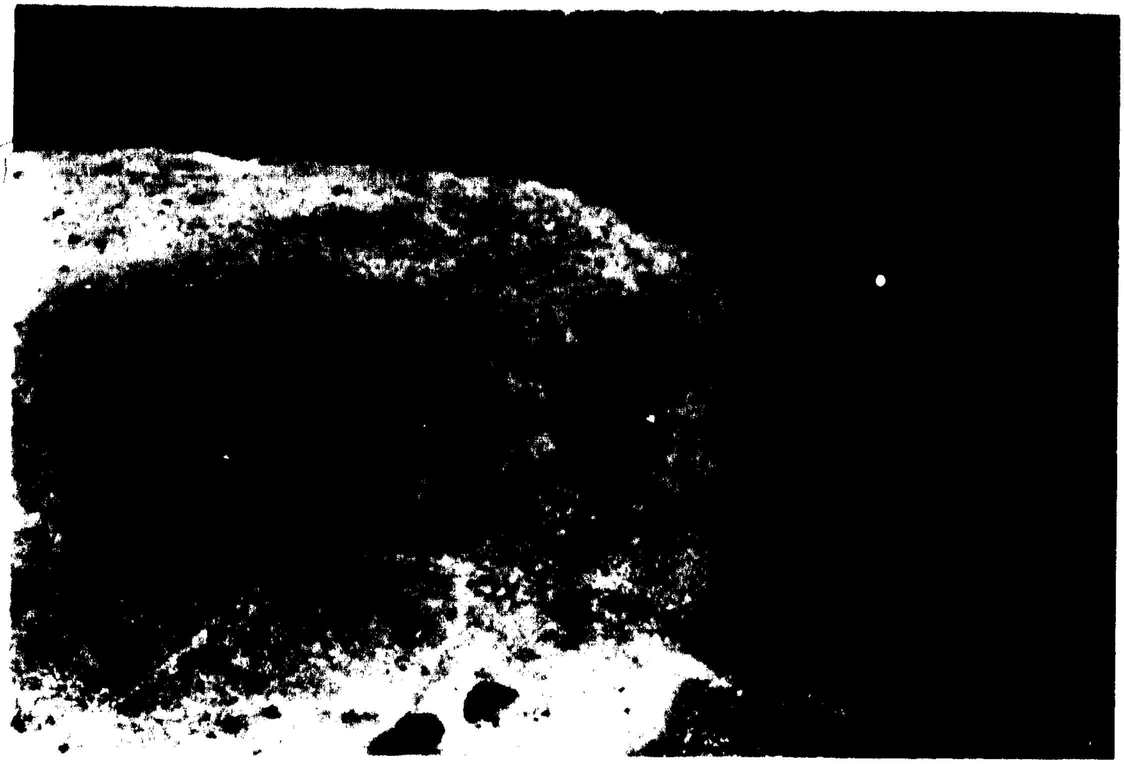
There was no reproduction by tree species.

X. Eleocharis pauciflora - Eleocharis compressa - Eriophorum angustifolium phytocoenon (No. 36).

This phytocoenon (Plates 15 and 16) occurred in very poorly drained marl fens below the escarpment. It contained the lowest total number of species, 10, and had the lowest mean NSQ, 4.3. Total cover was also very low, 6%. The soil was a Rego Gleysol.

Plate 15. Oblique aerial photograph of *Eleocharis pauciflora* - *Eleocharis compressa* - *Eriophorum angustifolium* phytocoenon (X: phytocoenose 36), is a marl fen. Larger but similar island (phytocoenose 35) were sampled in another marl fen.

Plate 16. Ground view of Plate 15 showing marl fen and islands. Contact communities were *Picea mariana* - *Betula glandulosa* fens (background) which ultimately changes to *Picea* feathermoss woodlands.



Total plant cover was the minimum recorded (6%) primarily composed of herbs (5%) with less than 1% as mosses (Table 6).

Dominant graminoids with a frequency greater than 60% were: Eleocharis pauciflora (cover <1%), E. compressa (<1%), and Eriophorum angustifolium (<2%). Characteristic but less frequent species were: Drosera anglica, Equisetum palustre, Potamogeton filiformis, Scirpus validus, Triglochin palustre, and Utricularia intermedia.

The one bryoid, Scorpidium scorpioides, was relatively frequent (60%) but with low cover (<1%).

Soils

The soils of the investigated area fell within the Brunisolic, Regosolic, Gleysolic, Cryosolic, and Organic orders. All were formed on calcareous parent materials that included till, colluvium, alluvium, and glaciolacustrine, each of which might be underlain by bedrock.

Descriptions

Study area Brunisols belonged to the Eutric great group and were represented by Orthic and Eluviated subgroups and lithic families. Areally, the most frequently encountered were Orthic Eutric Brunisols associated with pine woodlands (phytocoenon III), deciduous forests (IV), and coniferous and mixed forests (V). Although best developed on beach deposits, where they sometimes made a transition to Eluviated Eutric Brunisols, they also occurred extensively in the plateau-like uplands on deep glacial deposits. Two profiles were described. The first (No. 8) was associated with an alluvial white spruce forest (VB) where gleying was evident in the C horizon. It was described from the plateau-like uplands at 60°51.6'N, 116°37.3'W:

Horizon	Depth (cm)	Description
L-H	10-0	Very dark grayish brown (10YR 3/2 d) litter of living and dead feather-mosses, well decomposed toward the boundary; abundant micro roots with a few coarse roots; abrupt, clear boundary; pH 6.1.
Bm	0-10	Brownish yellow (10YR 6/4 d) gravelly clay loam; weak, fine granular; slightly hard; plentiful medium and micro roots; 20% angular gravel; clear, irregular boundary; pH 6.9.
II Ck	10-27	Yellowish brown (10YR 5/4 d) gravelly sand loam; few medium, fine and micro roots; 60% angular gravel; strongly effervescent; clear wavy boundary; pH 7.7.
III Ckn	27-64	Light yellowish brown (10YR 6/4 d) gravelly clay loam; few fine distinct yellowish brown (10YR 5/6 d) mottles; strongly effervescent; pH 7.8.
R	64+	Light gray (10YR 7/1 d) calcareous sandstone.

A second Orthic Eutric Brunisol (No. 32) sampled within a deciduous forest (IV) phytocoenon with unimpeded drainage was described from the following location, 60°51.4'N, 116°39.0'W and occurred on beach deposits:

Horizon	Depth (cm)	Description
L-H	9-0	Litter of matted deciduous leaves; well decomposed at the

		bottom; abundant micro roots; abrupt, clear boundary; pH 5.5.
Bm	0-18	Strong brown (7.5YR 5/4 d) gravelly sandy loam; moderate, medium angular blocky; soft; plentiful medium roots; 40% gravel; clear, smooth boundary; pH 6.3.
Ck1	18-58	Brown (10YR 5/3 d) gravelly sandy loam; weak, fine granular; loose; plentiful micro roots; 80% gravel; strong effervescence; clear, smooth boundary; pH 7.3.
Ck2	58-88	Brown (10YR 5/3 d) gravelly sand; loose; very few fine and micro roots; 30% gravel; strong effervescence; clear, smooth boundary; pH 7.5.
Ck3	80-100+	Brown (10YR 5/3 d) gravelly sand; loose; very few medium roots; roots continue beyond 108 cm; 50% gravel; strong effervescence; pH 7.5.

Eutric Brunisols (lithic family), formerly termed Lithic Eutric Brunisols, were found extensively in the plateau-like uplands, and were the second most abundant Brunisol. They were primarily associated with Arctostaphylos uva-ursi steppe scrub (II). These profiles were composed of thin drift over calcareous bedrock. A representative profile (No. 2) found at 60°51.5'N, 116°37.6'W was described as follows:

Horizon	Depth (cm)	Description
L-H	1-0	Poorly decomposed living and dead mosses and lichens, aspen leaves and twigs; abrupt, smooth boundary; pH 6.4.

Bm	0-5	Dark brown (7.5YR 4/4 d) silt loam; weak, fine granular; plentiful micro roots; 5% angular gravel; abrupt, smooth boundary; pH 6.8.
R1	5-10	Light gray (10YR 7/1 d) channery, shattered bedrock; strongly effervescent; pH 7.6.
R2	10+	Light gray (10YR 7/1 d) calcareous sandstone; strongly effervescent.

Eluviated Eutric Brunisols were infrequent within the study area. They were most common on beach deposits (No. 6) but might also be present in slight depressions (15), presumably due to greater percolation. Vegetation subclasses frequently associated with these soils were Populus tremuloides - Alnus crispa - Hylocomium splendens (V A) and Pinus banksiana - Arctostaphylos uva-ursi - Vaccinium vitis-idaea (III C). A particularly well developed example (6) occurred on a sandy beach deposit at 60°52.1'N, 116°42.9'W:

Horizon	Depth (cm)	Description
L-H	10-0	Poorly decomposed litter of pine needles, dead and living mosses and lichens; moderately well decomposed at boundary; plentiful coarse, medium and micro roots; clear, smooth boundary; pH 6.0.
Ae	0-13	Light gray (10YR 7/2 d) sand; single grain; nonsticky, nonplastic, loose; few coarse roots; clear, wavy boundary; pH 5.6

Bm	13-60	Yellowish brown (10YR 5/4 d) sand; single grain; nonsticky, nonplastic, loose; very few coarse, fine, and micro roots; clear, wavy boundary; pH 5.7.
Ck	60-110	Light yellowish brown (10YR 6/4 d) sand; single grain; strongly effervescent; clear, wavy boundary with root channels (7 cm diameter) present; pH 7.6.
II Ck	100+	Sandy gravel

Regosols are soils having horizon development too weak to meet the requirements of any other order. Two subgroups were described at Heart Lake: Orthic Regosols (lithic phase) and Orthic Humic Regosols.

Lithic phase Regosols occurred infrequently on the plateau-like uplands. These soils had a lithic contact at a depth greater than 10 cm but less than 50 cm. They were usually associated with *Juniperus horizontalis* dwarf shrublands (II A). These rapidly drained soils had developed on thin drift over bedrock. The extreme thinness of the surface deposit over rock almost placed it in the nonsoil group. A representative profile (No. 1) at 60°51.1'N, 116°37.5'W was described as follows:

Horizon	Depth (cm)	Description
L-H	0.5-0	Loose litter of dead and living lichens, mosses, bearberry and juniper leaves; abrupt smooth boundary; pH 6.4.

Ck	0-10	Very dark grayish brown (10YR 3.2 d) very gravelly silt loam; loose; abundant coarse, fine, and micro roots (mat of roots formed at lithic contact); weakly effervescent; 80% angular gravel (carbonate coating on underside of stones), abrupt, smooth boundary; pH 7.2.
R	10+	Light gray (10YR 7/2 d) calcareous sandstone.

Orthic Humic Regosols were abundant below the escarpment on well to imperfectly drained colluvium. These soils usually had a thick L-H (10cm) over a Ck horizon composed predominantly of angular gravelly to angular cobbly calcareous fragments mixed with some well decomposed litter. They were associated with deciduous forests (IV) and the Picea glauca - Betula papyrifera - Hylocomium splendens - Pleurozium schreberi phytocoenon (III D). A representative profile (No. 16) from an Orthic Humic Regosol is described below at 60°49.0'N, 116°35.4'W:

Horizon	Depth (cm)	Description
L	9-7	Litter of matted deciduous leaves, twigs; roots absent.
FH	7-0	Very dark grayish brown (10YR 3/2 d) litter from deciduous trees and shrubs; plentiful micro roots with very few, very fine roots; clear, wavy boundary; pH 6.2.
Ahk	0-50	Black (10YR 2.1 d) very gravelly and cobbly silt loam; single grain, loose; 75% angular gravel and angular cobbles; very weakly

		effervescent; plentiful coarse and medium roots; gradual wavy boundary; pH 7.1.
Ck	50+	Light brownish gray (10YR 6/2 d) very cobbly loam; structureless; 85% cobbles; strongly effervescent; very few micro and fine roots; pH 7.4.

Regosolic Static Cryosols occurred in some escarpment canyons . They were associated with the white spruce-feather moss phytocoenon (V C).

Gleysols usually developed on poorly to very poorly drained soils in the lowlands. Rego Gleysols commonly occurred on lacustrine deposits below the escarpment as marl, a mixture of calcium carbonate and clay. Associated vegetation consisted of patterned string fen (VII C) and marl fen (X). In VII C a well humified H (1-10 cm) layer was present, while in phytocoenon X it was absent. The soil described below was from a marl fen (No. 30) at 60°52.0'N, 116°37.6'W:

Horizon	Depth (cm)	Description
Ckg	0-50+	Light gray (10YR 7/1 d) marl; slightly sticky, nonplastic, loose; strongly effervescent; plentiful micro roots (0-30 cm); pH 7.7.

Rego Gleysols (peaty phase) covered extensive, moderately poorly drained lowland areas where the topography was flat to gently sloping on lacustrine deposits. Associated vegetation was coniferous swamp (VIII A). A Rego Gleysol (peaty phase) (No. 19) was described at 60°50.5'N, 116°37.9'W as follows:

Horizon	Depth (cm)	Description
Oh	30-0	Dark brown (10YR 4/3 d) well decomposed peat; amorphous; few coarse, fine, and micro roots; smooth, abrupt boundary; pH 6.6.
Ckg	0-25+	Very pale brown (10YR 8/4 d) gravelly sandy loam; many, medium prominent yellowish brown (10YR 5/6 d) mottles; amorphous; very few very fine roots; 60% angular gravel; strongly effervescent; pH 7.7.

Organic soils were widespread on poorly to very poorly drained lacustrine parent material within the Heart Lake lowlands and were represented in the Organic order as Mesisols and Humisols, and in the Cryosolic order by Fibric Organic Cryosols, formerly termed Cryic Fibrisols.

Fibric Organic Cryosols contained permafrost within one meter of the surface and had a dominantly fibric control section below a depth of 40 cm. Landforms associated with these soils were raised ombrotrophic peat plateaus. Although the mineral parent materials were highly calcareous, ombrotrophic conditions developed as a result of ice formation within organic material. The peat materials were then raised above the mineral contact and were ultimately nourished only by precipitation. Mean depth to the frozen layer was 36 $\pm$ 7 cm (df=19) in late June 1972 and 48 $\pm$ 2 cm in late August 1972. The depth of the organic buildup below a black spruce raised bog (phytocoenose 21) was estimated to be 4.5 m based on peat borings in a nearby collapse scar. A partial description for a typical Fibric Organic Cryosol (21) at 60°49.6'N, 116°38.9'W was as follows:

Horizon	Depth (cm)	Description
Of1	0-25	Yellowish brown (10YR 5/6 d) undecomposed sphagnum peat (dominantly *Sphagnum fuscum*); loose, few medium roots; clear, wavy boundary; pH 3.7.
Of2	25-35	Dark brown (10YR 3/3 m) poorly decomposed sphagnum peat (dominantly *Sphagnum fuscum* with traces of *Eriophorum*); very few fine and micro roots; intermittent band of ash and charcoal 9 cm thick at 35 cm; clear, wavy boundary; pH 3.8.
Of3	35-48+	Brownish yellow (10YR 6/8 m) poorly decomposed cryic sphagnum peat; very few fine and micro roots; pH 3.8.

Humisols were represented by two subgroups within the study area: Terric Humisols and Hydric Humisols. The former was by far the most abundant.

Terric Humisols had a terric layer beneath the surface tier. They were associated with the wet, wooded fens (VII B) from which two examples were described. The first (No. 39) came from a site with 75 cm of peat accumulation and supported a deciduous scrub (*Betula glandulosa*) with isolated *Picea mariana* and *Larix laricina*. It was sampled at 60°51.4'N, 116°38.9'W and was represented as follows:

Horizon	Depth (cm)	Description
Om	0-15	Dark reddish brown (5YR 2.5/2 m) moderately decomposed sedge and brown moss peat; somewhat layered; very few coarse, few fine, plentiful micro roots; isolated charcoal fragments; gradual, wavy boundary; pH 6.2.
Oh1	15-35	Black (5YR 2.5/1 m) well decomposed sedge fen peat; somewhat layered; very few fine, abundant micro roots; gradual, smooth boundary; pH 6.3.
Oh2	35-75	Black (5YR 2.5/1 d) well decomposed fen peat; amorphous; few micro roots; clear, smooth boundary; pH 6.5.
Ck	75+	Pale brown (10YR 6/3 d) loamy sand; soft, roots absent; strongly effervescent; pH 7.8.

A second Terric Humisol from phytocoenon VII B: No. 33 was associated with wooded fen vegetation and occurred on a shallower (55 cm) organic deposit over till. A soil sampled at $60^{o}51.1'N$, $116^{o}39.1'W$ was described as follows:

Horizon	Depth (cm)	Description
Oh	0-55	Black (10YR 2/1 d) well decomposed fen peat; loose; nonsticky, nonplastic; plentiful medium roots; charcoal traces; abrupt, clear boundary; pH 6.4.
Ckg	55-90+	Light brownish gray (2.5Y 6.5/2 d) clay loam; many, medium prominent brownish yellow (10YR 6/6 d) mottles; friable, slightly sticky, slightly

plastic, extremely hard; very few fine and micro roots; 5% angular gravelly; strongly effervescent; pH 7.6.

Hydric Humisols had a hydric layer that extends from a depth of not less than 40 cm to a depth of more than 160 cm. They were associated with floating shore fens (IX B) which encircled part of Heart Lake. A soil (No. 27) sampled at 60°50.5'N, 116°40.0'W was represented as follows:

Horizon	Depth (cm)	Description
Oh	0-50+	Black (2.5Y 2/0 w) highly decomposed sedge peat; plentiful fine, very few very fine, plentiful micro roots; pH 5.8.

Mesisols were organic soils developed primarily from mesic fen peat materials. Hydric Mesisols consisted of a subdominant fibric layer thicker than 25 cm in the remainder of the middle tier or in the bottom tier. At Heart Lake they were frequently associated with deciduous dwarf shrub peatland (VIII A) and occurred extensively in aapamire flarks. A soil (No. 26) sampled at 60°49.1'N, 116°39.7'W was frost free at 150 cm in late July 1972 based on 20 random probes. It was described as follows:

Horizon	Depth (cm)	Description
Of	0-36	Dark brown (7.5YR 3/2 w) poorly decomposed mixed fen peat; layered; abundant micro roots; gradual, smooth boundary; pH 6.1.

Om	36+	Very dark brown (7.5YR 3/2 w) moderately well decomposed fen peat; partially layered; plentiful micro roots; pH 6.3.

Typic Mesisols had a middle tier composed of organic materials in an intermediate stage of decomposition. The example (No. 38) described here was from a aapamire strang (VI B) sampled at 60°49.2'N, 116°39.8'W. Although the top horizon was dominantly sphagnum peat, fen peat in the second horizon suggested a fen origin.

Horizon	Depth (cm)	Description
Of	0-20	Dark brown (10YR 3/2 m) undecomposed sphagnum peat (dominantly *Sphagnum fuscum* with some sedge peat); loose, few fine roots; clear, wavy boundary; pH 5.2.
Om1	20-47	Black (10YR 2.5/1 m) moderately decomposed fen peat; amorphous; plentiful micro roots; clear, wavy boundary; pH 5.8.
Om2	47-62	Very dark grayish brown (10YR 3/2 m) partially decomposed sedge fen peat; seasonal frost; layered; very few fine and micro roots; pH 6.0.
Om3	62+	Black (10YR 2.5/1 m) moderately decomposed sedge fen peat with pockets of sphagnum peat, leaves of *Chamaedaphne*, *Betula glandulosa*, *Picea*, and *Myrica gale* fruits; layered; pH 6.0.

Hydric Mesisols had a hydric layer below a depth of 40 to 60 cm that extended to below 130 or 160 cm. They were associated with graminoid dominated shore fens. A Hydric Mesisol (No. 28) sampled at 60°49.7'N, 116°40.0'W along the southern margin of Heart Lake was described in part:

Horizon	Depth (cm)	Description
Om	0-30+	Very dark grayish brown (10YR 3/2 w) partially decomposed fen peat; layered; water table at surface; few fine; plentiful micro roots; pH 5.[illegible]

Soil-vegetation relationships

The relationships of some edaphic varibles to vegetation were determined by plotting these on the upland and lowland ordination fields.

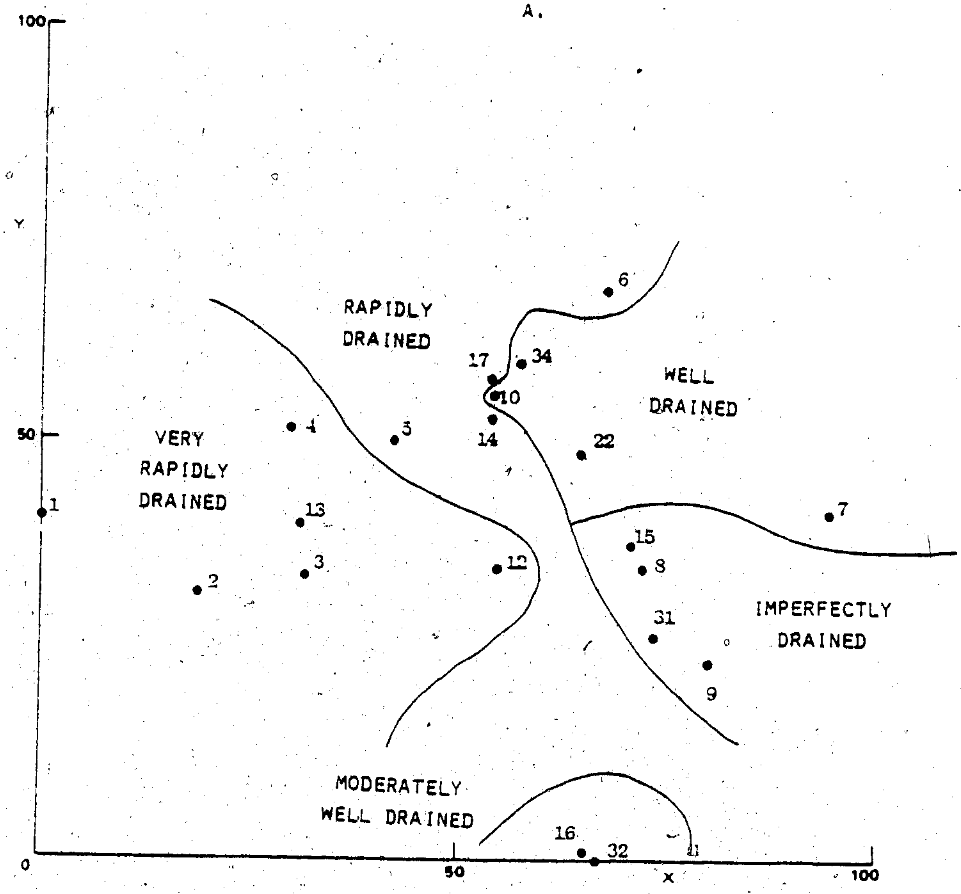
The association between phytocoenoses and soil drainage (Working Group on Soil Survey Data 1975) is shown in Fig. 11. Inspection of phytocoenose position in relation to soil drainage on the upland ordination indicated a xeric-to-mesic gradient from left center to lower right (Fig. 11A) and a mesic to wet gradient on the lowland ordination from middle right to lower left (Fig. 11B). Thus, upland and lowland phytocoena II through IX generally followed a gradient of increasing wetness. Phytocoenon I and X, which were not shown on the ordination, represented moisture extremes for the study

Figure 11. Soil drainage-classes on the upland and lowland ordination fields. Class definitions follow the Working Group on Soil Survey Data (1975). Phytocoenose numbers are represented in boldface print.

A. Upland ordination field. A gradient of increasing wetness was expressed by the classes: very rapidly drained, rapidly drained, well drained, moderately well drained, and imperfectly drained.

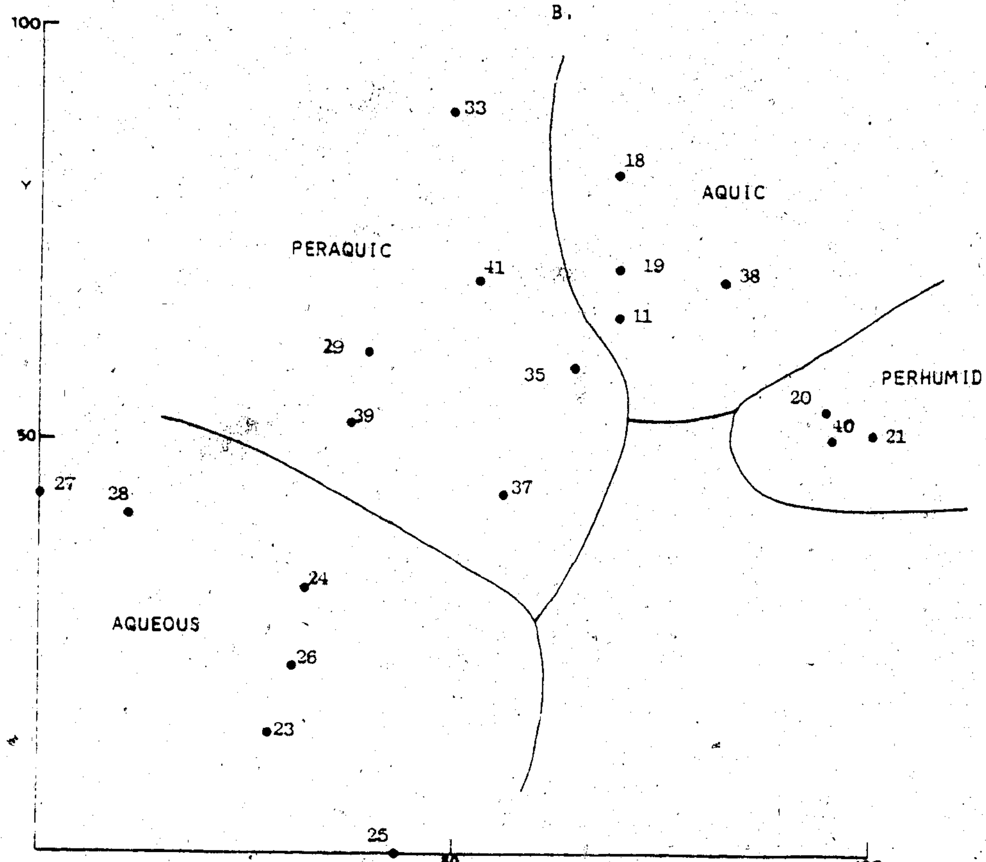
B. Lowland ordination field. A gradient of increasing wetness was expressed by the subclasses: perhumid, aquic, peraquic, and aqueous.

A.



100
Y
50
0
50
X
100
RAPIDLY
DRAINED
VERY
RAPIDLY
DRAINED
WELL
DRAINED
IMPERFECTLY
DRAINED
MODERATELY
WELL DRAINED

B.



100
Y
50
50
X
100
PERAQUIC
AQUIC
PERHUMID
AQUEOUS

area with I the most xeric and X the wettest.

The pattern of upland vegetation and bedrock is shown in Figure 12. Soil depth increases from left to right on the ordination field indicating a close relationship between soil depth and vegetation.

The pattern exhibited by upland and lowland soil subgroups and phases thereof is presented in Figs. 13 and 14. Both show a moderately close correspondence to phytocoena, particularly at the subclass level. From left to right on the upland ordination field, there is a transition from a Lithic phase Regosol through Eutric Brunisols (lithic family) and Orthic Eutric Brunisols to Eluviated Eutric Brunicols. This trend reflects an increase in soil profile development as implied by eluviation and B horizon depth. Also, it parallels an increase in soil depth to bedrock (Fig. 12).

Soils like Orthic Humic Regosols and Rego Static Cryosols did not conform to the above pattern. They developed on steep N-facing colluvium (Nos. 10, 16) and in an escarpment canyon (31) where soil temperatures were presumably colder, impeding profile development.

On the lowland ordination field Humisols and Mesisols predominate in the lower left-hand portion (Fig. 14). As might be expected, the pattern of hydric subgroups is very similar to that of soil drainage classes (Fig. 11). In the ordination center the soil types generally correspond to the three subclasses of

Figure 12. Depth to bedrock in cm on the upland ordination field. Actual values are shown in italics and phytocoenose numbers are shown as boldface print.

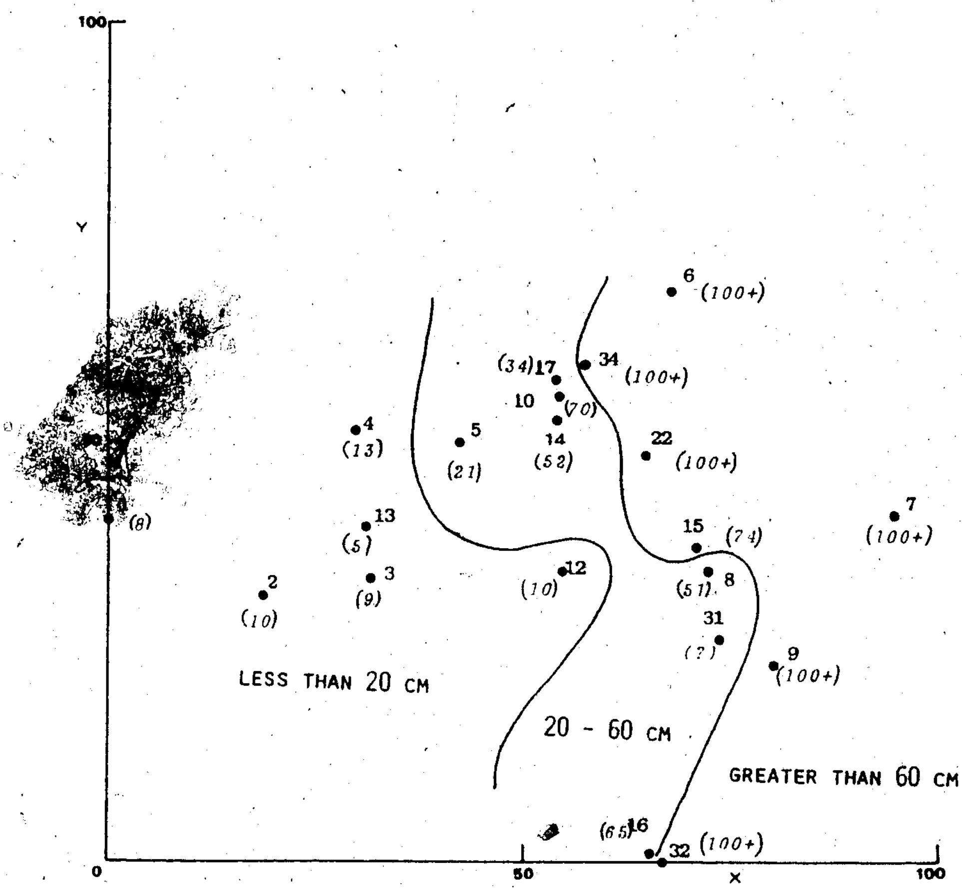


Figure 13. Soil subgroups on the upland ordination field. Phytocoenose numbers are shown in boldface print. Key: RL = Lithic phase Regosol; EBL = Eutric Brunisol (lithic family); OEB = Orthic Eutric Brunisol; EEB = Eluviated Eutric Brunisol; OHR = Orthic Humic Regosol; and RSC = Rego Static Cryosol.

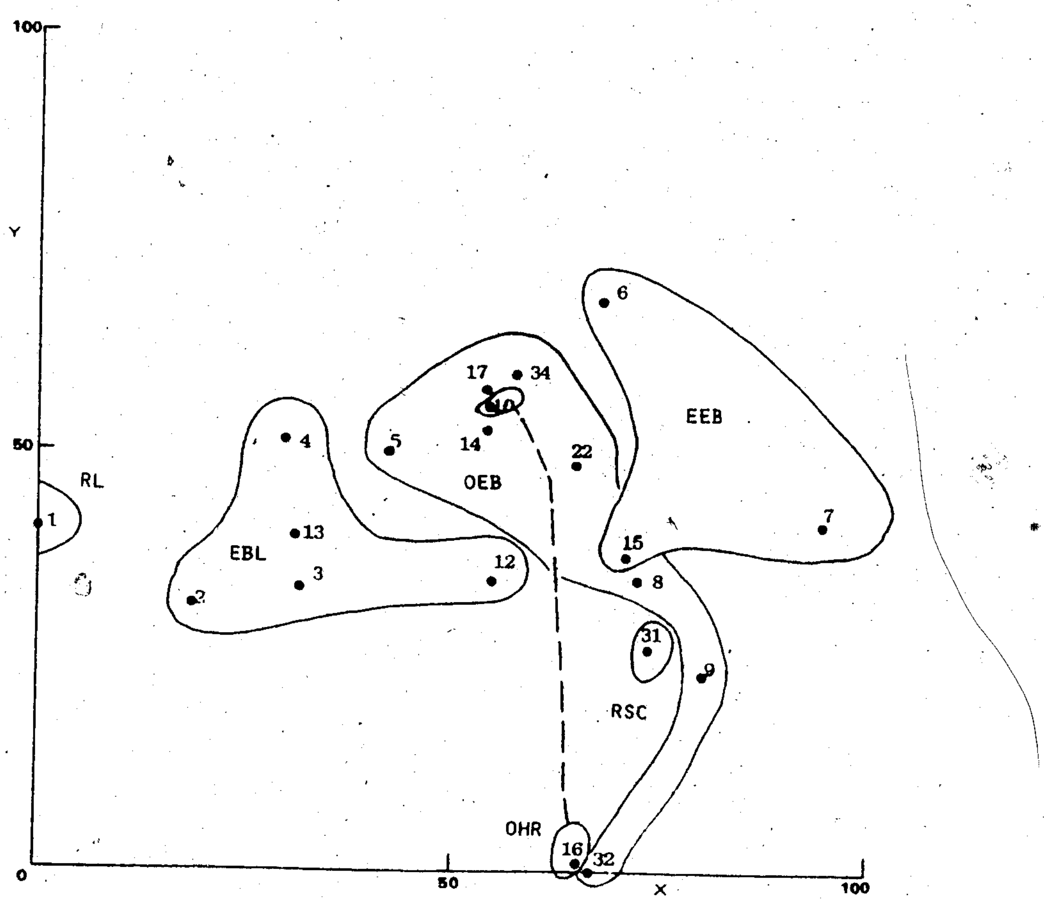
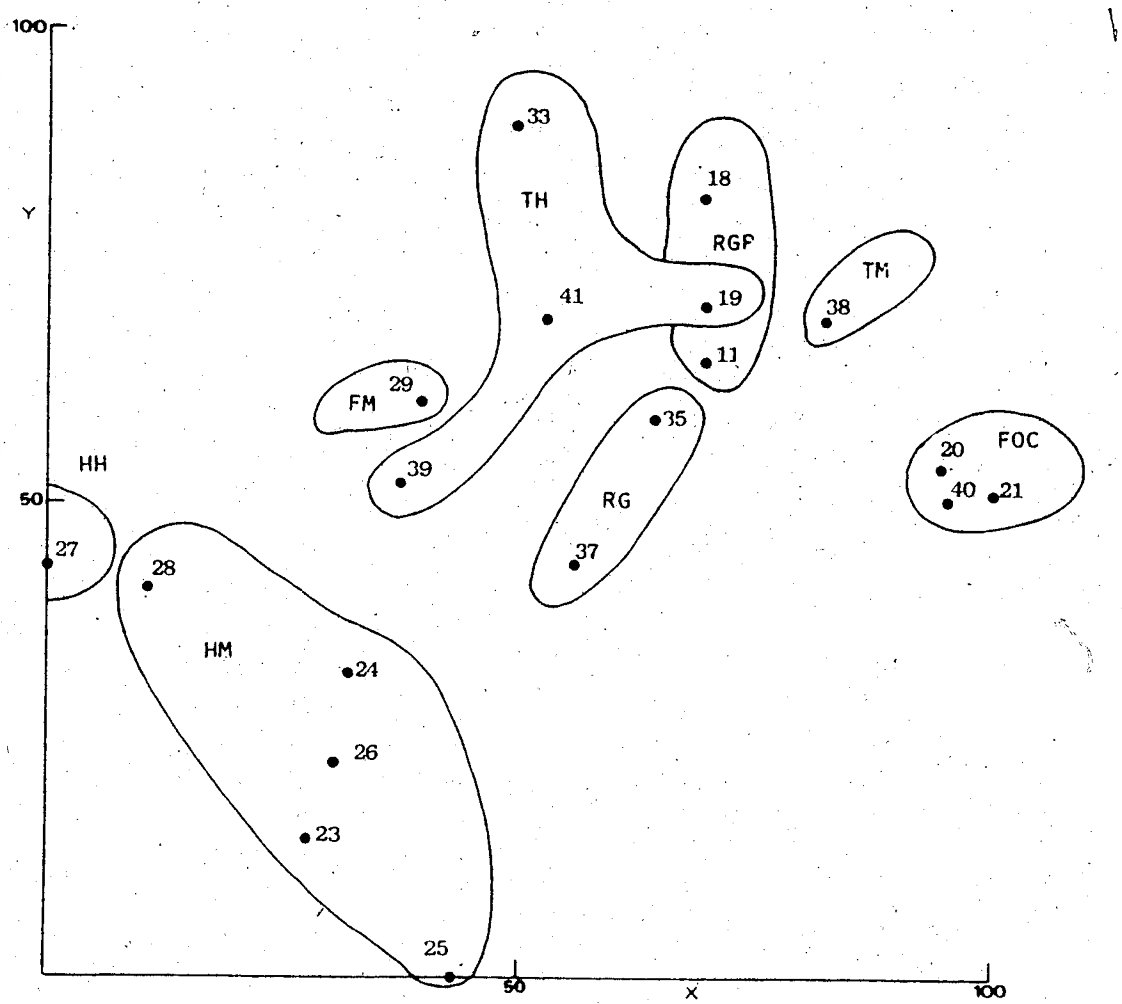


Figure 14. Soil subgroups on the lowland ordination field. Phytocoenose numbers are represented in boldface print. Key: HH = Hydric Humisol; HM = Hydric Mesisol; TH = Terric Humisol; RG = Rego Gleysol; RGP = Rego Gleysol (peaty phase); TM = Typic Mesisol; and FOC = Fibric Organic Cryosol.



phytocoenon VII (Fig. 9). This relationship may be interpreted in terms of decreasing peat depth to the C horizon where VII A occurred on deeper peat, 40-80 cm; VII B was usually found on peat of intermediate depth, 20-40 cm; and VII C on shallow peat, <20 cm. To the right of the ordination field a distinct subgroup of Fibric Organic Cryosols is formed corresponding to phytocoenon VI A, while Typic Mesisols characterize phytocoenon VI B.

Classification of phytocoenoses based on dominant life-forms of component vascular strata

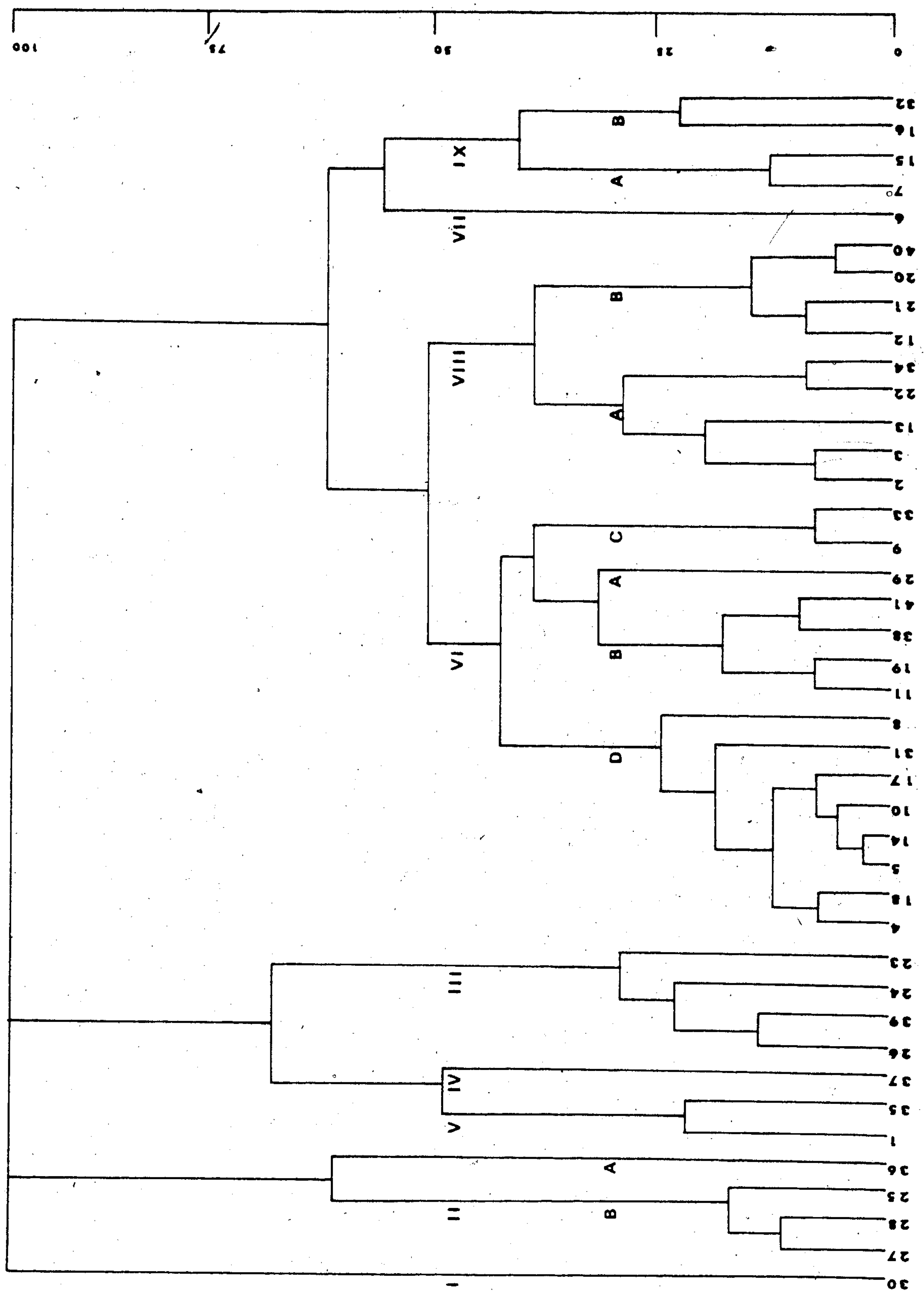
A classification of the 41 Heart Lake phytocoenoses was constructed on the basis of dominance of 32 vascular life-forms (Table 9). Nine major clusters or phytocoena were recognized at the 45% dissimilarity level (Fig. 15) with further subclasses at the 30% level for a total of 15.

An indication of relative prominence of life-form subclasses was determined by extracting life-forms occurring in Table 9 with a presence greater than 50%. These subclasses are presented in Table 10. The dominant life-form subclass (mean cover 9%) was prostrate dwarf shrub angiospermous chamaephyte represented by species such as Arctostaphylos rubra, A. uva-ursi, Linnaea borealis, Oxycoccus microcarpus, and Vaccinium vitis-idaea. Mesophanerophytes (7%) and microphanerophytes (6%) were primarily gymnosperms such as Picea and Pinus, while nanophanerophytes were mainly angiosperms (7%) typified by species like Chamaedaphne calyculata, Potentilla fruticosa, Rosa acicularis, Shepherdia canadensis, and Viburnum edule. Gymnospermous nanophanerophytes were less abundant (4%) and represented by Juniperus communis and immature tree species like Picea glauca. A similar species distribution was found in the erect dwarf shrub chamaephyte subclass, cover <1%. The

Table 10. Average percent cover and presence of life-forms with presence 50% or greater in 41 phytocoenoses. Code numbers followed Emberger and Savage (1968; Appendix II).

Code	Life-form Subclass	Cover (%)	Presence (%)
125	Gymnospermous mesophanerohytes	7.1	56
135	Gymnospermous microphanerophytes	7.3	65
145	Gymnospermous nanophanerophytes	3.5	78
215	Angiospermous nanophanerophytes	7.2	95
216	Erect dwarf shrub gymnospermous chamaephytes	0.9	78
227	Prostrate dwarf shrub angiospermous chamaephytes	6.0	90
316	Protohemicryptophytes with stolons	1.4	93
336	Semi-rosette hemicrypto-phytes with stolons	0.4	83
346	Basal rosette hemicrypto-phytes with stolons	0.5	66
428	Rhizome cryptophytes without rosettes	6.6	68

Figure 15. Classification hierarchy of 41 life-form phytocoenoses based on mean percent cover values and using absolute distance (Orloci 1967). Vertical scale indicates within-group mean squares (Q/k) expressed as percentages of sample mean square (Q/n). Nine major phytocoena (I-IX) are recognized at the 45% threshold. Subclasses are recognized at the 30% threshold (A-D).



100
75
50
25
0
I
II
III
IV
V
VI
VII
VIII
IX
A
B
C
D
32
16
15
7
6
40
20
21
12
34
22
13
3
2
33
9
29
41
38
19
11
8
31
17
10
14
5
18
4
23
24
39
26
37
35
1
36
25
28
27
30

prostrate dwarf shrub chamaephyte subclass was well represented (6%) and typified by the same species listed in the angiospermous nanophanerophyte subclass above. Protohemicryptophytes and hemicryptophytes were present but of low average cover, 1%. Examples included: protohemicryptophytes (Cornus canadensis, Epilobium angustifolium, and Galium boreale); semi-rosette hemicryptophytes (Achillea lanulosa, Elymus innovatus, and Solidago decumbens); and basal rosette hemicryptophytes (Fragaria virginiana and Pyrola spp.). All protohemicryptophytes and hemicryptophytes included in Table 10 are stoloniferous in contrast to the rather equal representation of stoloniferous and non-stoloniferous forms based on qualitative criteria (Appendix II). Although rhizome cryptophytes accounted for 7% cover this value was somewhat misleading, because they attained peak abundance only in wetlands. Examples are Carex aquatilis and C. limosa.

Examination of the classification hierarchy presented in Figure 15 indicated that the nine major phytocoena could be further agglomerated at about the 75% level into four super-clusters. Phytocoena VI-IX, forming one super-cluster, were distinguished from all others by a higher dominance of microphanerophytes, cover >2% averaging 15%, while in phytocoena I-V microphanerophytes were absent or nearly so, <2% cover.

A second super-cluster formed from the fusion of phytocoena III-V was distinguished by a chamaephyte cover 1%, averaging 29%, while in a third (I) and fourth (II) super-cluster chamaephyte cover was approximately 1% or less. The third cluster (I) was distinguished from the fourth (II) by extrememly low diversity, i.e. one life-form.

Descriptions of the nine life-form phytocoena follow. Mean percent cover of life-forms in phytocoena are expressed as averages of their member phytocoenoses (Tables 9 and 11). Examples of some species frequently found in life-form subclasses are included as a guide.

I. Herbaceous chamaephyte (desert) phytocoenon (No. 30).

This structurally simple phytocoenon, composed of one phytocoenose, corresponded to floristic phytocoenon I, bryoid-dominated talus.

II. Rhizome cryptophyte - emergent and submergent herbaceous hydrophyte phytocoenon (Nos. 25, 27, 28, 36).

Typical of very poorly drained sites with surface water present throughout the summer, this phytocoenon was

Table 11. Average percent cover of life-form classes and subclasses in 15 life-form phytocoena.

Life-form Classes / Subclasses	I	II	II A	II B	III	IV	V	VI	VI A	VI B	VI C	VI D	VII	VIII	VIII A	VIII B	IX	IX A	IX B
Mesophanerophytes		.	.	.	.	.	.	16	.	4	31	20	20	3	5	*t	35	27	43
Microphanerophytes	.	.	.	.	t	.	t	12	9	11	7	13	2	15	13	18	28	54	3
Nanophanerophytes	.	2	.	3	6	t	3	13	37	15	6	11	7	15	12	19	14	9	20
Chamaephytes	t	t	.	t	22	7	37	14	2	16	8	15	20	30	42	14	14	8	20
Hemicryptophytes	.	2	t	3	5	74	14	6	7	5	11	5	3	6	7	4	5	3	7
Cryptophytes	.	42	4	54	12	2	4	9	4	8	37	3	t	t	1	t	t	2	t
Hydrophytes	.	8	t	11	t	t	.	.	.	.	.	.	.	.	.	.	.	.	.
Therophytes	.	t	t	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

*t = trace (<1%)

dominated by cryptophytes represented by _Carex aquatilis_, _C. lasiocarpa_, and _C. limosa_.

IIA. Nanophanerophytes absent (No. 36).

This phytocoenose corresponded to floristic phytocoenon X, a marl fen. Total mean vascular cover was very low.

IIB. Nanophanerophytes present (Nos. 25, 27, 28).

This phytocoenon was found as shore fens where the water level fluctuated seasonally. Although rhizome cryptophytes, _Carex aquatilis_, and _C. lasiocarpa_, were the absolute dominants in this phytocoenon, nanophanerophytes, _Betula glandulosa_, _Myrica gale_, and _Salix candida_, are characteristic with some emergent hydrophytes, _Carex rostrata_, _Hippuris vulgaris_, and _Potentilla palustris_.

III. Woody chamaephyte - rhizome cryptophyte phytocoenon (Nos. 23, 24, 26,39).

This phytocoenon occurred in very poorly drained sites including the amire flarks south of Heart Lake. Water levels were high, but lower than those in phytocoenon II. Chamaephytes, _Andromeda polifolia_, _Myrica_ gale, and Salix candida, were the dominant life-form with cryptophytes, Carex aquatilis and C. limosa, subdominant.

IV. Caespitose hemicryptophyte - woody chamaephyte phytocoenon (No. 37).

Dominated entirely by caespitose hemicryptophytes, Scirpus caespitosus, this phytocoenon was found in poorly drained fens.

V. Prostrate woody chamaephyte - caespitose hemicryptophyte phytocoenon (Nos. 1, 35).

This phytocoenon was found in open sites on both shallow, well drained, upland soils and on poorly drained islands in marl fens below the escarpment.

Prostrate gymnospermous chamaephytes, Juniperus horizontalis, made up the majority of the chamaephyte class and angiospermous chamaephytes, Andromeda polifolia and Arctostaphylos uva-ursi, comprised a smaller but significant element.

VI. Gymnospermous microphanerophyte - rhizome cryptophyte phytocoenon (Nos. 3, 5, 8, 9, 10, 11, 14, 17, 18, 19, 29, 31, 33, 38, 41).

The four subclasses of this phytocoenon consistently contained gymnospermous microphanerophytes and rhizome cryptophytes. They occurred in a variety of habitats and followed a moisture gradient from poorly drained, VIA, to well drained, VID. The average abundance of mesophanerophytes increased over the gradient to where they dominated in VIC and VID. No single life-form was predominant in this phytocoenon and there was high equitability. Vascular cryptogamic cryptophytes, Equisetum spp., were usually present in VIA - VIC but almost absent in VID.

VI A. Mesophanerophytes absent (No. 29).

This phytocoenon corresponded with floristic phytocoenon IX A, a deciduous alluvial thicket, and was rich in deciduous nanophanerophytes and microphanerophytes but low in woody chamaephytes.

VI B. Mesophanerophytes sparse (Nos. 11, 19, 38, 41).

Covering large expanses of lowlands, this phytocoenon was typical of poor and rich wooded fens. Structurally, it was a relatively complex multi-layered phytocoenon wherein no single woody stratum dominated others. Microphanerophytes were Picea and Larix, while nanophanerophytes were dominated by Betula glandulosa, *Ledum groenlandicum*, *Potentilla fruticosa*, and *Rosa acicularis* with some immature spruce and larch. Chamaephytes were rich in prostrate forms, *Arctostaphylos rubra*, *Salix myrtillifolia*, and *Vaccinium vitis-idaea*.

VI C. Gymnospermous mesophanerophytes and vascular cryptogams dominant (Nos. 9, 33).

This phytocoenon occurred on moderately well to poorly drained sites with seepage. Like phytocoenon VIB, it was structurally diverse, but in contrast it was dominated by mesophanerophytes, *Picea glauca*, and cryptophytes, particularly cryptogamic forms with rhizomes, *Equisetum pratense*. There was a relatively even distribution of other life-form classes.

VI D. Gymnospermous mesophanerophytes and woody chamaephytes dominant (Nos. 4, 5, 8, 10, 14, 17, 18, 31).

Generally representative of upland sites, this phytocoenon chiefly occurred on moderately to well drained soils. Dominant life-forms were gymnospermous mesophanerophytes and microphanerophytes, *Pinus banksiana* and *Picea glauca*; nanophanerophytes represented by both gymnosperms, *Juniperus communis*, and angiosperms, *Rosa acicularis*, *Shepherdia canadensis* and *Viburnum edule*; and chamaephytes, Arctostaphylos uva-ursi, Linnaea borealis, and Vaccinium vitis-idaea. In contrast, hemicryptophytes, Aster spp., Elymus innovatus, and Galium boreale, and cryptophytes, Carex richardsonii, and Oryzopsis pungens, were considerably less abundant. Bulbous cryptophytes, Calypso bulbosa, and Zygadenus elegans, were constantly associated.

VII. Gymnospermous mesophanerophyte - prostrate woody chamaephyte phytocoenon (No. 6).

Occurring on a well-drained beach ridge, this phytocoenon corresponded to floristic phytocoenon III C and was characterized by an abundance of gymnospermous mesophanerophytes, Pinus banksiana, and prostrate woody chamaephytes, Arctostaphylos uva-ursi.

VIII. Gymnospermous microphanerophyte - woody chamaephyte phytocoenon (Nos. 2, 3, 12, 13, 20, 21, 22, 34, 40).

This phytocoenon was related to life-form phytocoenon VI with a similar distribution of abundances in gymnospermous microphanerophytes, nanophanerophytes, and hemicryptophytes, but was differentiated from the former by a lower mesophanerophyte and cryptophyte cover, more abundant chamaephyte cover, and less complex structure.

VIIIA. Angiospermous microphanerophytes present (Nos. 2, 3, 13, 22, 34).

This phytocoenon occurred on well drained soils and included very open xeric woodlands which could have a sparse mesophanerophyte cover, Pinus banksiana. The cover of prostrate woody angiospermous chamaephytes, Arctostaphylos uva-ursi and Vaccinium vitis-idaea, attained its highest value in this type.

VIIIB. Angiospermous microphanerophytes absent (Nos. 12, 20, 21, 40).

This phytocoenon usually occurred in raised bogs. The exception was phytocoenose 12 which was in an upland and still regenerating from the effects of a fire which occurred 30 years ago; it therefore did not truly reflect climatological or ecological conditions.

Gymnospermous, Picea mariana, microphanerophytes and nanophanerophytes were predominant. Cryptophytes were almost absent, and there were no bulbous cryptophytes.

There was a very strong evergreen element in microphanerophytes, nanophanerophytes, and woody chamaephytes, Andromeda, Chamaedaphne, Ledum, Oxycoccus microcarpus, and Vaccinium vitis-idaea.

IX. Angiospermous mesophanerophyte phytocoenon (Nos. 7, 15, 16, 32).

Occurring on moderately well to well drained sites, this phytocoenon was dominated by deciduous angiospermous mesophanerophytes. A significant representation by gymnospermous mesophanerophytes, however, did occur in phytocoenon IX A.

IXA. Gymnospermous mesophanerophytes subdominant (Nos. 7, 15).

This phytocoenon corresponded to floristic phytocoenon V A. Dominated primarily by deciduous angiospermous mesophanerophytes, Populus tremuloides, with an admixture of gymnospermous mesophanerophytes, Picea glauca and Pinus banksiana, the phytocoenon was also characterized by a distinct layer of angiospermous microphanerophytes, Alnus crispa, 48%.

IX B. Gymnospermous mesophanerophytes sparse (<2%); angiosperms dominant in all strata (Nos. 16, 32).

This phytocoenon was the same as floristic phytocoenon IV, deciduous forest, and was dominated by angiosperms in all strata.

Phytocoenose age

All forest phytocoenoses showed evidence of wildfires as charcoal was present in their soils. In order to better understand the relationship between stand age and vegetation pattern, a one-way analysis of variance was conducted using the five oldest trees in each of 25 phytocoenoses possessing mature trees to test the null hypothesis that there was no significant difference between phytocoenose mean ages:

$$F_{calc} = MS_{between}/MS_{within} = 14,927/794 = 19.04$$
$$F_{tabulated} = 1.80^{**} \text{ (24df, } P<0.01)$$

It was concluded that there was a significant difference in observation means. These were examined to determine which ones differed. After applying Duncan's new multiple range test (Duncan 1965, Harter 1960), the means were grouped into four significantly different subsets (Table 12).

Subset 1, composed of the 15 youngest phytocoenoses, had an average age of 82 years (range 62 to 95), and consisted almost entirely of upland stands.

Table 12. Subsets of Heart Lake phytocoenoses based on mean age of five oldest measured trees, using Duncan's (1965) new multiple range test. Phytocoenoses not underscored by the same line are significantly different in age.

Phytocoenose	13	38	7	22	15	16	4	20	32	14	34	5	6	17	8
Phytocoenose	II	VI	V	III	V	IV	II	VI	IV	III	III	III	III	III	V
Phytocoenose age	62	72	77	78	79	80	81	82	82	83	85	87	90	93	95
Subset number									1						

Phytocoenose	40	10	41	18	11	33	19	21	9	31
Phytocoenon	VI	III	VII	VII	VII	VII	VII	VI	V	V
Phytocoenose age	113	139	143	144	148	158	200	203	226	264
Subset number			2					3		4

Exceptions were phytocoenose 38, an aapamire strang, and phytocoenose 20, a relatively small raised bog surrounded by beach ridges.

Subsets 2 and 3 were composed almost entirely of wetland phytocoenoses. Four of the five members of subset 2 were wooded fens (11, 18, 33, and 41) but one occurred on a north-facing escarpment slope (10); their average age was 140 years (range 139 to 158). Subset 3 had an average of 210 years (range 200 to 226) and was composed of three members: alluvial white spruce (phytocoenose 9), wooded fen (19), and raised bog (21).

Subset 4, a single-member group, contained the oldest phytocoenose (31) which occurred in a deep escarpment canyon; its mean age was 264 years.

Phytocoenose 40, a lichen muskeg with a mean age of 113 years, potentially fell within either subset 1 or 2. This phytocoenose was placed in subset 2.

Thus, the Heart Lake study area consisted of at least four subsets of phytocoenoses of distinctly different age. The oldest trees in the two younger and larger subsets almost certainly became established soon after wildfires. The old white spruce trees in the escarpment canyon, however, could be close to their maximum lifespan; indeed it was likely that this protected site had not experienced fire for a much longer interval. Most of the relatively dry upland vegetation burned within the last 100 years. In contrast, fire occurrence in the wetter lowland vegetation was less frequent and approached or exceeded 200 years, suggesting a lower fire frequency where moister conditions retard burning.

Dynamics of Tree Populations

Analyses of tree diameter-classes demonstrated replacement of overstory species. Two major regeneration patterns were found to occur when the Heart Lake uplands were compared to the lowlands. In general, Picea glauca displayed clear replacement potential on upland habitats, except on some pine- and aspen-dominated sites, while Picea mariana was the most successfully reproducing lowland tree species (Table 13). At the extremes of the moisture gradient - very dry (phytocoenon I, II A) or very wet (VIII, IX, X) - tree reproduction was limited or absent (Appendix VII).

For the majority of dry upland sites, Picea glauca regeneration was either very sparse or missing in shallow, rapidly drained, steppe scrub (phytocoenon II B) and pine woodland (III A and C). Where white spruce regeneration was absent (phytocoenoses 6, 13 and 14), there was little evidence as to potential climax (Appendix VII). On mesic uplands and sites where white spruce predominated in the overstory, white spruce reproductive success increased (III D, V B, and V C).

Table 13. Population density of tree species as live stems per diameter class in the Heart Lake study area. Figures represent numbers of individuals in 18 upland and 10 lowland stands.[a]

Species	Uplands: Diameter (at breast height) classes in cm[b] 2.5-5	5-7.6	7.6-10	10-12.7	12.7-15.2	15.2-17.8	17.8-20.3	20.3-22.9	22.9-25.4	25.4	Max. diam. (cm)
Picea glauca	421	382	163	114	54	58	35	23	19	41	41
Pinus banksiana	13	175	396	258	197	111	36	12	20	4	28
Populus tremuloides	92	91	145	127	88	46	25	27	16	13	33
Picea mariana	30	52	30	17	13	1	.	.	.	.	
Populus balsamifera	5	.	2	4	6	18	20	20	1	6	33
Betula papyifera	13	7	11	3	3	3	2	1	.	.	

Species	Lowlands: Diameter (at breast height) classes in cm[b] 2.5-5	5-7.6	7.6-10	10-12.7	12.7-15.2	15.2-17.8	17.8-20.3	20.3-22.9	22.9-25.4	25.4	Max. diam. (cm)
Picea mariana	712	435	217	59	15	6	.	.	.	.	
Picea glauca	58	63	66	57	33	27	5	9	6	12	30
Larix laricina	41	28	16	5	6	2	.	1	1	.	
Pinus banksiana	1	10	6	7	2	1	.	.	.	.	

[a]Upland stands (2-10, 113-17, 22, 31-32, 34); Lowland stands (11, 18-21, 33, 38-41)

[b]Trees were measured by one-inch diameter class increments (exactly).

Aspen saplings and trees in phytocoenon III A typically developed sunscald scars on their south-facing trunks which ultimately resulted in trunk decay and windthrow. This appeared to result in a cyclical regeneration as young aspen suckers were initiated, grew to sapling size, and succumbed to sunscald.

Mortality of white spruce on both the dry and moist upland sites was relatively low. In contrast, pine displayed high mortality especially from thinning in the small size classes.

Aspen-dominated forests (IV and V A) showed little white spruce regeneration despite phytocoenose ages of about 80 years. Aspen mortality, like that of pine, was concentrated in the small diameter classes but white spruce mortality was not recorded.

Picea mariana rarely occurred in the uplands but some small trees were found on north-facing slopes (Phytocoenoses 7 and 10) and an escarpment canyon (31). *Picea mariana* reproduction was also found in an alluvial white spruce site (9). All these sites were contiguous to lowland communities where black spruce predominated.

Regeneration of *Betula papyrifera* and *Populus balsamifera* was scattered and seldom abundant in either the uplands or lowlands. Their successional role was minor throughout the study area.

In the lowlands, the abundance of *Picea mariana* in nearly every size class indicated its potential for sustained dominance. Once established, climax status was maintained because of the ability of black spruce to layer. Raised-bog black spruce populations (VI A) exhibited classic J-shaped curves, with no reproduction by other trees. In contrast, tree reproduction in wooded fens (VII) included both black and white spruce, but black spruce reproduction was usually more vigorous than white. Larix laricina was often a scattered component of wooded fens but seldom reproduced successfully in established stands. Information from one phytocoenose (No. 38) suggested that poor fens (VI B) were dominated by black spruce regeneration, limited larch regeneration, and an absence of white spruce.

Both black and white spruce mortality was higher in the lowlands than in the uplands, but a higher density of living spruces occurred in each diameter class in the lowlands than in the corresponding class in the uplands. Since lowland phytocoena were usually much older than upland types, higher mortality in the lowlands could reflect greater phytocoenon age. Larch mortality was relatively high except for phytocoenose 41 where, however, larch was not reproducing successfully. Pine invasion occurred occasionally in both raised-bog communities and wooded fens (phytocoenoses 20 and 11, respectively), but pine did not exhibit replacement potential.

Vegetation map

A direct comparison of the life-form and floristic classifications based on the Orloci (1975) test for independence indicated correspondence at the class level: $2\,I = 99.7$, $X^2 = 96.6$ ($p = 0.1$, $df = 80$) which was relatively close, $r = 0.82$ (Table 14). This demonstrated that the quantitative distribution of life-form classes at Heart Lake was not haphazzard but largely consistent with floristically defined phytocoena. This close relationship permitted and facilitated the synthesis of life-form and floristic classifications. Since the structural approach does not demand an extensive knowledge of the flora, it may be employed as an efficient means of vegetation description and classification by relatively untrained field staff. Users unfamiliar with the flora can quickly learn the classification. Therefore, structure became the primary vegetation descriptor for the final vegetation map, supplemented by the names of dominant species.

Fusion of classifications was accomplished based on the woody components of the understory since woody life-forms play a vital structural role in the vegetation of the Heart Lake study area (Table 10 and 11). Exceptions occurred in the lowlands in very wet sites where the absence of woody forms was diagnostic. Other reasons for focusing on woody life-forms were that they

Table 14. A comparison of the life-form and floristic classifications. Entries in body of table are phytocoenose numbers which correspond to Tables 9 and 11.

FLORISTIC PHYTOCOENA

LIFE-FORM PHYTOCOENA	I	II		III				IV	V			VI		VII			IX		X
		A	B	A	B	C	D		A	B	C	A	B	A	B	C	A	B	
I	30																		
VIII A			2 3 13			22 34													
VIII B					12							20 21 40							
VII						6													
IX B								16 32											
IX A									7 15										
VI D			4	5 14 17			10			8	31			18					
VI C										9					33				
VI B													38	11 19	41				
VI A																	29		
V		1															35		
IV																37			
III															39		23 24 26		
II B																		27 28	
II A																			36

had high discriminatory value and were readily determinable at any season of the year.

The vegetation map documents the spatial dimensions and recurrent patterns of the vegetation throughout the Heart Lake study area as 9 formation classes containing 17 formations and 40 phytocoena (Fig. 10, in pocket). A key to map phytocoena is presented in Table 15.

The areas occupied by formation classes are given in Table 16. The most abundant classes in order of decreasing areal extent were woodland, forest, and dwarf scrub. Woodland generally occurred on either well-drained shallow soils or poorly drained soils, while forest occupied deeper, mesic soils (cf. Figs. 2, 3, and 4). Dwarf scrub classes were primarily composed of raised ombrotrophic plateau bogs (Map unit 36) and reticulate patterned fens (37). Both these dwarf scrub types predominated on poorly drained sites encompassing the southwestern portion of the Heart Lake basin (Figs. 2, 4, and 6).

The accuracy of acreage summaries from the vegetation map was determined using a dot grid with 25 dots per 6.5 cm^2 (or 1 $in.^2$ exactly). The error of area estimates (Bonner 1975) was less than 5% for map types that cover more than 1-2% of the mapped area. For areas of 0.5% and 0.15%, the error was calculated to be 12% and 24%, respectively.

Table 15. Key to the vegetation map units of the Heart Lake study area.

I. FOREST. Trees at least 5 m tall with their crowns interlocking or nearly so.

A. Mainly evergreen forest. Majority of canopy is never without foliage.

1. Resinous evergreen narrow sclerophyll forest.

a. Picea glauca dominant

(1) Picea glauca - (Picea mariana) moss forest with deciduous dwarf shrubs (Arctostaphylos rubra, Salix myrtillifolia).

Map unit ... 1

(2) Picea glauca - Pinus banksiana - (Populus tremuloides) moss forest with tall deciduous shrubs (Alnus crispa, Populus tremuloides, P. balsamifera, Betula papyrifera, Cornus stolonifera).

Map unit ... 2

(3) Picea glauca - Pinus banksiana moss - lichen forest with low deciduous shrubs (Rosa acicularis, Shepherdia canadensis) distinct to nearly absent.

Map unit ... 3

b. Pinus banksiana dominant

(1) Pinus banksiana - Picea glauca - (Populus tremuloides) moss - lichen forest with tall deciduous shrubs (Alnus crispa)

Map unit ... 4

(2) Pinus banksiana - Picea glauca - (Populus tremuloides) moss-lichen forest with low deciduous shrubs (Rosa acicularis, Shepherdia canadensis)

Map unit ... 5

(3) Pinus banksiana - Picea glauca - (Populus tremuloides) lichen - moss forest with low evergreen shrubs (Juniperus communis).

Map unit ... 6

Table 15 (Continued).

c. *Picea mariana* dominant

(1) *Picea mariana* moss-lichen forest with low deciduous shrubs (*Rosa acicularis*).
Map unit ... 7

2. Resinous evergreen narrow sclerophyll swamp forest

a. *Picea glauca* dominant

(1) *Picea glauca* - *Larix laricina* moss swamp forest.
Map unit ... 8

b. *Picea mariana* dominant

(1) *Picea mariana* - (*Larix laricina*) moss swamp forest with deciduous dwarf shrubs (*Arctostaphylos rubra*, *Salix myrtillifolia*).
Map unit ... 9

(2) *Picea mariana* moss swamp forest with low evergreen shrubs (*Ledum groenlandicum*).
Map unit ... 10

(3) *Picea mariana* moss swamp forest with tall deciduous shrubs (*Betula glandulosa*).
Map unit ... 11

B. Mainly deciduous forest. Majority of canopy trees shed their foliage.

1. Winter deciduous orthophyll forest with evergreen trees admixed.

a. *Populus tremuloides* dominant

(1) *Populus tremuloides* - (*P. balsamifera*, *Betula papyrifera*) - *Picea glauca* - (*Pinus banksiana*) forest with low deciduous shrubs (*Rosa acicularis*, *Shepherdia canadensis*, *Viburnum edule*, *Cornus stolonifera*).
Map unit ... 12

Table 15 (Continued).

(2) *Populus tremuloides* - (*Picea glauca*, *Pinus banksiana*) forest with tall deciduous shrubs (*Alnus crispa*).
Map unit ... 13

II. WOODLAND. Open stands of trees with their crowns mostly not touching but covering at least 10% of the surface.

A. Mainly evergreen woodland, i.e. as defined in IA.

1. Resinous evergreen narrow sclerophyll woodland

a. *Picea glauca* dominant

(1) *Picea glauca* - *Pinus banksiana* (*Populus tremuloides*) moss-lichen woodland with low deciduous shrubs (*Rosa acicularis*, *Shepherdia canadensis*, *Potentilla fruticosa*).
Map unit ... 14

(2) *Picea glauca* - *Pinus banksiana* - (*Populus tremuloides*) lichen-moss woodland with low evergreen shrubs (*Juniperus communis*).
Map unit ... 15

b. *Pinus banksiana* dominant

(1) *Pinus banksiana* - (*Populus tremuloides* - *Picea glauca*) woodland with tall deciduous shrubs (*Alnus crispa*).
Map unit ... 16

(2) *Pinus banksiana* - (*Populus tremuloides*) moss-lichen woodland with low deciduous shrubs (*Rosa acicularis*, *Shepherdia canadensis*, *Potentilla fruticosa*, *Populus balsamifera*).
Map unit ... 17

(3) *Pinus banksiana* - *Picea glauca* - (*Populus tremuloides*) (*Betula papyrifera*) lichen-moss woodland with low evergreen shrubs (*Juniperus communis*). Map unit ... 18

Table 15 (Continued).

2. Resinous evergreen narrow sclerophyll swamp woodland

a. Picea mariana dominant

(1) Picea mariana - (Larix laricina) - (Betula glandulosa) (Sphagnum) moss swamp woodland with low evergreen shrubs (Ledum groenlandicum).
Map unit ... 19

(2) Picea mariana - (Larix laricina) - (Ledum groenlandicum) moss swamp woodland with deciduous dwarf shrubs (Arctostaphylos rubra, Salix myrtillifolia).
Map unit ... 20

b. Picea glauca dominant

(1) Picea glauca - (Larix laricina) moss swamp woodland with deciduous dwarf shrubs (Arctostahylos rubra, Salix myrtillifolia).
Map unit ... 21

B. Mainly deciduous woodland, i.e. as defined in IB.

1. Winter deciduous orthophyllous woodland

a. Populus tremuloides dominant

(1) Populus tremuloides - Pinus banksiana woodland with tall deciduous shrubs (Alnus crispa).
Map unit ... 22

(2) Populus tremuloides - Pinus banksiana lichen woodland with low deciduous shrubs (Rosa acicularis, Amelanchier alnifolia, Shepherdia canadensis).
Map unit ... 23

(3) Populus tremuloides - Pinus banksiana (Picea glauca) lichen woodland with low evergreen shrubs (Juniperus communis).
Map unit ... 24

2. Needleleaf winter deciduous swamp woodland

Table 15 (Continued).

a. *Larix laricina* dominant

(1) *Larix laricina* - *Picea mariana* moss swamp woodland with tall deciduous shrubs (*Betula glandulosa*).
Map unit ... 25

III. SAVANNA. Scattered trees covering not more than 10%.

A. Mainly evergreen savanna, i.e. as defined in IA.

1. Resinous evergreen narrow sclerophyll savanna.

a. *Pinus banksiana* dominant

(1) *Pinus banksiana* - *Picea glauca* lichen savanna with low evergreen shrubs (*Juniperus communis*). Map unit ... 26

b. *Picea glauca* dominant

(1) *Picea glauca* - *Pinus banksiana* - (*Populus tremuloides*) lichen savanna with low evergreen shrubs (*Juniperus communis*).
Map unit ... 27

B. Mainly deciduous savanna, i.e. as defined in IB.

1. Winter Deciduous orthophyll savanna with evergreen trees admixed

a. *Populus tremuloides* dominant

(1) *Populus tremuloides* - *Pinus banksiana* - (*Picea glauca*) lichen savanna with low evergreen shrubs (*Juniperus communis*).
Map unit ... 28

2. Needleleaf winter deciduous swamp savanna

a. *Larix laricina* dominant

(1) *Larix laricina* - (*Picea mariana*) moss swamp savanna with tall (*Betula glandulosa*) and low (*Myrica gale*) deciduous shrubs.
Map unit ... 29

Table 15 (Continued).

IV. SCRUB. Closed (thicket) or open (shrubland) woody vegetation 0.3 - 5 m tall.

A. Mainly evergreen scrub, i.e. as defined in IA.

1. Resinous evergreen narrow sclerophyll scrub

a. *Pinus banksiana* dominant

(1) *Pinus banksiana* - (*Populus tremuloides*) thicket (fire regeneration).
Map unit ... 30

B. Mainly deciduous scrub, i.e. as defined in IA.

1. Deciduous orthophyll scrub

a. *Salix planifolia* alluvial thicket.
Map unit ... 31

2. Deciduous orthophyll swamp scrub

a. *Betula glandulosa* - *Myrica gale* moss swamp scrub.
Map unit ... 32

V. GRAMINOID. Primarily closed sedge or grass vegetation less than 1 m tall.

A. Seasonal low graminoid marsh.

1. *Carex aquatilis* - *Carex rostrata* shore fen.
Map unit ... 33

2. *Scirpus caespitosus* fen (marl).
Map unit ... 34

VI. DWARF SCRUB AND RELATED PHYTOCOENA. Rarely exceeding 0.3 m in height.

A. Mainly evergreen dwarf scrub. Most dwarf shrubs evergreen.

1. Evergreen creeping dwarf scrub

a. *Arctostaphylos uva-ursi* - *Juniperus horizontalis* dwarf scrub.
Map unit ... 35

B. Moss bog formations with dwarf scrub.

Table 15 (Continued).

1. Raised bog. Raised above the general ground-water table by growth of Sphagnum species and having a ground-water table of its own.

   a. Raised ombrotrophic plateau bog (mosaic complex of open bogs and Picea mariana savanna of low productivity).
   Map unit ... 36

2. Non-raised bog. Not very distinctly raised above the mineral-water table. Generally wetter than VI.B.1a.

   a. String fen (Finnish "aapa" bog). The main part of the fen is similar to V.A.1 and rich in sedges. The so-called strings are narrow elongated hummocks rich in Sphagnum and dwarf shrubs.

   (1) Reticulate patterned fen (aapamire). Strings net-like. Map unit ... 37

   b. Evergreen shrub bog

   (1) Low evergreen (Ledum groenlandicum) bog.
   Map unit ... 38

VII. STEPPE SCRUB. Shrub layer and lower layers open, lower layers sparse. May often merge with "Shrub Savanna" (Fosberg 1967).

A. Mainly evergreen steppe scrub.

1. Evergreen narrow sclerophyll steppe scrub.

   a. Pinus banksiana - Populus tremuloides lichen steppe scrub with low evergreen shrubs (Juniperus communis).
   Map unit ... 39

B. Mainly deciduous steppe scrub.

1. Deciduous orthophyll steppe scrub.

   a. Populus tremuloides - Pinus banksiana lichen steppe scrub with low evergreen shrubs (Juniperus communis).
   Map unit ... 40

Table 16. Relative abundance of formation classes within the Heart Lake study area.

Formation Class	Surface Area Hectares	Percentage
Forest	436.3	19.8
Woodland	778.7	35.2
Savanna	88.8	4.0
Scrub	101.5	4.6
Graminoid	10.4	0.5
Dwarf scrub and related phytocoena	382.3	17.3
Steppe scrub	77.4	3.5
Other		
Water	313.5	14.2
Roads/gravel	20.4	0.9
Total	2209.3	100.0

Coniferous trees, particularly evergreen species, predominated within the study area (Fig. 6). Picea glauca and Pinus banksiana were most important in the uplands and Picea mariana and Larix laricina in the lowlands. Of the broadleaf deciduous species Populus tremuloides was often an important subdominant in the uplands, whereas Populus balsamifera and Betula papyrifera seldom made a significant contribution to the upland overstory. On sites transitional between uplands and lowlands Picea mariana - Pinus banksiana and Picea glauca - Picea mariana combinations were concentrated.

After arranging the actual vegetation map units into an an overstory-dominated hierarchical system (Table 15) similar to those of Fosberg (1967) and Ellenberg and Mueller-Dombois (1967a), it was possible to arrange the majority of phytocoena into upland and lowland structural series based on their woody understory components (Table 17 and 18). This latter approach was a useful means of grouping phytocoena into ecologically expressive structural types. A description of the vegetational characteristics of the upland and lowland structural series follows. Percent cover values were from the data gathered in the 571 phytocoenoses.

Table 17. Distribution of mapped upland phytocoena in four formation-classes in relation to overstory species and woody understory series. Numbers in body of table are those of actual vegetation map units of the Heart Lake study area (Fig. 10).

Overstory	*Picea glauca*	*Picea glauca* *Pinus banksiana* *Populus tremuloides*	*Picea glauca* *Pinus banksiana* *Populus tremuloides*	*Pinus banksiana* *Populus tremuloides* *Picea glauca*
Woody Understory Series / Formation Classes	Deciduous dwarf shrub *Salix myrtillifolia** *Arctostaphylos rubra*	Tall deciduous shrub *Alnus crispa*	Low deciduous shrub *Rosa acicularis* *Shepherdia canadensis* *Viburnum edule*	Low evergreen shrub *Juniperis communis*
Forest	1	2 4 13	3 5 12	6
Woodland		16 22	14 23	15 18 24
Savanna				26 27 28
Steppe scrub				39 40

* Dominant shrub species are listed beneath series name.

Table 18. Distribution of mapped lowland phytocoena in four formation-classes in relation to overstory species and woody understory series. Numbers in body of table correspond to those of actual vegetation map units of the Heart Lake study area (Fig. 10).

Overstory	*Picea mariana* *Larix laricina*	*Picea mariana* *Larix laricina*	*Picea mariana* *Larix laricina* *Picea glauca*	*Picea glauca* *Larix laricina*
Woody Understory Series	Tall deciduous shrub	Low evergreen shrub	Deciduous dwarf shrub	Moss carpet
Formation Classes	*Betula glandulosa*	*Ledum groenlandicum*	*Salix myrtillifolia* *Arctostaphylos rubra*	
Forest	11	10	9	8
Woodland	25	19	20, 21	
Savanna	29			
Scrub	32			

*Dominant shrub species are listed beneath series name.

Upland Tall Deciduous Shrub Series

The first upland series (Table 17) was dominated by *Alnus crispa* - whose average understory cover percent in forests (Nos. 2, 4, 13) and woodlands (16, 22) was 32% and 49%, respectively. Evergreen overstory trees were *Picea glauca* and *Pinus banksiana*, while *Populus tremuloides* was the main deciduous species. Low deciduous shrubs had lower cover in this series and consisted primarily of *Rosa acicularis*, while the reptant evergreen dwarf shrubs *Vaccinium vitis-idaea*, *Linnaea borealis* and *Arctostaphylos uva-ursi* formed an important understory cover component averaging 21% in forests and 26% in woodlands. Graminoids like *Elymus innovatus* and sedges were more abundant in woodlands, 15%, than forests, 8%. Herb cover, e.g., *Cornus canadensis*, *Geocaulon lividum*, *Galium boreale*, was low in both formation classes, 4%. In the bryoid stratum, mosses predominated in forests (65%) which had a sparse lichen cover (11%) while in woodlands mosses averaged 24% and lichens 8%. Phytocoena of this series were mainly located east of the Mackenzie Highway on the plateau-like uplands (Fig. 10). Elevationally, they predominated between 260-270 m (Table 19).

Upland Low Deciduous Shrub Series

This series (Table 17) also included forests (Nos. 3, 5, 7, 12) and woodlands (14, 17, 23). Its woody understory was characteristically dominated by low deciduous shrubs such as *Rosa acicularis*, *Shepherdia canadensis*, and *Viburnum edule*, which averaged 20% cover, ranging from 14-33%. Dominant trees were *Picea glauca*, *Pinus banksiana*, and *Populus tremuloides*. Reptant evergreen dwarf shrubs were also a significant cover component, averaging 20% in forests and 28% in woodlands, with *Arctostaphylos uva-ursi*, *Linnaea borealis*, and *Vaccinium vitis-idaea* dominant. Graminoid species like *Elymus innovatus* and sedges averaged 8% in both formation classes. The relatively sparse herb cover in forests (6%) and woodlands (3%) was exemplified by *Galium boreale*, *Geocaulon lividum*, *Fragaria virginiana*, and *Cornus canadensis*. The bryoid stratum in both evergreen forest and woodland formation classes, was dominated by mosses, 60%, whereas lichens averaged 20%. In deciduous forests and woodlands moss cover was 24% and lichen 16%. Phytocoena comprising this series were located in close proximity to the Mackenzie Highway (Fig. 10) and reached their optimum at elevatons of 255-265 m (Table 19).

Table 19. Relation of map phytocoena and elevation expressed as percent of the total actual vegetation.

ELEVATION CLASS

PHYTOCOENON	1 230- 235 m	2 235- 240 m	3 240- 245 m	4 245- 250 m	5 250- 255 m	6 255- 260 m	7 260- 265 m	8 265- 270 m	9 270- 275 m	10 275- 280 m	Σ Rows
1	-	.07	.05	-	.15	1.25	.43	-	-	-	1.95
2	.03	.08	-	.08	.21	-	.04	.13	.23	.16	.95
3	-	-	-	.02	.53	1.38	1.79	1.58	.29	-	5.60
4	-	-	-	-	.08	.21	1.32	.80	.15	-	2.57
5	-	.65	.64	1.14	.49	1.19	.62	.75	.07	-	5.53
6	-	-	-	-	-	-	.28	.76	.16	-	1.19
7	-	-	.04	.23	.05	.59	.34	.02	-	-	1.27
8	-	-	.16	.07	-	-	-	-	-	-	.22
9	-	.11	.11	.26	.08	.30	.02	.13	-	-	1.01
10	-	-	-	.07	.05	-	-	-	-	-	.11
11	-	-	.04	.11	-	-	-	-	-	-	.15
12	-	-	.16	.30	1.04	.77	.01	.14	-	-	2.42
13	-	.01	.09	.05	.09	-	.01	.04	-	-	.28
14	-	-	-	.07	.40	.63	.31	.40	-	-	1.82
15	-	-	-	-	-	-	.14	.83	.05	-	1.02
16	-	-	-	.02	.10	.44	.82	1.17	.23	-	2.78
17	-	-	-	-	.40	1.64	2.22	.59	-	-	4.84
18	-	-	.06	.19	.20	.78	.58	1.23	1.01	.69	4.74
19	-	.03	1.35	2.63	2.38	.47	.05	-	-	-	6.92
20	-	-	1.40	.96	4.74	2.13	.02	-	-	-	9.25
21	-	-	-	.10	2.42	.90	.10	.13	-	-	3.64
22	-	-	-	-	-	-	-	.32	.09	.04	.44
23	-	-	-	-	-	.05	.27	.02	.01	-	.35
24	-	-	-	-	-	.10	.30	.66	.09	-	1.15
25	.14	.29	.49	1.74	1.89	.02	-	-	-	-	4.57
26	-	-	-	-	.05	.58	.92	1.06	.23	.02	2.86
27	-	-	-	-	-	.09	.11	.46	.01	.06	.73
28	-	-	-	.02	.02	.14	.07	.19	.04	.07	.53
29	.05	.05	.26	.18	.08	-	-	-	-	-	.62
30	-	-	-	-	.01	.08	1.49	.24	.05	-	1.86
31	-	-	-	.06	-	-	-	-	-	-	.06
32	-	-	.05	2.06	1.32	.05	-	-	-	-	3.49
33	-	-	.10	.39	-	-	-	-	-	-	.49
34	-	-	.02	.05	-	-	-	-	-	-	.07
35	-	-	-	-	-	-	.06	.69	-	-	.75
36	-	-	-	8.03	2.21	.10	.01	-	-	-	10.34
37	-	1.26	.99	5.43	1.03	-	-	-	-	-	8.71
38	-	-	-	-	.58	-	-	-	-	-	.58
39	-	-	.13	.06	.06	.07	.92	.38	.68	-	2.30
40	-	-	.01	.04	.17	.22	.85	.34	.21	-	1.83
Σ Columns	.23	2.54	6.15	24.37	20.79	14.18	14.07	13.05	3.59	1.03	100.00

Upland Low Evergreen Shrub Series

Nine phytocoena had a significant low evergreen shrub component usually composed mainly of *Juniperus communis* (Table 17). This structural series ranges from forest (No. 6) through woodland (15, 18, 24) and savanna (26, 27, 28) to steppe scrub (39, 40). No other shrub species at Heart Lake was as predominant as *Juniperus communis* across such a wide spectrum of upland formation classes. Primary overstory species were *Picea glauca*, *Pinus banksiana*, and *Populus tremuloides*. The average cover of low evergreen shrubs was relatively low (7%)in the forest formation class (No. 6), rose to 31% in woodlands and 35% in savannas, but dropped back to 15% in steppe scrub. In the latter, patches of bedrock (20-40% cover) alternated with the vegetation. Reptant broadleaf evergreen dwarf shrubs, particularly *Linnaea borealis* but also *Arctostaphylos uva-ursi*, were abundant in forests, 57% cover, decreased to 41% in woodlands to 34% in savannas and 32% in steppe scrub. Average herb cover was 4%, range 3-8%, and graminoids 18%, range 13-19%, and varied only slightly among the four formation classes. Frequently encountered species were *Elymus innovatus*, *Carex richardsonii*, *Geocaulon lividum*, *Cornus canadensis*, and *Galium boreale*. In the bryoid stratum mosses averaged 43% and lichens 27%, in forest. Contrarily, in woodlands, savannas, and steppe scrub lichen cover increased to

43-57% while moss cover declined, 5-20%. Phytocoena of this series were most abundant east of the Mackenzie Highway (Fig. 10) and reached their peak development at elevations between 260 and 270 m, particularly between 265 and 270 m (Table 19).

Upland Deciduous Dwarf Shrub 'Series'

A single phytocoenon (Table 17) was dominated by deciduous dwarf shrubs, Salix myrtillifolia, Arctostaphylos rubra. This 'series' was included to complete the structural spectrum; although associated with the forest formation class it was not a true series. It occurred on wet-mesic, almost swampy sites. Low deciduous shrubs, mainly Rosa acicularis, were often prominent, while tall shrubs such as Salix bebbiana were poorly represented. Graminoids and herbs accounted for only 1-2% cover with sedges, Calamagrostis, Geocaulon lividum, and Mitella nuda being the most prominent. In contrast to the series described above, the prostrate evergreen dwarf shrub component was almost absent, 1% cover, but again characterized by Vaccinium vitis-idaea and Linnaea borealis. Mosses formed a nearly continuous carpet, cover 75%, and lichens 1%. This 'series' was located about 1 km NE of Heart Lake (Fig. 6) and reached peak abundance between 255-260 m (Table 19).

Lowland Tall Deciduous Shrub Series

The first lowland series (Table 18) ranged from forest (No. 11) through woodland (25) and savanna (29) to scrub (32). It was characterized by tall deciduous shrubs, Betula glandulosa, with cover averaging 14-20%, low deciduous shrubs, Myrica gale and Potentilla fruticosa, 20-37%, and deciduous dwarf shrubs, Salix myrtillifolia and Arctostaphylos rubra, 18-35%. In woodlands the dominant tree species was usually Larix laricina with Picea mariana subdominant, but in forests Picea mariana formed pure stands. Broadleaf evergreen species, e.g., Andromeda polifolia and Vaccinium vitis-idaea, were almost absent, 1%, as were herbs such as Petasites palmatus, Rubus acaulis, Smilacina trifolia, and Pyrola secunda. Graminoids (sedges, Calamagrostis) were sparse, 4-8%. Moss cover averaged 50%, while lichens were nearly absent, 1%. This series occurred sporadically throughout the lowlands (Fig. 10). Elevationally, they predominated between 245-255 m (Table 19).

Lowland Low Evergreen Shrub Series

This series was characterized by low broadleaf evergreen shrubs, Ledum groenlandicum, as well as prostrate evergreen dwarf shrubs, Empetrum nigrum, and

Vaccinium vitis-idaea; each of these two strata averaged 8% cover. *Picea mariana* again formed pure stands in forests (No. 10), while in woodlands (19) *Larix laricina* was usually admixed. Deciduous dwarf shrubs, particularly *Salix myrtillifolia*, comprised 12% cover, while shrubs like *Betula glandulosa* were usually rare, 3%. Herbs (2%) and graminoids (3%) were sparse and included *Geocaulon lividum*, *Pedicularis labradorica*, *Rubus chamaemorus*, *R. acaulis*, *Calamagrostis*, and sedges. In the bryoid layer, mosses were predominant (60%) with *Sphagnum* comprising about 20% cover. Lichens averaged 35% cover. This series occurred primarily in the lowlands due north of Heart Lake (Fig. 10) and predominated between 240-255 m (Table 19).

Lowland Deciduous Dwarf Shrub Series

In this series (Table 18) the woody understory was dominated by deciduous dwarf shrubs whose cover averaged 17% in forests (No. 9) and 31% in woodlands (20, 21). Characteristic dwarf shrub species were *Arctostaphylos rubra* and *Salix myrtillifolia*. The main evergreen overstory species was *Picea mariana* (Nos. 9, 20) but *P. glauca* also dominated (21). *Larix laricina* was rare in forests (1%) and sparse in woodlands, 8%. Prostrate evergreen dwarf shrubs, *Vaccinium vitis-idaea*, and low deciduous shrubs, *Potentilla fruticosa*, were frequent but each averaged only 4% cover. Tall deciduous shrubs were very rare (1%). Herb cover was also low (2%), while graminoids (sedges) averaged 4-8% cover. In the bryoid stratum mosses predominated averaging 13-23%. This series occurred throughout the lowlands (Fig. 10). Elevationally, it ranged between 240-260 m (Table 19).

Lowland Moss Carpet 'Series'

The last lowland phytocoenon (No.8) was dominated by a continuous moss carpet and a *Picea glauca* overstory. The woody understory was extremely sparse and the herb stratum, *Equisetum* and *Geocaulon*, was also depauperate. Like the upland deciduous dwarf shrub phytocoenon No. 1, it is not a true series but is included to complete the spectrum. It occurred 1.5 km N of Heart Lake between 240-250 m (Table 19).

Other mapped phytocoena - scrub (Nos. 30, 31), graminoid (33, 34) and dwarf scrub (35, 36, 37, 38) were not described here but fully treated in preceding sections with the exception of 38 which was not sampled due to time restrictions.

As a final step in the map interpretation process, the relationship between vegetation map units and elevation was assessed. Elevation classes were selected for the test because within the study area they were roughly equivalent to a moisture gradient, i.e. the highest elevations were dry and the lowest were wet (Table

19). Hence, the table is an indirect gradient analysis and represents a coenocline from the standpoint of communities. Chi-square was calculated to test the null hypothesis, i.e. independence of elevation and vegetation map units. In instances where expected frequencies were less than one, classes were combined (Snedecor and Cochran 1967). Accordingly, elevation classes 1, 2, and 3 were united to form one compound class. Similarly elevation classes 9 and 10; phytocoena 10 and 11; 31 and 32; and 33 and 34 were combined into compound classes. The resulting chi-square was 115.4 (df=216) at $P < 0.01$. The null hypothesis was therefore rejected; there is a very close relationship between elevation and phytocoena. It is concluded that map phytocoena have distinct but overlapping ecological ranges in the study area, and that these ranges vary greatly in width. Thus, the phytocoena have different ecological amplitudes with reference to the complex moisture gradient associated with elevation.

DISCUSSION

Flora

The vascular flora of the continental Northwest Territories numbers about 1135 taxa (Cody 1971). Of these about 573 taxa occur in Porsild and Cody's (1968) sixth phytogeograhic province which encompasses Heart Lake. One hundred sixty species were found in the relatively small Heart Lake study area i.e. 28% of the flora of the Continental Northwest Territories and 56% of the sixth province's flora. To a large degree the comparatively rich Heart Lake flora is accounted for by landscape diversity which provided numerous habitats in a relatively small area. Examples include escarpment canyons, talus, beach ridges, plateau-like uplands, raised bogs, string fens, lakes, streams, marl deposits, and both wooded and non-wooded fens. According to Porsild and Cody (1968), one of the unique features of the flora of the sixth phytogeographic province is that it contains the largest concentration of grassland and southern woodland species in the Territories. Several Heart Lake species are typical of grasslands but these represented a very minor portion of the study area flora: Antennaria campestris, Carex filifolia, Geum triflorum, Koeleria cristata, Potentilla arguta, and Linum lewisii. Similarly, Heart Lake species characteristic of southern woodlands were also present but not abundant. Examples include: Actaea rubra, Carex eburnea, Lathyrus ochroleucus, and Thalictrum venulosum.

The flora of the study area was not particularly unique and contained wide-ranging species. A comparison of Heart Lake floristic elements with adjacent areas to the east (Scotter 1966) and west (Annas 1973) and for the entire continental Northwest Territories (Cody 1971) showed that all were primarily composed of circumpolar and North American species:

	Region			
Floristic Element	Continental, N.W.T. (Cody 1971)	Ft. Nelson, B.C. (Annas 1973)	Heart Lake, N.W.T.	Eastern Arm, Great Slave, N.W.T. (Scotter 1966)
Circumpolar	~ 31	42.4	42.4	50.4
North American	38.8	39.6	44.0	36.9
Amphi-Beringian	~ 15	10.4	7.3	8.6
Cosmopolitan	6.8	5.0	4.4	1.8
Cordilleran	6.2	2.2	1.3	0.9
Amphi-Atlantic	2.2	0.4	0.6	1.4
Total (%)	100.0	100.0	100.0	100.0

From west to east the percentage of cordilleran species decreases with distance from the mountains; the percentage of amphi-Beringian species is lowest in the two eastern areas which were farthest from Beringia; and there is a very slight increase in the percentage of amphi-Atlantic species. The decrease in cosmopolitan species from west to east is probably related to the increase of human influence. Regions to the south, e.g., Manitoba (Scoggan 1957) and northern Ontario and Quebec (Baldwin 1958), report a far greater importance of the North American endemic element, 63-66%, than circumpolar, 17-19%.

Bird et al. (1977) report 94.7% of the 262 bryophytes including cosmopolitan species known from the Mackenzie River valley are circumpolar. A comparable value for Heart Lake equals 96.3%. In addition, they record a North American, 1.1%, and an amphi-Beringian, 4.2%, element. These latter two values did not quite correspond with Heart lake and the last value probably reflects a closer proximity to Beringia. Although the bryoid flora consists of a larger circumpolar element than does the vascular flora, the circumpolar vascular flora at Heart Lake is still larger than for regions to the south and represents a significant component of the flora. As new studies of the middle boreal flora are conducted, it is likely that the middle boreal will continue to reflect a higher circumpolar component than the southern boreal.

Four Heart Lake species were new to the District of Mackenzie: (1) Eleocharis compressa, a considerable extension from its known range in Jasper, Alberta; (2) Pedicularis parviflora, the only other collection from the continental Northwest Territories is from the eastern Keewatin District; (3) Sarracenia purpurea (Cody and Talbot 1973); and (4) Rhynchospora alba, a 400 km extension of its known range on the south shore of Lake Athabasca. Other range extensions were: Botrychium virginianum ssp. europaeum, previously known only from the foothills and slopes of the Mackenzie Mountains (Raup 1947, Cody 1963, and Scotter and Cody 1974); Carex filifolia, a very rare plant in the Mackenzie District with earlier collections from Nahanni Butte (Scotter and Cody 1974) and Wrigley (Porsild 1951); Carex livida, previously known in the Mackenzie District from the Eskimo Lake Basin (Porsild 1943); Carex richardsonii, first reported by Raup (1936, 1947) at Ft. Smith, N.W.T.; Cypripedium guttatum, the most southeasterly collection in the District (Porsild and Cody 1968); Draba oligosperma, previously known only from the southern Mackenzie Mountains (Mulligan 1972); Gentiana affinis, first reported by Porsild and Cody (1968) from Keele River in the Mackenzie Mountains and near Fort Good Hope; Lesquerella arctica, the nearest known sites are in the southern Mackenzie Mountains (Raup 1947, Scotter and Cody 1974); Oxycoccus quadripetalus, rare in the District with other collections from Norman Wells (Cody 1960, under Vaccinium oxycoccus) and along the Liard River (Jeffrey 1961); Cystopteris montana, this collection and that of Thieret (1961) from along the Kakisa River were the two most easterly records in the Mackenzie District, being otherwise known between Nahanni Butte and Fort Simpson (Raup 1947); and Potamogeton natans, the second record of this species in the Mackenzie District where it was reported at Rabbitkettle Lake near the South Nahanni River (Scotter and Cody 1974).

The occurrence of several arctic-alpine mosses in the bryoflora is of interest; Fissidens arcticus, Hypnum bridelianum, H. procerrimum, and Timmia norvegica. All were associated with the calcareous escarpments whose cold canyons provide an arctic habitat in an otherwise boreal region. The closest record of Fissidens arcticus occurs near Great Bear Lake (Steere and Brassard 1974). This was the most southerly record. The presence of Hypnum procerrimum is intriguing as Packer and Vitt (1974) hypothesized that the species is indicative of glacial refugia. The occurrence of Fontinalis dalecarlica, new to the Mackenzie District, represents a considerable extension of its known range at Lake Athabasca (Welch 1960). Thus, knowledge of plant species distributions in the Northwest Territories is still meagre and, hence, interpretation of the distribution of some northern species should still be regarded as tentative.

It is concluded that the wide array of species and habitats of the Heart Lake study area provides good sample of the middle boreal flora and is a demonstrably good location to carry on botanical research.

Life-forms

The qualitative biological spectrum serves as an indicator of climate which is characterized by the departure of life-form classes from the "normal spectrum" (Raunkiaer 1934). The spectrum at Heart Lake places it within the boreal zone of Raunkiaer which lies between the 10% and 20% chamaephyte boundary. At Heart Lake there was a strong tendency toward higher species richness in the lower strata (Table 4) where life-forms would be least exposed (i.e. snow-covered). In contrast, a more even distribution of species richness in phanerophytic subdivisions and/or higher concentration of mesophanerophytes has been demonstrated within milder climatic regions, e.g., southern Quebec (LeBlanc 1963), eastern United States (Ennis 1928), and Minnesota (Buell and Cantlon 1951).

Scoggan (1978) constructed life-form spectra for six subzones based on the flora of Canada. In Appendix VI the life-form spectrum at Heart Lake is compared with the subzone spectra of Scoggan (1978) using chi-square tests for goodness of fit. The comparison demonstrates that

Heart Lake is significantly different from all subzones except the "low subarctic". The latter generally coincides with the middle boreal subzone of Hämet-Ahti et al. (1974). It is concluded that the Heart Lake spectrum corresponds both statistically and geographically to the middle boreal subzone.

Of the many systems developed to classify life-forms, Raunkaier's is perhaps the most satisfactory because it is simple, clear, and aims at an ecological explanation (Emberger and Sauvage 1968). Although Raunkiaer's use of bud placement as the essential criterion has been criticized, Emberger (1966) criticizes both the definition and interpretation of the spectrum. He stresses that the Raunkiaer's spectrum is primarily a display of floristic diversity whose only ecological interest is indicative, by the presence and absence of biological types, i.e. qualitative composition. However the spectrum can have more ecological value if community structure (stratification) is shown, e.g., by indicating the percentages of dominance of the biological types in the different strata (cf. Bliss 1956:322) on the basis of natural units of vegetation (Emberger 1966:156). The close agreement between the phytocoenose classifications based on floristic composition and quantitative life-form criteria within the Heart Lake study area is highly complementary from a statistical as well as an ecological perspective, and reinforces the life-form approach to vegetation ecology.

One of the more significant findings of this study, I believe, is how useful quantitative life-form spectra can be for comparative studies of widely separated areas. However, published reports dealing with community spectra in boreal regions are scarce. For Finland Cajander (1926) cited data demonstrating that "forest type groups" differ in their life-form spectra, particularly in respect to the number of chamaephytes. In a comparison of New Jersey and Minnesota pine forests, Stern and Buell (1951) concluded that the northern stands have a far higher proportion of more protected life-forms, based on cover. For example, chamaephyte cover in New Jersey pine forests was absent, while in Minnesota it was 2.5%. In comparison, chamaephyte cover was far higher, approximately 20% within the pine woodlands of the study area. Together these studies demonstrate a trend of increasing chamaephyte cover with latitude. This ties in with the possibility of comparing circumboreal communities using quantitative life-form criteria since not all vascular species are circumboreal. The description from the middle boreal subzone at the Heart Lake study area provides a datum for characterizing a portion of the subzone for future comparative studies.

A potential value of the life-form approach in conjunction with a floristic classification can be demonstrated using phytocoenose 6 as an example. In the floristic classification No. 6 had 80% similarity to two other phytocoenoses, Nos. 22 and 34, all of which formed phytocoenon III C (Fig. 10). In the life-form classification, however, No. 6 comprised a single-member phytocoenon, VII (Fig. 11), which was quite distinct from the others. This distinction appeared ecologically justifiable since No. 6 occurred in a more extreme habitat than Nos. 22 and 34, i.e. sandier, drier, and lower pH implying poorer nutrient status. Thus, the designation of No. 6 as a separate class in the life-form classification may reflect an environmental difference. As expressed by Braun-Blanquet (1932:300) "The more extreme the habitat conditions the stronger the selection and the more pronounced are the ecological characteristics of the life-forms". Therefore, a classification based on life-forms used in conjunction with a floristic classification reveals characteristics of the vegetation and gives expression to an ecological phenomenon which was not readily evident in the latter (Mueller-Dombois and Ellenberg 1974:142).

These initial results are encouraging. Future studies might focus on one vegetation type such as pine woodlands, and examine the relationship between environmental factors and phytocoena. The life-form system of Ellenberg and Mueller-Dombois (1967b) is similar to that of Emberger and Sauvage (1968) but incorporates evergreenness in all life-form classes. Potentially, it should also yield meaningful results if used in the manner presented here and would be more compatible with Küchler's (1967) structural types used in the mapping effort.

An increase in the relative number of vegetatively propagating species at progressively higher latitudes in the northern hemisphere was observed by Steeves et al. (1969). Within the study area the cover-abundance of species with rhizomes or stolons far outnumbered those without. Steeves et al. (1969:132) note the "continued dependence of a new potential individual upon an already established plant is probably of great significance in explaining the success of rhizomatous and root-bud species in invading areas of dense and established vegetation in which seedlings are unable to survive competition".

Aside from the adaptation to cold winters by leaf shedding and the greater resistance of xeromorphic needles (Walter 1973), only tentative interpretations can be suggested regarding the high concentration of both low-growing (chamaephyte and nanophanerophyte) and evergreen species. The main advantage of the evergreen habit is that it disposes of the necessity "to spend food resources on a wholly new photosynthetic apparatus each year" (Billings and Mooney 1968:492). Grime (1977) stated that evergreen leaves are a common feature of plants in nutrient deficient soils; in the Heart Lake area low amounts of nitrogen and phosphorus are typical (Day 1968). In addition, chamaephytes and low-growing nanophanerophytes tend to be insulated from desiccation by a relatively stable snow cover during the winter months. Rowe et al. (1975:57) suggested that growth form may be decisive "so far as burning or surviving surface fires is concerned". They maintain that upright shrubs are more likely to burn than prostrate ones. Thus, as expressed by Mueller-Dombois and Ellenberg (1974), life-form composition may indeed give information on the response of vegetation to environmental factors and on probable competitive relations. However, Cain (1950) cautioned against presupposing causality between life-forms andenvironmental features without detailed studies. The groundwork for future studies is established and more intense investigations can now be undertaken.

Soils

There was close agreement between the soil descriptions from the study area and the reconnaissance survey of Day (1968). Specifically, Heart Lake Brunisolic soils correspond directly to those of the Escarpment and Twin Falls complexes and Enterprise series of Day (1968). Luvisols, a minor component of the Twin Falls complex, were not observed at Heart Lake. Rego Gleysols, Terric Humisols, and Fibric Organic Cryosols from the study area fell within the Dory, Desmarais, and Grainger series (Day 1968), respectively.

No account was provided by Day of the soils within his land types. Thus, the profile descriptions given within the study area for the escarpment land type (Orthic Humic Regosols) and the slough and marsh land type (Hydric and Typic Mesisols, Hydric Humisols) extended Day's study and added to our knowledge of this area. Soils comparable with the Rego Gleysols associated with marl fens (phytocoenon X) were not mentioned by Day. However, they often form an important component of the landscape in the upper Mackenzie River area. Not only were they common below the escarpment, but based on my aerial observations, they covered vast expanses of the terrain approximately 150 km west of the city of Yellowknife.

Other investigators (e.g., Achuff 1974, Daubenmire and Daubenmire 1968) found little correspondence between community types and soils at the subgroup level. Achuff (1974) suggested that because the soil subgroup is a rather broadly defined unit, classification to a lower level might reveal relationships more clearly. It is concluded that the data from the Heart Lake study area show general correspondence between soil types and phytocoenon and subclasses. Also, phases of subgroups which incorporated such factors as depth to a lithic contact and peat depth were decisive in explaining vegetational variation.

The observations of Rowe (1972b) regarding the relationship of soil moisture and peat development in the Fort Simpson area applied equally well for Heart Lake. Thus, soil materials that were well drained, moderately well drained, and imperfectly drained have insufficient moisture to promote peat accumulation. Typical examples at Heart Lake were Orthic Eutric Brunisols and Eluviated Eutric Brunisols. However, moderately poorly drained surface materials might have a thin peat capping, e.g., Rego Gleysol (peaty phase), whereas poorly drained to very poorly drained materials usually had a thick peat capping. Typically, these were Mesisols or Fibrisols.

Fire and succession

The Heart Lake study area has a complex fire history which consists mostly of subclimax communities in the uplands and climax communities in the lowlands. The relatively complex vegetation pattern is related to fire frequency as well as the varying rates of succession on differently drained sites. More frequent fire occurrence in the uplands than the lowlands was consistent with the statement of Rowe and Scotter (1973) that landforms and soils possessing dry surfaces, whether due to topographic position or relief, were more susceptible to fire.

Most of the upland phytocoenoses surveyed showed evidence of succession to climax communities of Picea glauca, while in the lowlands Picea mariana demonstrated the strongest regeneration potential. In this respect the Heart Lake study agrees with the field observations of Rowe (1972) from the middle boreal Fort Simpson area where succession was related to drainage classes.

Poor reproduction in some upland phytocoenoses suggested that a more open canopy might develop without fire disturbance. Similar conjecture has been made for northwestern Alberta (Rowe 1961) and central Saskatchewan (Dix and Swan 1971). Field observation within the Heart Lake uplands indicated that Pinus banksiana is subject to windthrow, exposing mineral soil which provides for the invasion of Picea glauca, especially on mesic sites. White spruce did not readily invade drier windthrow sites, suggesting the canopy might become even more open or treeless with age. Studies in mature (200-300 years) northern boreal woodlands of the lower Mackenzie River valley (Strang 1973) indicate that, without periodic fires, trees would be eliminated and the climax vegetation would be a "moss-lichen association". Within the Heart Lake uplands this trend did not occur except on the most xeric sites. Nor did it occur in the lowlands where vegetative layering from black spruce provided for continual replacement.

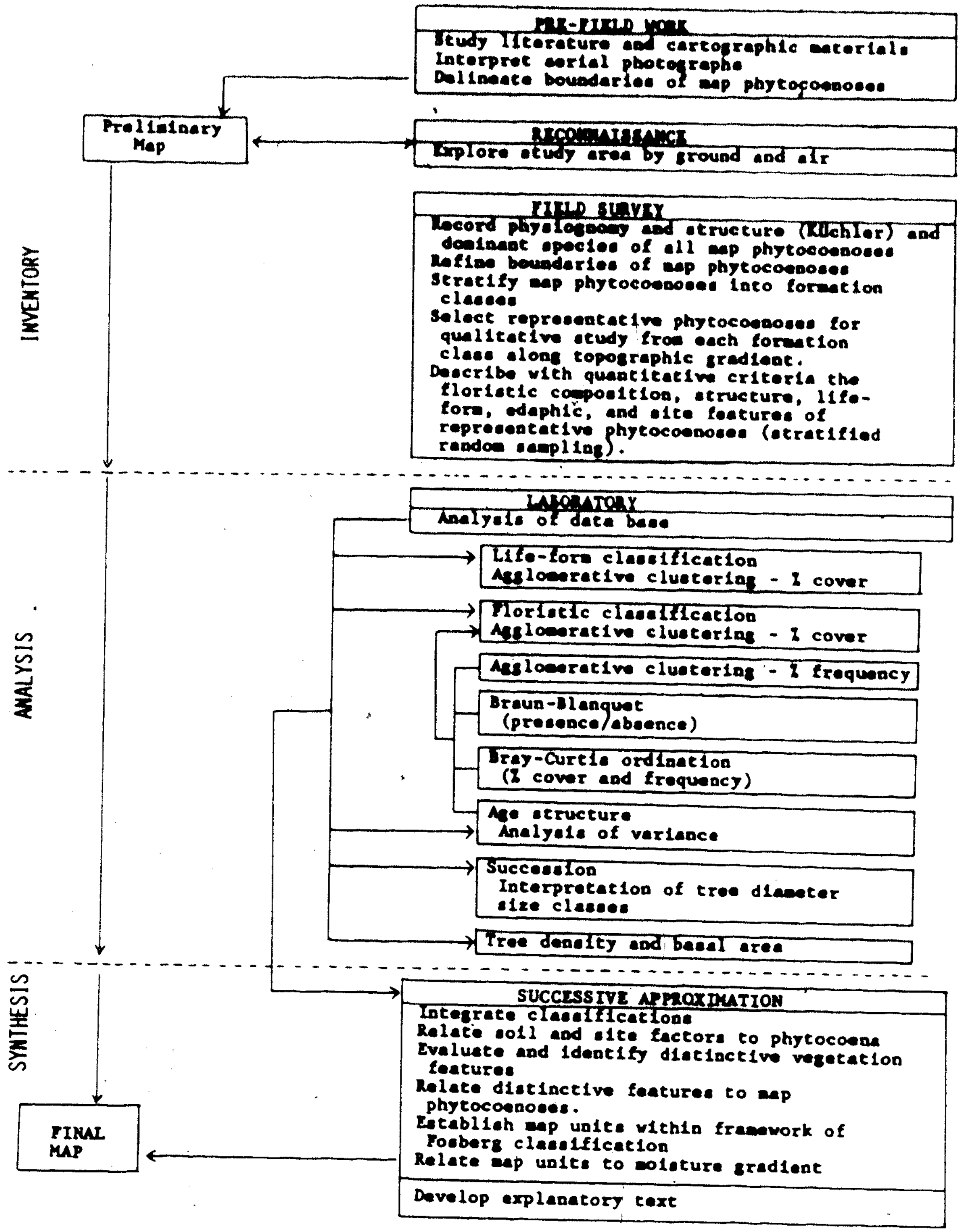
Johnson (1981) studied vegetation dynamics on non-calcareous substrates in the northern boreal subzone east of Great Slave Lake, and described upland sites dominated by closed or open forests of black spruce and jack pine. This pattern was in marked contrast to the Heart Lake study area where black spruce seldom was important in the uplands.

Vegetation classification and mapping

The vegetation map was prepared by agglomerating 571 phytocoenoses into 40 map units. The mapping procedure was developed in a stepwise manner as summarized in the flow diagram (Figure 16). This approach elaborates on the Küchler (1967) comprehensive method and presents a more definitive basis for mapping vegetation. Not all steps in the approach are required and future studies should consider this in relation to the time and finances available.

In contrast to the Küchler (1967) comprehensive mapping method, I developed an approach which described the structural composition of all stands, stratified them into formation classes and selected examples from the formation classes for detailed quantitative study. Like Küchler (1967) I think that every phytocoenose delineated on the map should be visited in the field to understand its content because aerial photographs can give only the phytocoenose boundaries. However, recording the floristic

Figure 16. Flow chart showing the vegetation mapping procedure.



composition of all stands in the field is time consuming and costly. In the alternative proposed here, the general level provided for: 1) on-site examination of the totality of the vegetational variation within the study area, 2) documentation of the general nature of the vegetation, 3) establishment of a data base for the refinement of formation classes into subtypes, and 4) efficient time expenditure throughout the more detailed quantitative study. The detailed level recorded the floristic composition, life-form structure, age structure, successional trends and major edaphic/site factors. These detailed features could then be related directly to the mapping process as guides in establishing the map classification. They also could serve as individual classifications describing different aspects of the vegetation in an explanatory text to supplement and extend the map content. Ordination data (e.g., soil depth) related to the floristic classification could also be used to amplify the vegetation map. A very desirable feature of the process is that the life-form and floristic classifications are related, which facilitates synthesis of the final map units.

As a test of the alternative procedure it was statistically determined that the map units had ecological meaning because they were related to a complex moisture (topographic) gradient.

A significant finding of this study was the high correlation between different floristic classification approaches. Whether based on qualitative (presence/absence) or quantitative floristic data, the classifications gave very similar results. This suggests that the criterion of abundance was not critical to the end result. Therefore, classifications based on different criteria are comparable. La Roi and Hnatiuk (1980) reached a similar conclusion in their syntaxonomical study of Pinus contorta forests.

R-type analysis using the Orloci (1967) agglomerative clustering method was applied to both qualitative and quantitative data in an attempt to form species groups, but the results were not as clear as those obtained with the Ceska and Roemer (1971) program. In addition, the latter established species groups which were highly complementary to the agglomerative clusters of phytocoenoses. Thus, use of differential species groups was both consistent with the classification and complemented it by typifying phytocoenon clusters.

The final vegetation map of the Heart Lake study area is a pioneering effort since there were no published large scale vegetation maps of the continental Northwest Territories. This was the first rigorous attempt to map the vegetation of the Territories in a quantitative and systematic manner. A potential use of the approach could be the mapping of ecological reserves.

The purpose of the vegetation map was to provide a basic inventory of the plant cover representative of a portion of the middle boreal zone. Since the development and refinement of vegetation zonation is inseparably linked to vegetation mapping (Gribova and Isachenko 1972), this map should be viewed as an attempt to characterize a part of middle boreal zone which could later serve as a reference for comparative zonation studies. It could also function as ground truth for studies involving remote sensing imagery where smaller scale maps are desired. The map has considerable flexibility in serving as ground truth at various scales, because the map classes were hierarchical with subclasses unified according to a coordinational scheme of patterns. Thus the map could easily be interpreted at a number of cluster levels - general through detailed. Finally, the map could assist in future ecological studies correlating plant communities and wildlife in the middle boreal zone.

Comparison of the vegetation with areas outside the Heart Lake area

A synthesis of North American boreal vegetation was presented by Knapp (1965:72-89). As an overview it establishes a framework of higher vegetation units utilizing physiognomy, flora, and edaphic factors, and offers a suitable basis for vegetation comparisons with types outside the study area. Knapp (1965) identifies five major boreal regions which he further subdivides. In relation to his zonation scheme, Heart Lake lies in the northernmost portion of the "central main boreal region". This is equivalent to the "southern spruce region" (Hustich 1949), "main boreal" (Sjörs 1961), and "closed coniferous forest" (Ritchie 1960a). On the northeastern shore of Great Slave Lake, the main boreal area becomes the "subarctic" (Knapp 1965; Sjörs 1961), also termed "open coniferous forest" (Ritchie 1960a) and "taiga" (Hustich 1949).

The unevenness and scarcity of suitable boreal vegetation studies generally precluded quantitative comparison of plant community types. However, a subjective assessment may be made on the basis of floristic composition and dominance (<u>sensu</u> Achuff and La Roi 1977) with communities described by other investigators.

Spruce-fir forests

Spruce-fir forests ("Abieto-piceetea albae", Knapp 1957) form a major component of boreal vegetation whose main areal distribution lies in northern Canada extending from Newfoundland to the Mackenzie River region in Canada and the Yukon River region in Alaska. Of the 42 species frequently encountered in spruce-fir forests (Knapp 1965), 16 species (38%) occurred in comparable Heart Lake forests: Picea glauca, P. mariana, Larix laricina, Betula papyrifera, Populus tremuloides, Geocaulon lividum, Linnaea borealis, Cornus canadensis, Lycopodium annotinum, Pyrola asarifolia, P. secunda, Moneses uniflora, Hylocomium splendens, Pleurozium schreberi, Ptilium crista-castrensis, and Peltigera aphthosa. Examples of species not present in the study area but present in Knapp's list included Abies balsamea, Sorbus americana, Acer spicatum, Vaccinium myrtilloides, Clintonia borealis, Maianthemum canadense, Trientalis borealis, Epigaea repens, Coptis trifolia, and Dryopteris austriaca.

Knapp (1965) further distinguishes six subclasses of boreal spruce-fir forests: (1) lichen spruce woodlands; (2) blueberry-feathermoss spruce-fir forests; (3) herb-rich spruce-fir forests; (4) rich coniferous swamp forests; (5) open tamarack swamps, and (6) black spruce muskeg woodland. Spruce vegetation at Heart Lake was closely related to Knapp's last three subclasses (4, 5, 6), which are treated in separate sections below; less related to subclasses 1 and 2; and least related to subclass 3.

With respect to general comparisons between the study area and subclasses 1 and 2 above, it is important to stress that at Heart Lake monotypic white spruce stands were rare. Despite the potential importance of white spruce across much of the Mackenzie Basin (Raup 1936), it was usually less predominant than black spruce or jack pine in the Heart Lake area. Furthermore, subclasses 1 and 2 are best represented in different climatic regimes and, therefore, do not often occur together. "Lichen spruce woodlands" are chiefly subarctic with a predominance of lichen species (Cladonia alpestris, C. rangiferina, C. mitis, C. arbuscula, and Stereocaulon; Knapp 1965). They resemble the more open, edaphically controlled types on shallow or rapidly drained sites at Heart Lake. Lichens, although subdominant on moister sites at Heart Lake, represented a significant component of the vegetation. In contrast, "blueberry feathermoss spruce-fir forests" are more characteristic of the southern boreal (Knapp 1965:80), possessing a "dense dwarf-shrub cover where Vaccinium species are especially predominant with abundant feather-mosses (Hylocomium splendens, Pleurozium schreberi, Ptilium crista-castrensis and others)". At Heart Lake Abies balsamea and blueberry, Vaccinium myrtilloides, were absent, but Vaccinium vitis-idaea was frequent and feathermosses abundant. The exception, Ptilium, was rare within the study area. Thus, rather than fitting comfortably into either of Knapp's subclasses, Heart Lake white spruce vegetation appears to be transitional between the subarctic and main boreal, reflecting gradual latitudinal climatic change.

In addition to Knapp's (1965) overview of North American boreal vegetation, there are two other major syntheses applicable to the Heart Lake area: Larsen (1972) and La Roi (1967). Larsen (1972) regionalized a vast expanse of central Canada from the Great Lakes to the Mackenzie River delta into nine zones. These divisions are based on a principal components analysis of 12 environmental parameters from 44 sites (Larsen 1972:1) in the "hope...that differences in forest understory vegetation from place to place would demonstrate a high degree of correlation with climatic differences". In a substudy of four zones, Larsen (1972) then related the environmentally established zones to vegetation, arranging dominant species in "white spruce (forest) understory communities" by study area and region. Using the average species-frequency values provided by Larsen (1972:72, Table 7) and equivalent values from the Picea glauca - Hylocomium splendens phytocoenon (V) at Heart Lake which lies outside Larsen's area, it was possible to compare the vegetation at each site.

Quantitative comparisons based on the Spearman rank-correlation coefficient (Table 20), ordination (Bray and Curtis 1957; Figure 17), and agglomerative clustering (Orloci 1967: Figure 18) confirm that phytocoenon V (represented as number 13 in the comparisons above) belonged to the "northern boreal zone" of Larsen (1972).

These comparisons also demonstrate the good correspondence between the classification based on environmental parameters and those based on vegetation characteristics, with two exceptions: Clear Lake lies at the "southern edge of the southern boreal zone" in the environmentally defined classification (Larsen 1972), but was classified as "southern boreal" based on both ordination (Fig. 17) and clustering (Fig. 18); and Waskesiu, although environmentally defined as "southern boreal" (Larsen 1972) was classed as northern boreal in the ordination (Fig. 17) and clustering dendrogram (Fig. 18).

An examination of Larsen's (1972:72, Table 7) white spruce understory data reveals a number of species-zone relationships, e.g., the southern boreal is characterized by Aralia nudicaulis, Maianthemum canadense, Mertensia paniculata, Petasites palmatus, Abies balsamea (seedlings), Clintonia borealis, Mitella nuda, and Arctostaphylos uva-ursi. Of these only the last two occur in Heart Lake spruce understory communities with average frequencies of 22% and 2%, respectively. Species listed

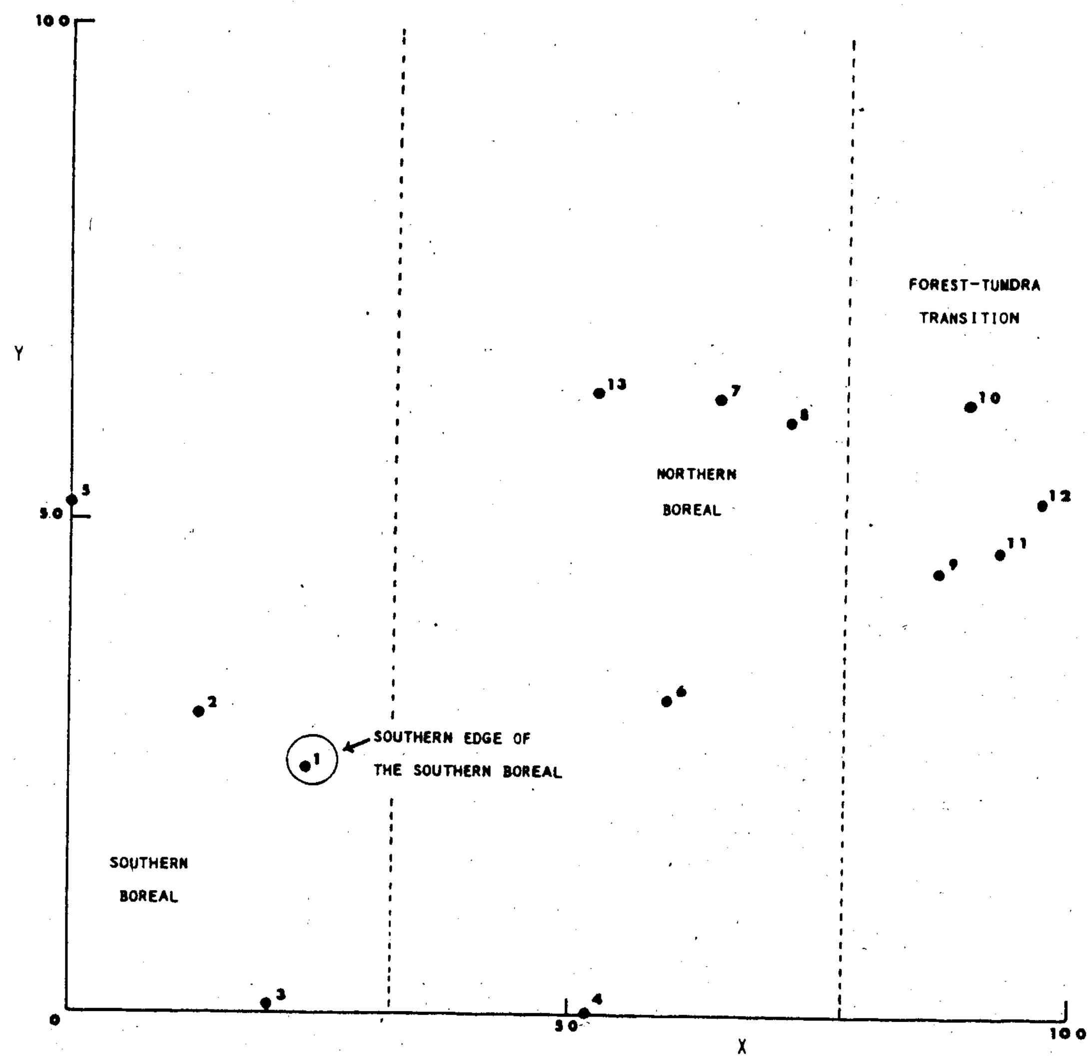
Table 20. A comparison of the species structure in white spruce understory communities at Heart Lake (13) with those of Larsen (1972:72) based on Spearman's rank-correlation coefficient using species' average frequency values in stands.

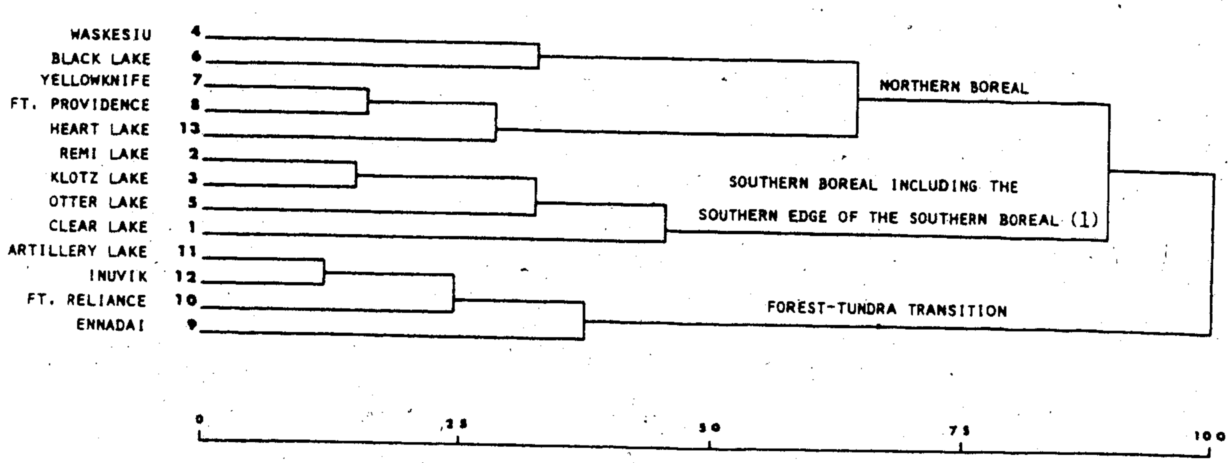
Rank Correlation Coefficient[a]	Site	Zone (Larsen 1972)
+1.000	Heart Lake, N.W.T	Northern boreal
+0.813**	Fort Providence, N.W.T. (8)	Northern boreal
+0.681**	Black Lake, Sask. (6)	Northern boreal
+0.666**	Yellowknife, N.W.T. (7)	Northern boreal
+0.443*	Waskesiu, Sask. (4)	Southern boreal
+0.302	Fort Reliance, N.W.T. (10))	Forest-tundra transition
+0.273	Ennadai, N.W.T. (9)	Forest-tundra transition
+0.190	Inuvik, N.W.T. (12)	Forest-tundra transition
+0.141	Clear Lake, Man. (1)	Southern edge of southern boreal
+0.126	Otter Lake, Sask. (5)	Southern boreal
+0.109	Artillery Lake,	Forest-tundra transition
-0.174	Klotz Lake, Ont. (3)	Southern boreal
-0.297	Remi Lake, Ont. (2)	Southern boreal

[a]Confidence limit is .381 for 5% level and .48 for 1% level, df = 25, ** = significant at 1%, * = significant at 5%.

Figure 17. Bray-Curtis ordination of white spruce (forest) understory communities based on data from Heart Lake (13) and Larsen (1972:72). Zonation terminology follows Larsen (1972). Site numbers correspond to the sites and numbers in Table 20.

Figure 18. Agglomerative hierarchical classification of white spruce (forest) understory communities based on data from Heart Lake (13) and Larsen (1972:72). Zonation terminology follows Larsen (1972). Explanation in text.


100
Y
50
0
50
100
X
FOREST-TUNDRA
TRANSITION
NORTHERN
BOREAL
SOUTHERN EDGE OF
THE SOUTHERN BOREAL
SOUTHERN
BOREAL
13
7
8
10
5
12
11
9
6
2
1
3
4


WASKESIU 4
BLACK LAKE 6
YELLOWKNIFE 7
FT. PROVIDENCE 8
HEART LAKE 13
REMI LAKE 2
KLOTZ LAKE 3
OTTER LAKE 5
CLEAR LAKE 1
ARTILLERY LAKE 11
INUVIK 12
FT. RELIANCE 10
ENNADAI 9
NORTHERN BOREAL
SOUTHERN BOREAL INCLUDING THE
SOUTHERN EDGE OF THE SOUTHERN BOREAL (1)
FOREST-TUNDRA TRANSITION
0
25
50
75
100

by Larsen as occurring in both the southern and northern boreal include Viburnum edule, Rubus pubescens, and Cornus canadensis, occurring in the study area with average frequencies of 46%, 2%, and 38%, respectively. Another species group is confined largely to the northern and forest-tundra transition (average frequencies in phytocoenon V are shown in parentheses): Shepherdia canadensis (44%), Picea mariana seedlings (40%), Vaccinium vitis-idaea (52%), Geocaulon lividum (28%), Rubus acaulis (4%), Empetrum nigrum (2%), Betula glandulosa (absent), Arctostaphylos alpina (absent). Vaccinium uliginosum and Dryas integrifolia mainly occurred in the forest-tundra transition and correspondingly did not occur in Heart Lake understory white spruce communities. Other species like Rosa acicularis (90%), Linnaea borealis (70%), Epilobium angustifolium (10%), and Pyrola secunda (32%) are relatively ubiquitous but are near their boreal optimum in the northern boreal zone.

Based on visual comparison a close correspondence exists between the zonal boundaries recognized in the maps of Larsen (1972:55) and Hämet-Ahti (1976:58). Therefore, I considered the following terms to be approximately equivalent:

Larsen (1972)	Hämet-Ahti (1976)
Southern edge of the southern boreal forest	Hemiboreal
Southern boreal	Southern boreal
Northern boreal	Middle boreal
Forest-tundra transition	Northern boreal

Because of the potentially wider applicability of the Hämet-Ahti (1976) biotemperature approach, I have followed her terminology in all subsequent comparisons. The similarity between the two classifications was helpful in extrapolating Larsen's species-zone relationships into regions outside his study area permitting comparison of plant communities from widely separated areas.

Like Larsen's (1972) regionalization, La Roi's (1967) classification of spruce-fir stands was based on an extensive investigation. In contrast to the former which generally samples north-south across vegetation zones, La Roi sampled mainly NW-SE within the middle and southern boreal subzones of Hämet-Ahti (1976) from central Alaska to Newfoundland. Based on vascular florsitic criteria, La Roi recognized six classes. The Heart Lake stands correspond both floristically and geographically to his "Lonicera/Rubus-Lathyrus" class of the "Populus/Salix/Shepherdia stand group." Species from this class with high regional presence values (La Roi 1967:244, Fig. 2) in common with phytocoenon V were: Populus tremuloides, P.

balsamifera, Betula papyrifera, Salix spp., Shepherdia canadensis, Rosa acicularis, Lonicera dioica, Amelanchier alnifolia, Rubus pubescens, Lathyrus ochroleucus, Fragaria virginiana, Vaccinium vitis-idaea, Geocaulon lividum, Elymus innovatus, Pyrola asarifolia, and Equisetum scirpoides.

In a subsequent report La Roi and Stringer (1976) described the bryophyte components of the same stands sampled in La Roi's (1967) study. For North American white spruce-fir stands, they recognized a single order, "Hylocomium splendens - Pleurozium schreberi" composed of two alliances, "Ceratodon purpureus - Pylaisiella polyantha" in the west and "Rhynchostegium serrulatum - Tetraphis pellucida" in the east. In relation to the western alliance, which comprises three associations, white spruce stands of the study area appeared transitional between the "Aulacomnium palustre - Lophozia spp." and "Mnium cuspidatum - Oncophorus wahlenbergii" association which straddled Heart Lake geographically.

A subjective assessment of floristic similarity of white spruce communities by subzone in west central Canada is given in Table 21. This compairson shows that the white spruce forests at the Heart Lake study area most closely resemble those within the middle boreal subzone. They also support some of species-zone relationships reported by Larsen (1972). In general, they show that several species, usually forbs, are typically found in the

Table 21. Occurrence by subzone of similar white spruce forests in west central Canada. Strong similarity = xx, moderate similarity = x.

Subzone / Reference	Phytocoenon V A & V B
Northern Boreal[a]	
Inglis 1975 "white spruce-tall shrub-moss type"	x
Johnson 1981 white spruce communities	x
Raup 1935, 1946 "park like white spruce forests"	x
Maini 1966 "*Picea glauca* parkland"	x
Middle Boreal[a]	
Thieret 1964 "white spruce forest"	xx
Looman 1969 "climax white spruce woods, type 13"	xx
Moss 1953a "white spruce association" (Alta-NWT boundary)	xx
La Roi 1967 "*Populus*/*Salix*/*Shepherdia*" (Ft. Providence site)	xx
Rowe 1972b white spruce communities	xx
Southern Boreal[a]	
Stringer 1976 "upland white spruce-aspen"	x
Achuff & La Roi 1977 "*Viburnum edule*/*Hylocomium splendens*"	x
Van Grounewoud 1965 upland white spruce communities	x
Lesko & Lindsay 1973 white spruce communities	x
Swan & Dix 1966 "*Picea glauca* dominant"	x
Moss 1953a "white spruce association" (excluding Alta-NWT Boundary)	x
La Roi 1967 "*Populus*/*Salix*/*Shepherdia*" (excluding Ft. Providence)	x

a *sensu* Hämet-Ahti (1976).

southern boreal forest: Aralia nudicaulis, Maianthemum canadense, Mertensia paniculata, Petasites palmatus, Abies balsamea (seedlings), and Galium triflorum, while the northern boreal was characterized by shrubs: Betula glandulosa, Ledum decumbens, Empetrum nigrum, and Vaccinium uliginosum. In contrast, the middle boreal subzone has no species which are restricted to it.

The "upland mesophytic white spruce forests" (Raup 1946) bear a strong floristic resemblance to those of the study area; 72% of the species listed by Raup occurred in phytocoenon V. As noted by Rowe (1956), however, Raup's group is too broad to convey much information on the characteristics of particular communities. Raup (1946) characterized his type with four "primary species": Picea glauca, Salix bebbiana, Ptilium crista-castrensis, and Pleurozium schreberi. One major difference with the study area was the apparent importance of Ptilium in Raup's type rather than Hylocomium splendens. The only site in the Heart Lake area where Ptilium becomes prominent was the mesic escarpment canyon. Achuff and La Roi (1977) also note an affinity of Ptilium for mesic sites. A number of "secondary species" (Raup 1946) are common to both areas such as: Salix bebbiana, Rosa acicularis, Shepherdia canadensis, Linnaea borealis, Pyrola asarifolia, Mitella nuda, Geocaulon lividum, Cornus canadensis, Pleurozium schreberi, and Peltigera aphthosa. Three of Raup's secondary species were not observed in Heart Lake white spruce forests: Equisetum sylvaticum, Lycopodium annotinum, and Maianthemum canadense.

For northwestern Alberta, Moss (1953a, 1955) recognized a single Clementsian "white spruce association" which comprises several faciations. Of all faciations, the "grass shrub faciation" most closely resembles the upland white spruce vegetation at Heart Lake. Moss (1953a) characterized this faciation by Elymus innovatus, Shepherdia canadensis, and Alnus crispa, regarding it as an edaphic climax of dry and poor sites. Aster conspicuus was also considered characteristic by Moss but not recorded within the study area. In contrast, the "feathermoss faciation" considered by Moss (1953a) to be comparable to the "upland mesophytic forest" of Raup (1946) is less abundant at Heart Lake.

The "flood plain white spruce forests" studied by Raup (1934, 1946, 1947) for the Peace and Liard River regions, Athabasca-Great Slave region, and Fort Simpson area, respectively, were all closely related to the alluvial white spruce forests at Heart Lake (VB: No. 9). Characteristic species common to all include Picea glauca, Populus balsamifera, Salix bebbiana, Viburnum edule, Cornus stolonifera, Alnus incana, Equisetum pratense, Mitella nuda, Rubus acaulis. Species notably absent from the alluvial forest in the study area included Actaea rubra, Maianthemum canadense, and Mertensia paniculata.

Although *Alnus incana* and *Ribes* spp. were absent from phytocoenose 9, they were nevertheless common in other alluvial Heart Lake forests.

Floristically similar spruce types on floodplains in western Canada have been described by a number of other investigators: "white spruce-balsam poplar forests", lower Liard River, Northwest Territories (Jeffrey 1964:73); "white spruce forest", lower Peace River, Alberta (Jeffrey 1961:6); and "alluvial lowlands spruce forest", lower Peace River, Alberta and Northwest Territories (Lacate et al. 1965:19). Other studies within the District of Mackenzie briefly mentioned possibly comparable types, but absence of detailed species lists precluded a valid assessment: Mackenzie River Valley ("white spruce/*Hylocomium* unit" in part, Reid 1974; "*Picea glauca*/*Rosa*/*Hylocomium* unit", Reid and Janz 1974); Liard River valley ("white spruce forests in recent floodplains", Day 1966); Fort Simpson area (Rowe 1972b); and the Peace-Athabasca region ("shrub-horsetail-moss community", Duffy 1965).

To the southeast, Jeglum (1973a) described a similar type in central Saskatchewan, the "*Picea glauca* - *Equisetum pratense*, *Mitella nuda* - *Hylocomium splendens* - moist forest" where *Alnus incana* is replaced by a related species, *Alnus rugosa*. Nearby on the Saskatchewan River delta, Dirschl and Coupland (1972) reported a related type, "alluvial mixed *Populus balsamifera* - *Picea glauca*" with an understory similar to that described by Jeglum (1973a). Previously Rowe (1956) noted the resemblance between Raup's alluvial types and his own white spruce stands observed on very moist alluvium in the "southern boreal forest". Moss (1953b) regarded his "shrub-herb faciation" of central and northwestern Alberta as somewhat akin to Raup's floodplain forests. Similar observations may be made for comparable types in the "Mixedwood Section" of central Alberta (Duffy 1965). In making these comparisons, it should be remembered that nearly all the studies mentioned were from the southern boreal and possessed a greater dominance and diversity of forb species than Heart Lake.

Bottomland balsam poplar forests are often regarded as an intermediate successional stage usually culminating in a white spruce forest (Jeffrey 1964). In phytocoenose 9 this sequence was suggested by the occurrence of decaying poplar trees. Thus, alluvial white spruce types are allied to Knapp's (1957, 1965) "*Populetalia balsamiferae*" characterized by such species as *Populus balsamifera*, *Cornus stolonifera*, *Rosa acicularis*, *Viburnum edule*, *Calamagrostis canadense*, and *Equisetum pratense*. Similarly, Krajina (1969) described an "*Equiseto* (*arvensis*) - *Mertensis* (*paniculatae*) - *Viburno* (*edulis*) - *Corno* (*stoloniferae*) - *Larico* (*laricina*) - *Piceo* (*glaucae*) - *Populetum* (*balsamiferae*) on floodplain gleyed Regosols for his boreal white and black spruce zone in British Columbia.

In summary, the white spruce forests of the Heart Lake area are transitional between the main boreal and subarctic (Knapp 1965; and corresponding zones of other authors). This transition is interpreted as a middle boreal subzone (Hämet-Ahti 1976) whose phytocoena are most closely related to other types within the subzone. Reports cited in the literature and the data from the study area support the species/zone relationships established by Larsen (1972) and extended his observations into areas outside his original study area.

Jack pine woodlands

Boreal pine forests on sandy sites ("Boreale Sand-Kiefernwalder" Knapp 1965:83) or jack pine barrens are recognized as a significant component of North American boreal vegetation and were distinguished as an order Pinetalia banksianae (Knapp 1957) in an earlier review. Knapp (1965) lists ten characteristic taxa and of these four are present (*) at Heart Lake: Pinus banksiana*, Arctostaphylos uva-ursi*, Epigaea repens, Maianthemum canadense, Chimaphila umbellata, Gaylussacia baccata, Vaccinium angustifolium, V. myrtilloides, V. vitis-idaea*, Cladonia spp.*.

Subjective comparison was made between jack pine types recognized here and those of other workers. The strongest similarity occurred between the jack pine woodlands of the study area and those in the middle boreal subzone (Table 22). Characteristic species usually common to these types include: Shepherdia canadensis, Rosa acicularis, Juniperus communis, Arctostaphylos uva-ursi, Linnaea borealis, Vaccinium vitis-idaea, Zygadenus elegans, Galium boreale, Elymus innovatus, and Cladonia spp. Northern boreal pine woodlands (Johnson 1981) differ from those of the study area primarily because of the importance in them of species like Empetrum nigrum, Vaccinium uliginosum, Ledum groenlandicum, and Stereocaulon paschale. There was moderate similarity between the Heart Lake jack pine communities and those of the southern boreal. The latter usually differed due to the presence of Vaccinium myrtilloides, richer herb component, e.g., Mainthemum canadense, Aralia nudicaulis, Solidago spp., and lower lichen cover.

Table 22. Occurrence by subzone of similar jack pine woodlands in west central Canada. Strong similarity = xx, moderate similarity = x.

Subzone Reference	Phytocoenon III
Northern Boreal[a]	
Johnson 1981 "open jack pine-lichen"	x
Middle Boreal[a]	
Theiret 1964 "jack pine forest"	xx
Lindsey 1952 "white spruce-jack-pine-aspen"	xx
Rowe 1972b jack pine communities	xx
Raup 1947 "upland jack pine forests"	x
Looman 1969 "climax jack pine woods, type 20"	x
Southern Boreal[a]	
Moss 1953a "pine heath", "pine feathermoss"	x
Dowding 1929 "pine heath", "pine moss"	x
Stringer 1976 "upland jack pine forests"	x
Duffy 1965 "Productivity class III"	x
Swan and Dix 1966 "_Pinus banksiana_ leading dominant"	x

[a] _sensu_ Hämet-Ahti (1976).

The jack pine forests of the Athabasca - Great Slave Lake region were described by Raup (1946) as occurring in two phases: (1) sandy plains or ridges, and (2) rocky hills of granite or very hard metamorphic rocks. Primary species (Raup 1946) common to these phases are Pinus banksiana, Betula papyrifera, Arctostaphylos uva-ursi, Cladonia rangiferina, and Cetraria nivalis; while rocky woods contain Picea glauca, Amelanchier alnifolia, Saxifraga tricuspidata, and Artemisia frigida; and sandy woods have Picea mariana, Alnus crispa, Vaccinium myrtilloides, and V. vitis-idaea. Based on a floristic comparison between Raup's detailed floristic lists and the study area, 76% of the flora from the Heart Lake jack pine woodlands was in common with the "sandy woods phase", but only 41% was in common with the "rocky woods phase". Thus, the study area showed the greatest resemblance to Raup's "sandy woods phase". In comparing the two areas it should also be noted that Betula papyrifera and Picea mariana, although present at Heart Lake, did not usually attain the status of "primary species" as they did in Raup's work. Examples of species notably absent at Heart Lake were Vaccinium myrtilloides, Maianthemum canadense, Hudsonia tomentosa, Pulsatilla ludoviciana, and Aralia nudicaulis. Moss (1955:536) stated that Raup's "sandy woods" phase was somewhat like jack pine forests farther south but differs in several important respects, principally in its primary species:

Picea mariana, Cladonia rangiferina, and Cetraria nivalis.

Spanning the middle and northern boreal subzones between latitudes 60°-65°N along the proposed Mackenzie Valley pipeline route, Reid and Janz (1974) described a "Pinus (contorta,banksiana)/Shepherdia/Linnaea unit". However, Reid (1974) did not report the type north of 65°. All 16 species mentioned by Reid and Janz (1974) occurred in the jack pine barrens at Heart Lake.

In summary, jack pine woodlands of the Heart Lake study area are most clearly related to jack pine types located within the middle boreal subzone which is characterized by higher lichen cover and lower herb diversity than the southern boreal.

Aspen-poplar forests and related types

The most comprehensive treatment of aspen forests occurring in central and northern Alberta is that of Moss (1932, 1953a, 1955) who regarded the poplar vegetation of Alberta as a Clementsian association within which balsam poplar and aspen consociations are recognized. Of these two consociations, the latter is most nearly related to the Populus tremuloides - Viburnum edule phytocoenon (IV) at Heart Lake.

The aspen consociation was characterized by Moss (1955) as consisting of five strata: (1) nearly continuous tall tree; (2) poorly developed, intermittent small tree and tall shrub; (3) rich or sparse lower shrub; (4) prominent tall herb; and (5) low herb, including mosses and lichens. A close structural conformity exists between the first three strata and those of the study area. At Heart Lake the tall herb stratum never achieved the degree of dominance suggested by Moss whose tall herb stratum may obscure the low shrub stratum in summer. The low herb stratum of the study area was poorly developed. Although the three lowest vascular strata were dominated by low shrubs at Heart Lake, tall forbs attained their maximum development in the Populus tremuloides - Viburnum edule phytocoenon.

Typical species of the aspen consociation (Moss 1953a, 1955) which also occur in phytocoenon IV include: Salix bebbiana, Amelanchier alnifolia, Cornus stolonifera, Rosa acicularis, Viburnum edule, Shepherdia canadensis, Ribes oxyacanthoides, Cornus canadensis, Vicia americana, Lathyrus ochroleucus, Epilobium angustifolium, Rubus pubescens, and Elymus innovatus. Also characteristic of both are the "stockings" of Pylaisiella polyantha on tree trunk bases. Several other species regarded as characteristic or prominent by Moss were not recorded, notably Symphoricarpos albus, Rubus strigosus, and Maianthemum canadense. These three species, however, are also either absent or infrequent in Moss's northernmost stands, suggesting their lesser role to the north. Moss (1955) also mentions the rarity in northern aspen forests of species such as *Corylus cornuta*, *Prunus* spp., *Aralia nudicaulis*, and *Disporum trachycarpum* which are leading dominants in central Alberta. Investigations of aspen forests in the study area confirmed his observations.

Descriptions of aspen stands (Thieret 1964; Rowe 1972b) from the middle boreal subzone of the southern Mackenzie District, as far as can be determined from the brief species lists, resembled those of the study area.

Aspen communities of the southern and hemiboreal "mature aspen forest" (Bird 1930), "aspen consociation (variant)" (Moss 1952), and "aspen woodlands" (Breitung 1954) are only weakly related floristically to the Heart Lake aspen types. Other investigators described types from the middle and southern boreal subzones, but further north latitudinally than the above, resembling Moss's consociation: "aspen - black poplar pioneer woods" (Day 1972, Looman 1969), "closed aspen forest" (Jeffrey 1961), and "aspen woods" (Raup 1934:93, 1935:27, and 1946:48). Although they closely correspond with the Heart Lake study area, their species composition differed by the presence of several species which are often associated with northern prairies, e.g., *Agropyron trachycaulon*, *Botrychium lunaria*, *Delphinium glaucum*, *Smilacina stellata*, and *Symphoricarpos occidentalis*.

Species composition of "*Populus tremuloides* dominated tree stands" (Dix and Swan 1971) in the southern boreal subzone of central Saskatchewan were related to those of aspen stands in the study area but there were considerable differences, e.g., the central Saskatchewan aspen stands contain more southern species like *Aralia nudicaulis*, *Rubus strigosus*, *Viola rugulosa*, *Maianthemum canadense*, and *Trientalis borealis*. With the exception of three species, i.e., *Amelanchier alnifolia*, *Ribes*, and *Shepherdia canadensis*, they possess species characteristic of Moss's (1955) aspen consociation. The first two species are very common in the Saskatchewan boreal forest but were not mentioned by Dix and Swan (1971).

Looman (1977) observed that although aspen grows in nearly pure stands throughout the Prairie Provinces, *Populus balsamifera* or *Betula papyrifera* may form important admixtures with it in most northern parkland areas. Accordingly, the aspen forests at Heart Lake contain a prominent balsam poplar and a minor white birch component.

Aspen forests in the Rocky Mountains of western Alberta (Lulman 1976) are related to those of the study area but differed both in structure and floristic composition. Contrary to the study area, his shrub stratum was depauperate, while the herb stratum was the predominant understory layer. Floristically, Lulman's three community types, *Elymus innovatus*, *Shepherdia*/*Aster conspicuus*, and *Vicia americana*, share 35%, 31% and 24%, respectively of their vascular flora with phytocoenon IV.

Aspen was also a significant component of the Populus tremuloides (Picea) - Alnus crispa - Hylocomium splendens phytocoenon (V A), as well as phytocoenon IV. In fact, the two were agglomerated in both the life-form and floristic dendrograms at the 40% and 60% levels, respectively. Unlike phytocoenon IV, however, phytocoenon VA was a mixedwood type whose understory was characterized by Alnus crispa and feathermosses.

It follows, accordingly, that mixedwood forests described for the Mackenzie District by Jeffrey (1964:27) "B4, Mixedwood forest, Mackenzie Lowland", Rowe et al. (1974:77) "mature open mixed forest", Reid and Janz (1974) "Populus/Rosa unit" are more nearly relatable to phytocoenon VA. Examples of common understory species are: Alnus crispa, Rosa acicularis, Viburnum edule, Linnaea borealis, Cornus canadensis, Geocaulon lividum, Epilobium angustifolium, and Hylocomium splendens.

There is some evidence which suggests an increase in the prominence of Alnus crispa in the middle and northern boreal deciduous forests (Rowe 1956), while to the south investigators like Moss (1955) and Raup (1946) did not report it as being prominent. Such an increase ties in very well with the elevational sequence in Jasper and Banff National Parks, Alberta, where Shepherdia canadensis, Alnus crispa, and Menziesia glabella sequentially peak in cover with increasing altitude (La Roi and Hnatiuk 1980).

Distinctly different aspen types resembling the xeric *Populus tremuloides* - *Juniperus communis* - *Ditrichum flexicaule* phytocoenon (IIB) were described in two studies from western Alberta. On steep south-facing colluvial slopes in the mountains Corns and Kojima (1977) delineated an "open type" whose characteristic species are shared with the study area: *Populus tremuloides*, *Rosa acicularis*, *Juniperus communis*, *Achillea millefolium*, *Arctostaphylos uva-ursi*, *Elymus innovatus*, *Fragaria virginiana*, and *Epilobium angustifolium*.

There are no published descriptions of types comparable to the aspen consociation (Moss 1955) in the northern boreal subzone. It is therefore suggested that the aspen consociation reaches its northern limits in the middle boreal subzone. Supporting evidence came from several investigations. In the Norman Wells area of the Mackenzie Valley, Porsild (1943) notes that aspen and balsam poplar are either not very abundant or have dropped out and that *Picea glauca* and *Betula papyrifera* are the principal upland forest trees. This coincided with a study by Reid (1974) in the middle Mackenzie Valley for which no descriptions of aspen types were made. Instead, he described deciduous and mixedwood forest types such as the "white birch/*Rosa*, *Salix* unit" and the "white spruce, white birch/*Alnus crispa* unit". Further north, Hettinger et al. (1973) described a "winter deciduous orthophyll forest and shrub formation" with *Betula papyifera*, *Alnus* crispa, Vaccinium vitis-idaea, and Linnaea borealis on the Peel Plateau, but did not mention aspen.

In summary, the aspen-poplar forests (IV) of the study area are most similar to aspen types described from the middle boreal subzone and represent a northern variant of Moss's (1955) "aspen consociation" whose northern limit appears to lie within this subzone. In contrast, mixedwood types (VA) possessing a prominent Alnus crispa understory are best developed in the middle and northern boreal subzone.

Woodland muskeg

At the highest Braun-Blanquet syntaxonomic level, the black spruce bogs of the study area (VI A) belong to the circumboreal class of raised bog communities, Oxycocco - Sphagnetea. Within this class Tüxen et al. (1972) distinguished the North American order Sphagnetalia fusci with the character species Sphagnum fuscum, Rubus chamaemorus, Chamaedaphne calyculata, Mylia anomala, Polytrichum strictum, Dicranum undulatum, and Sphagnum imbricatum and differential species Empetrum nigrum, Cladonia rangiferina, and Cladonia arbuscula. All were recorded within phytocoenon VI A except Sphagnum imbricatum (Tüxen et al. 1972).

Within Sphagnetalia fusci, Tüxen et al. (1972) recognized two North American alliances: (1) Ledum decumbentis - Sphagnion fusci from the northwest, characterized by Ledum decumbens, Pedicularis labradorica, and Betula nana; and (2) Kalmia - Sphagnion fusci from central and eastern regions, characterized by Ledum groenlandicum, Kalmia polifolia, and K. angustifolia. Rather than fitting decisively into either of these alliances, the treed bog vegetation at Heart Lake exhibited intermediate characteristics as might be expected from an examination of the vegetation map (Fig. 11). Phytocoenon VI A contained both Ledum groenlandicum and L. decumbens but lacked all other character species found in either alliance. In addition, species often characteristic of eastern Kalmia - Sphagnion fusci such as Sarracenia purpurea, Andromeda glaucophylla, Vaccinium angustifolium, and others were absent in VI.

According to Knapp (1965:87) the floristic composition of "woodland muskeg" or "Acidiphile Waldmoore" does not change markedly across North America. Using the apparently synonymous term "black spruce bog association", Katz (1971:157) states that the association is mainly three-layered throughout its range, i.e. "spruce-low shrub - Sphagnum bogs".

Although woodland muskegs are frequently mentioned in western North American literature, comparisons are difficult because complete species lists were seldom presented. When lists were published, they often incorporated slightly richer types or "transition bogs" (Lavkulich 1972; Raup 1934, 1946) which are not homologous with the ombrotrophic conditions implied by the vegetation of the Heart Lake peat plateaus. Black spruce bogs in west central Canada (Table 23) share a number of species with the study area. The tree stratum was dominated by Picea mariana, while the low shrub and dwarf shrub strata were usually dominated by Ledum groenlandicum, Chamaedaphne calyculata, Andromeda polifolia, Oxycoccus microcarpus, O. palustris, Kalmia polifolia, and occasionally Ledum decumbens and Betula glandulosa. Frequent herbaceous species were Rubus chamaemorus, Drosera rotundifolia, and Smilacina trifolia with the bryoid layer usually composed of Sphagnum fuscum, Dicranum undulatum, Polytrichum spp., and Cladonia spp.

Communities showing the strongest floristic similarity occurred in the middle and northern boreal subzones, particularly those described as peat plateaus (Table 23). Southern boreal types were not as closely related to the study area. For example, although the "black spruce-peat moss association" (Moss 1953b) described from the southern boreal subzone of northwestern Alberta exhibit some similarities to phytocoenon VI A, such as the presence of Picea mariana, Ledum groenlandicum, Rubus chamaemorus, Sphagnum fuscum, Polytrichum strictum, and Icmadophila ericetorum, there were marked differences, e.g., absence of Andromeda polifolia, Chamaedaphne calyculata, Ledum decumbens,

Table 23. Occurrence by subzone of similar black spruce bogs in west central Canada. Strong similarity = xx, moderate similarity = x.

Subzone Reference	Phytocoenon VIA
Northern to Middle Boreal[a]	
Reid 1974 "scattered black spruce/*Cladonia*, *Sphagnum* unit"	xx
Reid and Janz 1974 "Sparse *Picea mariana*/*Rubus* *Cladonia* unit"	xx
Rowe et al. 1974 "peat plateau"	x
Middle Boreal[a]	
Day 1972 "black spruce woods, type 16" in part	
Larsen 1972 "open muskeg" in part	x
Lavkulich 1972 "black spruce - *Sphagnum-Ledum*"	xx
"black spruce - *Cladonia-Ledum*"	xx
Rowe 1972b "vegetation of poorly drained organic soil; bogs"	xx
Rowe et al. 1975 "treed ombrotrophic peat plateaus"	xx
Thieret 1964 "wet phase of bog forest"	x
Middle to Southern Boreal[a]	
Raup 1934 "muskeg forest" in part	x
Raup 1946 "wet phase of bog forest"	x
Southern Boreal[a]	
Hansen 1950, 1952 "muskeg"	x
Jeglum 1973b "*Picea mariana* - *Ledum groenlandicum* *Sphagnum* type"	x
Lewis et al. 1928 "young bog forest"	x
Moss 1953b "black spruce-peat moss association"	x

[a] *sensu* Hämet-Ahti (1976).

Cladonia alpestris, C. arbuscula, and C. rangiferina. Also, many species like Habenaria hyperborea, Rubus acaulis, and Tomenthypnum nitens mentioned by Moss were characteristic of richer habitats, and were more similar to phytocoenon VI B, a poor fen. Another southern boreal example, the "Picea mariana - Ledum groenlandicum - Sphagnum fuscum vegetation type" (Jeglum 1973a) described from central Saskatchewan, when related to the Heart Lake study area, shared a number of species but lacked others like Andromeda polifolia, Chamaedaphne calyculata, and Ledum decumbens. Also, the flora was relatively rich with species such as Rhamnus alnifolia, Ribes hudsonianum, Lonicera villosa, Salix planifolia, Aster junciformis and many others.

It is noteworthy that ombrotrophic vegetation described from the Hudson Bay Lowlands of Ontario (Sjörs 1963) is similar to phytocoenon VI A, with many shared vascular species. Collectively, species from the study area growing under ombrotrophic conditions accounted for 50% of the ombrotrophic flora of the Hudson Bay Lowlands.

Although peatlands may be classified according to floristic composition, they may also be described as organic landforms. Descriptions of peat plateaus by Lavkulich 1972, Rowe et al. 1975, Tarnocai 1970, and Zoltai 1972 applied equally well to the study area. For example, Lavkulich (1972:15) described raised ombrotrophic peat plateaus in the Fort Simpson area as consisting of "frozen sphagnum derived peat deposits with hummocky surfaces raised 1-2 m above the surrounding fen deposits...low fertility and low pH of the peat are characteristic". When seen from the air, peat plateaus often have a pock-marked appearance, termed "collapse scars" (Lavkulich 1972) as in the study area. In contrast to the treed portions of the peat plateau, the collapse scars were dominated by dwarf shrubs or graminoids.

A classification of the wetland regions of Canada by Zoltai et al. (1975:508-509) appropriately includes the study area in the region of "subarctic bogs, peat plateaus, and string fens...characterized by bogs (often somewhat elevated by permafrost) and string fens". To the south, at about 57°N latitude in Alberta, this region changes to one of "continental boreal bogs and fens", while north of a line roughly passing through Fort Providence and Fort Smith, the region of subarctic bogs passes into one of "subarctic peat plateaus and fens" characterized by the presence of palsa bogs. No palsas were observed within the study area.

In a study of peat plateaus in central Manitoba and Saskatchewan, Zoltai (1972) recognized four developmental stages of peat plateaus: incipient, young, mature and overmature. Peat plateaus in the study area appeared to be in the late mature stage. Zoltai (1972) described the mature stage as supporting open stands of stunted black spruce with _Ledum groenlandicum_ and some

Chamaedaphne calyculata usually with a nearby continuous *Cladonia* mat on the surface, as in the study area. The overmature stage is characterized by thermokarst features (water filled depressions) and collapsing edges with dense stands of tall black spruce and a ground cover of feathermosses. Although some peat plateaus within the study area exhibited thermokarst features, feathermosses were rare.

"Treeless lichen peat plateaus" (Rowe et al. 1975) did not occur within the study area, supporting Rowe's observation that such assemblages occur at higher latitudes (Norman Wells) and higher elevations (Horn Plateau) than the study area. Rowe believes they are related to past fires that destroyed the living *Sphagnum*. Fires might kill *Sphagnum* on the higher portions of peat plateaus at Heart Lake but the black spruce either withstood the fires (VI A: No. 40) or regenerated.

Patterned fens or string fens ("Strangmoore", Knapp 1965) are often associated with peat plateaus. Their occurrence as a terrain feature is well documented in North America: District of Mackenzie (Crampton 1972, Lavkulich 1972, Reid 1974, Reid and Janz 1974, Zoltai and Pettapiece 1973); Alberta (Lewis et al. 1928, Moss 1953b); and Saskatchewan (Jeglum 1973a). However, few previous studies have closely examined their floristic composition.

An aapamire study in central Canada (Knollenberg 1964) correlated string fen development with maximum freeze-thaw depths. It further indicated that string fens are mainly a boreal phenomenon with northern limits approximately paralleling the boundary of the main boreal zone. Katz (1971) reported they are a circumboreal phenomenon. Tarnocai (1970) distinguishes two types of patterned fens: "string fens", where the ridges or "strangs" are more or less parallel; and "net-like patterned fens" where the ridges are interlocked forming a reticulate pattern as in the Heart Lake area. Tarnocai (1977, personal communication) observes that the net-like strang pattern predominates in the middle boreal subzone of Manitoba and the parallel pattern predominates in the southern boreal. Zoltai (1977, personal communication), however, suggests the two patterns may be related to slope rather than latitude with net-like patterns developing on very slight slopes and parallel patterns where slopes are steeper.

The vegetation of North American strang communities is not well known. Because most studies of patterned fens are terrain oriented, the investigators usually give a brief vegetation description and mention only a few species. Also, strang vegetation frequently intergrades and forms complexes due in part to the edge effect of the minerotrophic flarks.

Two general descriptions resembling the study area are given by Rowe (1972b) for the Fort Simpson area, Northwest Territories, and by Tarnocai (1970) for

Manitoba. When combined, these descriptions include most of the strang variation observed within the study area. Rowe (1972b:123) stated: "The ridges are usually darker green from such shrubbery as *Salix candida*, *Myrica gale*, and *Betula glandulosa*, although open forest stands of tamarack, white spruce, white birch, and black spruce are occasionally seen". White birch was not encountered on comparable strangs within the study area, however. Tarnocai (1970:18) described strang communities as "*Larix* - feathermoss" or "*Larix* - black spruce - *Sphagnum*" types. Both have *Betula glandulosa*, *Salix* spp., some ericaceous species, and various sedges and bryophytes.

Comparisons with flark vegetation are given in the "Boreal sedge-brown moss fens" subsection.

Thus, the woodland muskegs within the study area are most relatable to raised ombrotrophic peat plateaus of the middle boreal subzone and belong to the order *Sphagnetalia fusci* of the circumboreal class *Oxycocco - Sphagnetea*. The circumpolar ridge vegetation of net-like patterned fens is not well documented in the literature but appears most nearly related to those of the middle boreal in North America.

Coniferous swamps

Knapp (1965:81) subdivides boreal coniferous swamps into "rich coniferous swamp forests" and "open tamarack swamps". These are roughly equivalent to the *Picea mariana* - *Tomenthypnum nitens* phytocoenon (VII A) and the *Picea mariana* - *Larix laricina* - *Campylium stellatum* phytocoenon (VII B). Tamarack rarely occurred in pure stands at Heart Lake and was admixed with black and white spruce. Most stands seemed intermediate between Knapp's two swamp types.

As characterized by Knapp (1965) rich coniferous swamp forests consist of a mixture of diverse coniferous species. In the southeast *Thuja occidentalis* is often dominant but it is replaced by *Picea glauca* in the north. The group is differentiated by brown mosses, minerotrophic *Sphagna*, and by many of the same species which distinguish the "spruce-fir forests rich in herbs" (Knapp 1965). At Heart Lake these include *Viburnum edule*, *Rosa acicularis*, *Equisetum pratense*, and *Mitella nuda*. Within the study area, however, one cannot expect to find examples closely equivalent to Knapp's descriptions which are mainly extracted from more southerly types. Accordingly, many of the species Knapp mentions are southern in distribution and absent from Heart Lake swamps, e.g., *Actaea rubra*, *Aralia nudicaulis*, *Gymnocarpium dryopteris*, *Oxalis montana*, and *Viola pallens*.

"Open tamarack swamps" are not clearly defined by Knapp (1965:18) but the importance of sedges and "species characteristic of boreal coniferous forests, constituting the shrub, herbaceous, and moss layers" is stressed.

After Knapp (1965) published his review, a number of studies appeared which, combined with earlier reports, make it possible to obtain an overview of coniferous swamp composition in northern and western Canada. From an examination of the literature for this région, I established a broad framework of typical coniferous swamp understory species: "Picea mariana, Salix myrtillifolia, Arctostaphylos rubra, Aulacomnium palustre association" (Annas 1971); "Picea mariana - Ledum groenlandicum - Tomenthypnum nitens vegetation type"(Corns and Kojima 1977); "black spruce woods, type 15" (Day 1972); "shallow bog", deep bog", and bog border" (Horton and Lees 1961); "B3, black spruce flats", "D7, black spruce bog forest, ancient and intermediate floodplain", and "C11, black spruce bog forest, terrace"; Jeglum 1973a "tamarack swamp" (Jeffrey 1964); "black spruce vegetation - Tomenthypnum group"; "Hylocomium group", "Mixed character group", and "Potentilla group" (Laidlaw 1971); "vegetation of poorly drained mineral soils" (Lavkulich 1973); "black spruce - tamarack in the Mackenzie lowlands" (Lindsey 1953); "tamarack swamp" (Moss 1953b); "birch bog" and "muskeg" in part (Raup 1935); "tamarack - black spruce - Vaccinium uliginosum - moss unit" (Reid 1974); "vegetation of poorly drained mineral soil" (Rowe 1972b); and "black spruce bog forest, dry phase" in part (Thieret 1964). The characteristic species are Betula glandulosa, Ledum groenlandicum, Potentilla fruticosa, Salix myrtillifolia, *Arctostaphylos rubra*, *Vaccinium vitis-idaea*, *Equisetum scirpoides*, *Geocaulon lividum*, *Tomenthypnum nitens*, *Hylocomium splendens*, and *Aulacomnium palustre*. Other less constant species include: *Salix glauca*, *Vaccinium uliginosum*, *Empetrum nigrum*, *Linnaea borealis*, *Mitella nuda*, *Carex aquatilis*, *C. capillaris*, *Rubus acaulis*, and *Smilacina trifolia*.

The coniferous swamps at Heart Lake fitted without difficulty into the general framework outlined above and were generally comparable to the references cited. Detailed comparisons were often hindered by methodological differences and lack of information on species composition. Some sites geographically far removed from Heart Lake were quite similar. For example, black spruce vegetation described by Laidlaw (1971) in Banff and Jasper National Parks, Alberta, exhibited very close parallels with the study area, both by the calcareous nature of the parent material and by species composition. Of 65 vascular species recorded by Laidlaw (1971, Table 7), 60% were present in phytocoenon VII A and VII B, many being well represented. A similar relationship existed within the bryoflora, 60% of which were present in phytocoenon VII A and VII B.

From the Alberta Foothills, Horton and Lees (1961) described black spruce swamps, termed "shallow bog" and "deep bog". Ninety-five percent of the shallow bog species were found within phytocoenon VII A and 97% of deep bog species occurred in phytocoenon VII B.

Descriptions from the Hudson Bay Lowlands (Sjörs 1959, 1961, 1963) also bear a close floristic and edaphic relationship to the study area. For Heart Lake the similarity to the Lowlands extended to ombrotrophic vegetation as well as swamps. Of the 55 vascular species listed by Sjörs (1961:8-10) for rich, mature, black spruce forests 69% were present within Heart Lake coniferous swamps. The similarity was greatest between phytocoenon VII A and Hawley Lake, both of which have a shallow peat layer.

In summary, the coniferous swamps occurring on calcareous parent material in the study area are closely related to a number of previously reported swamp types from similar calcareous substrates in west central Canada. The characteristic species of the regional coniferous swamps are identified and listed, extending the account of Knapp (1965). The Heart Lake types demonstrated a strong floristic similarity with the coniferous swamps of western Alberta and the Hudson Bay Lowlands.

Boreal sedge - brown moss, fens

Under this class Knapp (1965) included boreal basophilous to neutrophilous sedge - brown moss associations. Corresponding vegetation from Heart Lake included the Lobelia kalmii - Scirpus caespitosus - Campylium stellatum phytocoenon (VII C) and Salix pedicellaris - Menyanthes trifoliata - Drepanocladus revolvens phytocoenon (VIII).

Thirty-three characteristic species are listed by Knapp (1965:86) of which 76% occurred at Heart Lake. The class is primarily composed of small sedge species as well as brown mosses. Species common to Knapp's list and the study area included: Carex aquatilis, C. gynocrates, C. lasiocarpa, C. leptalea, C. livida, Eriophorum viridicarinatum, Equisetum palustre, Habenaria hyperborea, H. obtusata, Lobelia kalmii, Parnassia parviflora, Pinguicula vulgaris, Primula mistassinica, Triglochin palustris, Tofieldia glutinosa, and the brown mosses, Campylium stellatum, Drepanocladus revolvens, Scorpidium scorpioides, and Tomenthypnum nitens. Examples of species not recorded from Heart Lake were: Carex angustior, Juncus stygius, Arethusa bulbosa, Bartsia alpina, Drosera linearis, and Paludella squarrosa. Some of the latter species are more common to the south, while others showed a disjunct distribution. According to Knapp (1965) sedge - brown moss fens reach their optimum development in regions underlain by calcareous bedrock, as in the study area.

The Salix pedicellaris dwarf shrub peatland (VIII) compared closely with a number of related types:

"*Carex-Hypnum* association" (Lewis et al. 1928), "*Carex Drepanocladus* - *Salix* association" (Moss 1949); "sedge - wet moss community (*Carex* - *Drepanocladus*)" (Horton and Lees 1961); "Strang moor hollows" (Drury 1956); "*Carex* - *Drepanocladus* type" and "*Carex* - *Drepanocladus* - *Betula* type" (Tarnocai 1973); "marl fens" (Seaborn 1966); "string fen hollows" (Reid 1974); "dwarf birch - sedge fen" (Ritchie 1960b); and "eutrophic open muskeg" (Stanek 1975). The "low shrub fen" and "sedge fen" (Jeglum 1972a:5) should also be included here. Jeglum (1972a) stated there is "continuum of variation from low shrub fen into sedge fen" and utilizes 25-20% shrub cover as the level of separation. These distinctions were applicable to phytocoenon VIII A and VIII B, respectively.

Homologous types were reported from Ontario, "eutrophic sedge fens" (Anti and Hepburn 1967) and flarks (Sjörs 1961:15-17); Finland, "Rimpibraunmoore" (Ruunijarvi 1960), and Sweden, "*Scorpidium* association" (Sonneson 1970).

Comparison of the *Lobelia kalmii* - *Scirpus caespitosus* - *Campylium stellatum* phytocoenon (VIII C) with those described by other workers shows that several are closely related: Alberta "calcareous bogs" (Moss and Turn 961), "marly flats" (Turner 1949), "minerotrophic vegetation" (Pakarinen and Talbot 1976:74, Fig. 9); British Columbia - "wet *Larix* fens" (Porsild and Crum 1961:139-140); and Ontario - "rich fens" (Sjörs

1961:14-18), "riparian rich fens" (Sjörs 1963). It is of interest that the Heart Lake phytocoenon (VIII C) shared 81% of its rich fen vascular flora with the Hudson Bay Lowlands (Sjörs 1963). Examples of Heart Lake species in common with the types mentioned above are: Antennaria pulcherrima, Carex capillaris, Dodecatheon pauciflorum, Lobelia kalmii, Pinguicula vulgaris, Scirpus caespitosus, Selaginella selaginoides, Tofieldia glutinosa, T. pusilla, Triglochin maritima, and the mosses, Campylium stellatum, Catoscopium nigritum, and Scorpidium scorpioides.

Vegetation homologous to phytocoenon VIII C has been described from Newfoundland, "brown - moss fen" (Heikurainen 1968:48) and Finland, "Campylium stellatum - Braunmoore" (Ruuhijarvi 1960).

In summary, phytocoenon VIII is floristically very similar to corresponding sedge - brown moss fens described from boreal calcareous sites across North America and northern Europe.

Willow thicket

In Knapp's (1965:84) treatment of "boreal willow and alder thickets" a number of species were listed, including Salix planifolia and S. bebbiana, which are components of the Salix planifolia - Carex aquatilis - Brachythecium salebrosum phytocoenon (IXA). Boreal willow thickets generally occur along the banks of lakes and rivers (Knapp 1965) as in the study area. Homologous vegetation, "thicket swamps" (Jeglum et al. 1974:28) and "tall shrub fens" (Jeglum 1973a:6), are described for Ontario and central Saskatchewan, respectively. They also include the willows Salix planifolia and S. bebbiana. Particularly revealing is Jeglum's (1973a:6) characterization of "tall shrub fens" which strongly resemble those of Heart Lake: "only one tall shrub is important in a stand, and low shrubs of fens are unimportant. One to two species of graminoids, including most of the leading dominants of broad-leaved sedge fen, attain importance in each stand."

Few phytosociological descriptions closely resemble the Heart Lake phytocoenon. This might be due to the wide ecological amplitude attributed to species in "shore habitats" (Raup 1975) and the the absence of a general phytosociological treatment of shrub vegetation in boreal North America. Nevertheless, there are a number of general references whose dominant species were relatable to the study area.

From the southern District of Mackenzie Lindsey (1953) described a zonal sequence of Carex aquatilis - Salix planifolia - Salix bebbiana. If foreshortened, it would resemble the phytocoenon at Heart Lake. Raup (1946) also mentioned an apparent variation of Lindsey's (1953) sequence as follows: Salix planifolia - Salix petiolaris - Salix bebbiana. Raup further notes that Salix bebbiana persists into the forest and becomes a primary species of "flood plain timber". Similarly at Heart Lake, the abundance of Salix bebbiana peaks in phytocoenon IXA and the Picea glauca - Hylocomium splendens phytocoenon (V).

Dirschl et al. (1974) mentioned that for the Peace - Athabasca Delta Salix planifolia and S. bebbiana are dominant on perched basins and levee backslopes. They affirm that Salix planifolia is replaced by S. bebbiana as drainage conditions improve.

In the Slave River Lowlands, Day (1972:24) described a "willow brush" type that included, among other shrubs, Salix planifolia. Thieret (1964) also referred to a related thicket type occurring as a shrub zone on river islands.

Few investigators described the floristic composition of shrub understories. A comparison based on available information indicates that each is rather unique floristically but graminoids and mosses usually play a prominent role.

Tall-sedge meadows

"Boreal tall-sedge meadows" (Knapp 1965:84) are found along lake shores and slow-flowing water bodies. They closely resemble the Carex aquatilis - Carex rostrata - Potentilla palustris phytocoenon (IXB) which contains 7 of the 14 characteristic species listed by Knapp: Carex *aquatilis*, *C. rostrata*, *Calamagrostis inexpansa*, *C. canadensis*, *Lysimachia thyrsiflora*, *Scutellaria galericulata*, and *Sium suave*. One important species mentioned by Knapp, *Carex atherodes*, was apparently absent at Heart Lake.

Communities physiognomically similar to those of the study area consisting of tall graminoid emergents - usually with only 2-3 dominant emergents and a poorly developed bryoid stratum (Jeglum 1973a) - are described from a number of boreal North American sites in addition to those cited by Knapp: Alberta, "*Carex aquatilis* - *Carex rostrata* vegetation type" (Corns and Kojima 1977); "wet sedge meadow" (Day 1972); "*Carex* - *Potentilla* type" (Dirschl et al. 1974); District of Mackenzie, "pond fen" in part (Lavkulich 1972); "*Carex* fen" in part (Reid and Janz 1974); "shore fen" (Rowe 1972b); "rhizomaceous sedge mat around muck bottom lakes" (Thieret 1964); "shore fen" (Zoltai et al. 1975); and Saskatchewan, "emergent fen" (Jeglum 1973b).

Fully 75% of the vascular species occurring in Heart Lake shore communities (IXB) are circumpolar. Thus it is not surprising that a parallel exists with the "magnocariceta" of Sonneson (1970) in northern Sweden. The magnocariceta also occur along lake shores and are characterized by a poorly developed bryoid stratum and dominant emergents like *Carex aquatilis* and *C. rostrata*.

Floristic comparisons with Heart Lake are relatively uncertain due partially to the lack of floristic information, species poverty, and the open nature of the meadows (Raup 1957). Raup (1957:161), in an unsuccessful attempt to classify communities in shore habitats from the Athabasca - Great Slave Lake region, concluded that shore species did not behave as members of communities but "as populations of individual species that have found, perhaps in part by chance, sites that are satisfactory to them". For shore vegetation he suggests the term "community" be replaced by "assemblage".

Talus communities

No comparable published accounts from the boreal zone were found for the "Hypnum cupressiforme - Grimmia apocarpa phytocoenon" (I), but similar rock debris communities probably occur on calcareous substrates in other northern Rocky Mountains.

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APPENDIX I. Checklist of the vascular plants, bryopsida, hepaticopsida, and lichens of the Heart Lake area. Key to geographic category: C, Circumpolar; NA, North American; AB, Amphi-Beringian; AA, Amphi-Atlantic; Cos, Cosmopolitan; and Cord, Cordilleran. A subclass of circumpolar and cosmopolitan, widespread, w, indicated extremely wide-ranging species. The geographic classification of a taxon of lower rank was given after the species' geographic category if their distributions differ.

Vascular Plants

Geographic Category	
	OPHIOGLOSSACEAE
C	*Botrychium virginianum* (L.) Sw. var. *europaeum* Angstr.
	POLYPODIACEAE
Cos	*Cystopteris fragilis* (L.) Bernh.
C	*C. montana* (Lam.) Bernh.
C	*Polypodium vulgare* L. ssp. *virginianum* (L.) Hulten
C	*Woodsia glabella* R. Br.
	EQUISETACEAE
Cos	*Equisetum arvense* L.
C	*E. fluviatile* L.
C	*E. palustre* L.
C	*E. pratense* Erhr.
C	*E. scirpoides* Michx.
C	*E. variegatum* Schleich.

LYCOPODIACEAE

C	Lycopodium annotinum L. s. lat.
C	L. complanatum L. s. lat.

SELAGINELLACEAE

C	Selaginella selaginoides (L.) Link

PINACEAE

C	Juniperus communis L. s. lat.
NA	J. horizontalis Moench
NA	Larix laricina (Du Roi) Koch
NA	Picea glauca (Moench) Voss s. lat.
NA	P. mariana (Mill.) B.S.P.
NA	Pinus banksiana Lamb.

TYPHACEAE

C	Typha latifolia L.

SPARGANIACEAE

C	Sparganium angustifolium Mic[illegible]
C	S. minimum (Hartm.) Fries
NA	S. multipedunculatum (Morong) Rydb.

POTAMOGETONACEAE

C	Potamogeton filiformis Pers. var. borealis (Raf.) St. John
C	P. gramineus L.
C	P. natans L.
C	P. praelongus Wulfen
C	P. pusillus L.
NA	P. richardsonii (Benn.) Rydb.
C	P. vaginatus Turcz.

JUNCAGINACEAE

C, NA	Scheuchzeria palustris L. var. americana Fern.
C	Triglochin maritima L.
C	T. palustre L.

GRAMINEAE

NA	Agropyron trachycaulum (Link) Malte s. lat.
NA	A. violaceum (Hornem.) Lgd.
NA	Agrostis scabra Willd.
AB	Arctagrostis arundinacea (Trin.) Beal

C	Beckmannia syzigachne (Steud.) Fern.
C	Calamagrostis canadensis (Michx.) Beauv.
NA	C. inexpansa A. Gray
C, NA	C. lapponica (Wahlenb.) Hartm. var. nearctica Porsild
C	C. purpurascens R. Br.
C	Deschampsia caespitosa (L.) Beauv.
NA	Elymus innovatus Beal
NA	Festuca saximontana Rybd.
NA	Glyceria striata (Lam.) Hitchc. var. stricta (Scribn.) Fern.
C	Hierochloe odorata (L.) Wahlenb.
C	Hordeum jubatum L.
C	Koerleria cristata (L.) Pers.
NA	Muhlenbergia glomerata (Willd.) Trin. var. cinnoides (Link) Hermann
NA	Oryozopsis asperifolia Michx.
NA	O. pungens (Torr.) Hitchc.
Cos	Phleum pratense L.
C	Poa alpina L.
C	P. glauca Vahl. s. lat.
Cos	P. pratensis L.

CYPERACEAE

NA	Carex aenea Fern.
C	C. aquatilis Wahlenb.
NA	C. atratiformis Britt. ssp. raymondii (Calder) Porsild
NA	C. aurea Nutt.
C	C. canescens L.
C	C. capillaris L.
C	C. capitata L.
C	C. chordorrihiza Ehrh.
NA	C. concinna R. Br.
C	C. diandra Schrank
C	C. disperma Dewey
NA	C. eburnea Boott
NA	C. filifolia Nutt.
NA	C. foenea Willd.
NA	C. garberi Fern.
C	C. gynocrates Wormskj
NA	C. interior Bailey
C, NA	C. lasiocarpa Ehrh. var. americana Fern.
NA	C. leptalea Wahlenb.
C	C. limosa L.
C, NA	C. livida Willd. var. grayana (Dewey) Fern.
C	C. media R. Br.
C	C. paupercula Michx.
C	C. physocarpa Presl.

NA	C. richardsonii R. Br.
NA	C. rossii Boott
C	C. rostrata Stokes
NA	C. scirpoidea Michx.
C	C. tenuiflora Wahlenb.
C	C. vaginata Tausch
NA	C. viridula Michx.
NA	Eleocharis compressa Sulliv.
C	E. palustris (L.) R. & S.
C, NA	E. pauciflora (Lightf.) Link var. fernaldii Svenson
C	Eriophorum angustifolium Honck.
C	E. brachyantherum Trautv.
C	E. vaginatum L.
NA	E. viridicarinatum (Engelm.) Fern.
C	Kobresia simpliciuscula (Wahlenb.) Mack.
C	Rynchospora alba (L.) Vahl
C	Scirpus caespitosus L. ssp. austriacus (Pall.) Asch. & Graebn.
NA	S. validus Vahl

LEMNACEAE

C	Lemna minor L.

JUNCACEAE

NA	Juncus albescens (Lange) Fern.
C	J. alpinus Vill. ssp. nodulosus (Wahlenb.) Lindm.
C	J. balticus Willd. var. littoralis Engelm.

LILIACEAE

C	Allium schoenoprasum L. var. sibiricum (L.) Hartm.
NA (E. Asia)	Smilacina trifolia (L.) Desf.
NA	Tofieldia glutinosa (Michx.) Pers.
C	T. pusilla (Michx.) Pers.
NA	Zygadenus elegans Pursh

ORCHIDACEAE

C	Calypso bulbosa (L.) Oakes
C	Corallorhiza trifida Chat.
C, NA	Cypripedium calceolus L. var. parviflorum (Salisb.) Fern.
AB	C. guttatum Sw.
NA	C. passerinum Richards
C	Goodyera repens (L.) R. Br.
NA	Habenaria hyperborea (L.) R. Br.

C (?)	H. obtusata (Pursh) Richards.
NA	Listera borealis Morong
NA	Orchis rotundifolia Banks
NA	Spiranthes romanzoffiana Cham. & Schlecht.

SALICACEAE

NA	Populus balsamifera L.
NA	P. tremuloides Michx.
NA (?C)	Salix arbusculoides Anders.
NA	S. arctophila Cock. ex Heller
NA	S. athabascensis Raup
C	S. bebbiana Sarg.
NA	S. candida Fleugge
NA	S. discolor Muhl.
C, NA	S. glauca L. var. villosa (Hook.) Anders.
NA	S. mccalliana Rowlee
NA	S. myrtillifolia Anders.
NA	S. nova-angliae Anders.
NA	S. padophylla Rydb.
NA	S. pedicellaris Pursh
NA	S. planifolia Pursh
C	S. reticulata L.
NA	S. serissima (Bailey) Fern.

MYRICACEAE

C	Myrica gale L.

BETULACEAE

NA (E. Asia)	Alnus crispa Ait.
NA	A. incana (L.) Moench.
NA	Betula glandulosa Michx.
NA	B. papyrifera Marsh.

URTICACEAE

NA	Urtica gracilis Ait.

SANTALACEAE

NA	Geocaulon lividum (Richards.) Fern.

POLYGONACEAE

Cos	Polygonum aciculare L. s. lat.
C	P. viviparum L.
NA	Rumex occidentalis Wats.

CHENOPODIACEAE

Cos	Chenopodium album L. s. lat.
C (?)	C. capitatum (L.) Asch.

CARYOPHYLLACEAE

NA	Arenaria dawsonensis Britt.
NA	A. humifusa Wahlenb. (= A. longipendunculata Hult.)
C	A. lateriflora L.
C	A. rubella (Wahlenb.) Smith
Cos	Cerastium arvense L.
NA	Melandrium ostenfeldii Porsild
Cord	Silene menziesii Hook
C	Stellaria calycantha (Ledeb.) Bong.
C	S. crassifolia Ehrh.
C	S. longifolia Muhl. s. lat.
C	S. longipes Goldie s. str.

NYMPHAEACEAE

NA	Nuphar variegatum Engel.

RANUNCULACEAE

NA	Actaea rubra (Ait.) Willd.
NA	Anemone multifida Poir s. lat.
NA	Anemone parviflora Michx.
NA	Aquilegia brevistyla Hook.
NA	Ranunculus abortivus L.
C	R. lapponicus L.
NA	R. macounii Britt.
NA	R. purshii Richards.
C, AB	R. sceleratus L. var. multifidus Nutt.
NA	Thalictrum venulosum Trel.

FUMARIACEAE

NA	Corydalis aurea Willd.
NA	C. sempervirens (L.) Pers.

CRUCIFERAE

NA	Arabis divaricarpa A. Nels.
C	A. hirsuta (L.) Scop.
NA	A. holboellii Hornem. var. retrofracta (Grah.) Rydb.
Cos	Capsella bursa-pastoris (L.) Medic
Cos	Descurainia sophia (L.) Webb
C	Draba glabella Pursh
C	D. lanceolata Royle (= D. cana Rydb.)
Cord	D. oligosperma Hook.

C	Erysimum cheiranthoides L.
NA	E. inconspicuum (S. Wats.) MacMill.
NA (Europe)	Lepidium densiflorum Schrad.
N (E. Asia)	Lesquerella arctica (Wormskj.) S. Wats.
Cos	Rorippa islandica (Oeder) Borbas

SARRACENIACEAE

NA	Sarracenia purpurea L.

DROSERACEAE

C	Drosera anglica Huds.
C	D. rotundifolia L.

SAXIFRAGACEAE

NA (E. Asia)	Mitella nuda L.
C	Parnassia palustris L., var. neogaea Fern.
NA	Ribes glandulosum Grauer
NA	R. hudsonianum Richards.
NA (E. Asia)	R. lacustre (Pers.) Poir.
NA	R. oxyacanthoides L.
NA (E. Asia)	R. tristte Pall.
NA	Saxifraga tricuspidata Rottb.

ROSACEAE

NA	Amelanchier alnifolia Nutt.
NA	Dryas drummondii Richards.
NA	Fragaria virginiana Duchesne ssp. glauca (S. Wats.) Staudt
NA	Geum triflorum Pursh
NA	Potentilla arguta Pursh s. lat.
C	P. fruticosa L.
C	P. multifida L.
C, AB	P. nivea L. ssp. hookeriana (Lehm.) Hiit.,
C	P. norvegica L.
C.	P. palustris (L.) Scop.
NA	Prunus pennsylvanica L.
C	Rosa acicularis Lindl. s. lat.
NA	Rubus acaulis Michx.
C	R. chamaemorus L.
NA	R. pubescens Raf.
C	R. strigosus Michx.

LEGUMINOSAE

NA	Astragalus americanus (Hook.) M.E. Jones

NA	A. yukonis M.E. Jones (= A. bodinii Sheldon)
C, NA	Hedysarum alpinum L. var. americanum Michx.
NA	H. mackensii Richards.
NA	Lathyrus ochroleucus Hook.
Cos	Melilotus alba L.
Cos	M. officinalis (L.) Lam.
NA	Oxytropis varians (Rydb.) Hulten
Cos	Trifolium hybridum L.
NA	Vicia americana Muhl.

GERANIACEAE

NA	Geranium bicknellii Britt.

LINACEAE

NA	Linum lewisii Pursh

EMPETRACEAE

C	Empetrum nigrum L. var. hermaphroditum (Lge.) Sor.

VIOLACEAE

NA	Viola adunca J.E. Smith
NA	V. nephrophylla Greene
NA	V. renifolia Gray

ELAEAGNACEAE

NA	Shepherdia canadensis (L.) Nutt.

ONAGRACEAE

C	Epilobium angustifolium L. s. lat.
NA	E. glandulosum Lehm. var. adenocaulon (Haussk.) Fern.
C	E. palustre L.

HALORAGACEAE

C	Hippuris vulgaris L.
C	Myriophyllum verticillatum L. var. pectinatum Wallr.

UMBELLIFERAE

NA	Cicuta bulbifera L.
NA	C. mackenzieana Raup
NA (E. Asia)	Sium suave Walt.

CORNACEAE

NA	(E. Asia)	Cornus canadensis L.
NA		C. stolonifera Michx.

PYROLACEAE

C		Moneses uniflora (L.) Gray
NA	(E. Asia)	Pyrola asarifolia Michx.
C		P. grandiflora Radius s. lat.
C		P. minor L.
C		P. secunda L.
C		P. virens Schweigg.

ERICACEAE

C		Andromeda polifolia L.
C		Chamaedaphne calyculata (L.) Moench
NA		Kalmia polifolia Wang.
NA	(E. Asia)	Ledum decumbens (Ait.) Lodd.
NA		L. groenlandicum Oed.

VACCINIACEAE

NA	(E. Asia)	Arctostaphylos rubra (Rehb. & Wils.) Fern.
C		A. uva-ursi (L.) Spreng. s. lat.
C		Oxycoccus microcarpus Turcz.
C		O. quadripetalus Gil.
C		Vaccinium uliginosum L. s. lat.
C		V. vitis-idaea L.

PRIMULACEAE

C		Androsace septentrionalis L.
NA		Dodecatheon pauciflorum (Durrand) Greene
C		Lysimachia thyrsiflora L.
NA		Primula mistassinica Michx.

GENTIANACEAE

NA	(E. Asia)	Gentiana acuta Michx.
NA		G. affinis Griseb.

MENYANTHACEAE

C		Menyanthes trifoliata L.

APOCYNACEAE

NA	*Apocynum androsaemifolium* L.

HYDROPHYLLACEAE

NA	*Phacelia franklinii* (R. Br.) Gray

BORAGINACEAE

C	*Lappula echinata* Gilib.
NA	*Mertensia paniculata* (Ait). G. Don

LABIATAE

NA	*Dracocephalum parviflorum* Nutt.
C	*Mentha arvensis* L. var. *villosa* (Benth.) Stewart
C	*Scutellaria galericulata* L. var. *pubescens* Benth.

SCROPHULARIACEAE

NA	*Castilleja raupii* Pennell s. lat.
C	*Pedicularis labradorica* Wirsing
NA	*P. parviflora* Smith
NA	*Rhinanthus borealis* (Sterneck) Chab.

LENTIBULARIACEAE

C	*Pinguicula villosa* L.
C	*P. vulgaris* L.
C	*Utricularia intermedia* Hayne
C	*U. vulgaris* L.

PLANTAGINACEAE

Cos	*Plantago major* L. s. lat.
Cord	*P. septata* Morris (= *P. canescens* Adams)

RUBIACEAE

C	*Galium boreale* L.
NA	*G. labradoricum* L.

CAPRIFOLIACEAE

C, NA	*Linnaea borealis* L. var. *americana* (Forbes) Rend.
NA	*Lonicera dioica* L. var. *glaucescens* (Rydb.) Butters
NA	*Viburnum edule* (Michx.) Raf.

CAMPANULACEAE

C	Campanula rotundifolia L. s. lat.

LOBELIACEAE

NA	Lobelia kalmii L.

COMPOSITAE

NA	Achillea lanulosa Nutt.
NA	Antennaria campestris Rydb.
NA	A. nitida Greene
NA	A. pulcherrima (Hook.) Greene
NA	A. rosea (Eat.) Greene
C, NA	Arnica alpina (L.) Olin spp. angustifolia (J. Vahl) Maguire
C, NA	A. alpina (L.) Olin ssp. tomentosa (J.M. Macoun) Maguire
Cos	Artemisia biennis Willd.
NA	A. canadensis Michx.
C, NA	Aster alpinus L. ssp. vierhapperi Onno
NA	A. ciliolatus Lindl.
NA	A. junciformis Rydb.
AB	A. sibiricus L.
Cos	Crepis tectorum L.
C	Erigeron angulosus Gaud. var. kamtschaticus (DC.) Hara
NA	E. elatus (Hook.) Greene
NA	Erigeron glabellus Nutt.
NA	E. hyssopifolius Michx.
NA	Hieracium scabriusculum Schwein
Cos	Matricaria matricarioides (Less.) Porter
NA (E. Asia)	Petasites palmatus (Ait.) Gray
NA	P. sagittatus (Pursh) Gray
NA	P. vitifolius Greene
C	Senecio congestus (R. Br.) DC.
Cord	S. cymbalarioides Nutt. var. borealis (T. & G.) Greenm. (= S. streptanthifolius Greene)
NA	S. indecorus Greene
NA	S. lugens Richards.
NA	S. pauperculus Michx.
NA	Solidago decumbens Greene var. oreophila (Rydb.) Fern. (= S. streptanthifolius Greene)
Cos	Taraxacum officinale Weber

Bryopsida

SPHAGNACEAE

C	Sphagnum angustifolium (Russ.) C. Jens.
C	S. fuscum (Schimp.) Klinggr.
C	S. jensenii Lindb.
C	S. lindbergii Schimp. ex Lindb.
C (w)	S. magellanicum Brid.
C	S. nemoreum Scop.
C	S. riparium Angstr.
C.	S. russowii Warnst.
C	S. squarrosum Crome
C	S. warnstorfii Russ.

ANDREACEAE

C	Andreaea rupestris Hedw.

FISSIDENTACEAE

C	Fissidens adiantoides Hedw.
NA	F. arcticus Brynn

DITRICACEAE

C (w)	Ditrichum flexicaule (Schwaegr.) Hampe
Cos	Ceratodon purpureus (Hedw.) Brid.
Cos (w)	Distichium capillaceum (Hedw.) B.S.G.

SELIGERIACEAE

NA (?)	Seligeria tristicnoides Kindb.

DICRANACEAE

C	Cynodontium polycarpum (Hedw.) Schimp.
C	C. strumiferum (Hedw.) Lindb.
C	Oncophorous virens (Hedw.) Brid.
C	O. wahlenbergii Brid.
C	Dicranum acutifolium (Lindb. & Arnell) C. Jens. ex Weinm.
C	D. angustum Lindb.
C	D. elongatum Schliech. ex Schwaegr
C	D. flagellare Hedw.
AB	D. fragilifolium Lindb.
C	D. fuscescens Turn.
C	D. groenlandicum Brid.
C	D. muehlenbeckii B.S.G.
C	D. polysetum Sw.
C (w)	D. scoparium Hedw.
C	D. undulatum Brid.

ENCALYPTACEAE

C	Encalypta procera Bruch
C	E. rhaptocarpa Schwaegr.
C	E. vulgaris Hedw.

POTTIACEAE

C	Gymnostomum aeruginosum Sm.
Cos (w)	C. recurvirostrum Hedw.
C	Tortella fragilis (Drumm.) Limpr.
C (w)	T. tortuosa (Hedw.) Limpr.
C	Didymodon rigidulus Hedw.
C (w)	Bryoerythrophyllum recurvirostrum (Hedw.) Chen
C	Barbula convoluta Hedw.
C	B. icmadophila Schimp. ex C. Muell.
C	Tortula norvegica (Web.) Wahlenb ex Lindb.
C (w)	T. ruralis (Hedw.) Gaertn., Meyer & Scherb.

GRIMMIACEAE

C	Grimmia alpicola Hedw.
Cos (w)	G. apocarpa Hedw. (= Schistidium apocarpum (Hedw.) B.S.G.
C	G. apocarpa Hedw. var stricta (Turn.) Hook. & Tayl.
C	G. ovalis (Hedw.) Lindb. (= Schistidium gracile (Schliech) Limpr.)
C	G. tenera Zett. (= Schistidium tenerum (Zett.) Nyholm)

FUNARIACEAE

Cos	Funaria hygrometrica Hedw.

SPLACHNACEAE

C	Tetraplodon angustatus (Hedw.) B.S.G.
C	T. mnioides (Hedw.) B.S.G.

BRYACEAE

Cos (w)	Pohlia cruda (Hedw.) Lindb.
Cos (w)	P. nutans (Hedw.) Lindb.
C	P. sphagnicola (B.S.G.) Lindb. & Arnell
C (w)	P. wahlenbergii (Web. & Mohr.) Andr.
Cos	Leptobryum pyriforme (Hedw.) Wils.
C	Bryum angustirete Kindb. ex Macoun
Cos (w)	B. argenteum Hedw.

Cos	B. caespiticium Hedw.
Cos (w)	B. creberrimum Tayl.
C (w)	B. pseudotriquetrum (Hedw.) Gaertn., Meyer & Scherb
C	B. weigelii Spreng

MNIACEAE

C	Mnium ambiguum H. Muel.
C	M. blyttii B.S.G.
C	M. orthorrhynchum Brid. (= M. thomsonii Schimp.)
C	M. marginatum (With.) Brid.
C	M. riparium Mitt.
C	Cyrtomnium hymenophylloides (Hueb.) Koponen
C	P. cuspidatum (Hedw.) Koponen
Cos (w)	P. ellipticum (Brid.) Koponen
C	P. medium (B.S.G.) Koponen
Cos (w)	P. rostratum (Schrad.) Koponen
C	Rhizomnium gracile Koponen
C	R. pseudopunctatum (Bruch & Schimp.) Koponen
C (w)	Cinclidium stygium Sw.

AULACOMNIACEAE

c (w)	Aulacomnium palustre (Hedw.) Schwaegr.

MEESIACEAE

C	Meesia triquetra (Richt.) Angstr.
C	M. uliginosa Hedw.

CATOSCOPIACEAE

C	Catoscopium nigritum (Hedw.) Brid.

BARTRAMIACEAE

C	Plagiopus oederiana (Sw.) Limpr.

TIMMIACEAE

C	Timmia austriaca Hedw.
C	T. megapolitana Hedw. var. barvarica (Hessl.) Brid.
C	T. norvegica Zett.

ORTHOTRICHACEAE

C	Orthotrichum anomalum Hedw.
NA	P. jamesianum Sull. ex James

C	O. obtusifolium Brid.
C	O. speciosum Nees ex Sturm var. elegans (Schwaegr. ex Hook. & Grev.) Warnst.
	FONTINALACEAE
?NA	Fontinalis dalecarlica B.S.G.
	F. duraiea Schimp.
	HEDWIGIACEAE
C	Hedwigia ciliata (Hedw.) P. -Beauv.
	NECKERACEAE
C	Neckera pennata Hedw. var. tenera C. Muell.
	THELIACEAE
C	Myurella julacea (Schwaegr.) B.S.G.
C	M. sibirica (C. Muell.) Reim.
	LESKEACEAE
C	Leskeella nervosa (Brid.) Loeske
C	Pseudoleskeella tectorum (Funck ex Brid.) Kindb. ex Broth.
	THUIDIACEAE
C	Thuidium abietinum (Hedw.) B.S.G.
C	T. recognitum (Hedw.) Lindb.
	AMBLYSTEGIACEAE
Cos (w)	Cratoneuron filicinum (Hedw.) Spruce
C	Campylium chrysophyllum (Brid). J. Lange
C	C. hispidulum (Brid.) Mitt.
C	C. stellatum (Hedw.) C. Jens.
C	Leptodictyum riparium (Hedw.) Warnst.
Cos (w)	Amylystegium serpens (Hedw.) B.S.G.
C	Platydictya jungermannioides (Brid.) Crum.
C (w)	Drepanocladus aduncus (Hedw). Warnst.
C	D. exannulatus (B.S.G.) Warnst
Cos (W)	D. fluitans (Hedw.) Warnst.
C	D. revolvens (Sw.) Wanrst.
C	D. sendtneri (Schimp.) Warnst.
Cos (w)	D. uncinatus (Hedw.) Warnst.

C	D. vernicosus (Lindb. ex C. Hartm.) Warnst.
C	Hygrohypnum alpestre (Hedw.) Loeske
C	H. luridum (Hedw.) Jenn.
C	Calliergon giganteum (Schimp.) Kindb.
C	C. richardsonii (Mitt.) Kindb. ex Warnst.
C	C. stramineum (Brid.) Kindb.
C	C. trifarium (W. & M.) Kindb.
C	Scorpidium scorpioides (Hedw.) Limpr.
C	S. turgescens (T. Jens.) Loeske

BRACHYTHECIACEAE

C	Tomenthypnum nitens (Hedw.) Loeske
C	Brachythecium albicans (Hedw.) B.S.G.
C	B. rivulare B.S.G.
C	B. salebrosum (Web. & Mohr) B.S.G.
C	B. turgidum (Hartm.) Kindb.
C	B. velutinum (Hedw.) B.S.G.
C	Eurhynchium pulchellum (Hedw.) Jenn.

ENTODONTACEAE

C	Orthothecium chryseum (Schwaegr. ex Schultes) B.S.G.
C	O. intricatum (Hartm.) B.S.G.
C	Pleurozium schreberi (Brid.) Bitt.

HYPNACEAE

C	Pylaisiella polyantha (Hedw.) Grout
C	Hypnum bambergeri Schimp.
C	H. bridelianum Crum, Steere & Anderson (= H. recurvatum Brid).
Cos (w)	H. cupressiforme Hedw.
C	H. lindbergii Mitt.
C	H. pallescens (Hedw.) P. -Beauv.
C	H. pratense Koch ex Brid.
C	H. procerrimum Mol.
AB	H subimponens Lesq.
C	H. vaucheri
C	Isopterigium pulchellum (Hedw.) Jaeg. & Sauerb.
C	Herzogiella turfacea (Lindb.) Iwats.
C	Ptilium crista-castrensis (Hedw.) De Not.

RHYTIDIACEAE

C	Rhytidium rugosum (Hedw.) Kindb.

HYLOCOMIACEAE

C (w)	Hylocomium splendens (Hedw.) B.S.G.

TETRAPHIDACEAE

C	Tetraphis pellucida Hedw.

POLYTRICACEAE

Cos (w)	Polytrichum juniperinum Hedw.
Cos (w)	P. piliferum Hedw.
C	P. strictum Brid.

Hepaticopsida

BLEPHAROSTOMACEAE

C	Blepharostoma trichophyllum (L.) Dum.

PTILIDIACEAE

C	Ptilidium ciliare (L.) Hampe
C	P. pulcherrimum (Web.) Hampe

LEPIDOZIACEAE

C	Lepidozia reptans (L.) Dum.

CALOPGEIACEAE

C	Calopogeia neesiana (Maas. & Carest.) K. Mull.

LOPHOCOLEACEAE

C	Lophocolea minor Nees

LOPHOZIACEAE

C	Anastrophyllym minutum (Schreb. ex Cranz) Schust.
C	Lophozia barbata (Schmid.) Dum.
	L. incisa (Shrad.) Dum.
C	L. rutheana (Limpr.) M.A. Howe
C	Tritomaria exsectiformis (Breidl.) Schiffn.
C	T. quinquedentata (Huds.) Buch

JUNGERMANNIACEAE

C	Mylia anomala (Hook.) S. Gray

SCAPANIACEAE

C	**Scapania gymnostomophila Kaalaas**

PLAGIOCHILACEAE

C	**Plagiochila asplenoides** (L.) Dum.

SOUTHBYACEAE

C	**Arnellia fennica** (Gott.) Lindb.

RADULACEAE

C	**Radula complanata** (L.) Dum.

DILAENACEAE

C	**Moerckia hibernica** (Hook.) Goot.
C	**Pellia endiviifolia** (Dicks.) Dum.

ANEURACEAE

C	Aneura pinguis (L.) Dum.

CONOCEPHALACEAE

C	Conocephalum conicum (L.) Dum

CLEVEACEAE

C	Clevea hyalina (Samm.) Lindb.

MARCHANTIACEAE

C	Marchantia polymorpha L.
C	Preissia quadrata (Scop.) Nees.

Lichens

NA	Alectoria glabra Mot.
C	Anaptychia kaspica Gyeln.
C	Buellia papillata (Somm.) Tuck.
C	Caloplaca murorum (Hoffm.) Th. Fr.
C	C. cerina (Ehrn.) Th. Fr.
C	Cetraria cucullata (Bell.) Ach.
C	C. ericetorum Opiz.
C	C. hepatizon (Ach.) Vain.
C	C. halei Culb.
C	C. nivalis (L.) Ach.
C	C. pinastri (Scop) S. Gray
C	C. tilesii Ach.
C	C. sepincola (Ehrn.) Ach.

C Cladonia alpestris (L.) Rabenh. (= Cladonia stellaris (Opiz.) Pouz. & Vezda.; Cladina alpestris (L.) Harm.)
C C. amaurocraea (Fik.) Schaer.
C C. arbuscula (Wallr.) Rabenh. (= Cladina arbuscula (Wallr.) Hale & W. Culb.)
C C. bacillaris (Ach.) Nyl.
C C. capitata (Michx.) Sprenbg.
C C. cariosa (Ach.) Spreng.
C C. chlorophaea (Florke) Spreng.
C C. coniocraea (Florke) Spreng. em Sanst.
C C. coccifera (L.) Willd.
C C. conista (Ach.) Robb.
C C. cornuta (L.) Hoffm.
C C. crispata (Ach.) Flot.
C C. cyanopes (Somm.) Nyl.
C. C. deformis (L.) Hoffm.
C C. fimbriata (L.) Fri.
C C. furcata (Huds.) Schrad.
C C. gonecha (Ach.) Asah.
Cos C. gracilis (L.) Willd.
C C. mitis Sandst. (= Cladina mitis (Sandst.) Hale & W. Culb.)
NA C. multiformis Merr.
C C. nemoxyna (Ach.) Arnold
C C. norrlinii Vain.
C C. phyllophora Hoffm.
C C. pleurota (Fik.) Schaer.
C C. pyxidata (L.) Hoffm.
C C. uncialis (L.) Wigg.
C C. rangiferina (L.) Wigg. (= Cladina rangiferina (L.) Harm.)
C C. squamosa (Scop.) Hoffm.
C C. subulata (L.) Wigg.
C C. verticillata (Hoffm.) Schaer.
C Collema tunaeforme (Ach.) Ach.
C Cornicularia aculeata (Schreb.) Ach.
C Dermatocarpon fluviatile (G. Web.) Th. Fr.
C D. miniatum (L.) Mann.
C Diploschistes scruposus (Schreb.) Norm.
C Evernia mesomorpha Nyl.
AB(?) E. perfragilis Llano
C Hypogymnia physodes (L.) Nyl.
C Icmadophila ericetorum (L.) Zahlbr.
C Lecanora calcarea (L.) Somm.
C L. epibryon (Ach.) Ach.
C Lecidea atrobrunnea (Ram.) Schaer.
C L. rubiformis (Wasnlenb. ex Ach.) Wahlenb.

C	Parmelia centrifuga (L.) Ach.
C	P. saxatilis (L.) Ach.
C	P. septentrionalis (Lynge) Ahti
C	P. subaurifera Nyl.
C	P. subolivacea Nyl.
C	P. sulcata Tayl.
C	P. taratica Kremp. s. lat.
C	Parmeliopsis hyperopta (Ach.) Arn.
C	Peltigera aphthosa (L.) Willd.
C	P. canina (L.) Willd.
C	P. malacea (Ach.) Funck
C	P. pulverrulenta (Tayl.) Krempn. (= P. scabrosa Th. Fr.)
C	P. rufescens (Weiss) Humb.
C	P. spuria (Ach.) DC
C	Physcia adscendens Bitt.
C	P. aipolia (Ehrn.) Hampe
C	P. muscigena (Ach.) Nyl.
C	P. orbicularis (Neck.) Poetsch.
C	Ramalina miniscula (Nyl.) Nyl.
C	R. pollinaria (Westr.) Ach.
C	Solorina bispora Nyl.
C	Stereocaulon tomentosum Fr.
C	Thamnolia subuliformis (Ehrh.)Culb.
AB(?)	Umbilicaria muhlenbergii (Ach.) Tuck.
C	Usnea cavernosa Tuck.
C	U. hirta (L.) Wigg.
C	U. subfloridana Stirt.
C	U. substerilis Mot.
C	Xanthoria elegans (Link) Th. Fr.

APPENDIX II. Enumeration of the vascular life-forms following Emberger and Sauvage (1968). Each type was preceded by the code number used by the authors above for reference. Two numbers were given in parentheses under the code number. The first indicated the number of species within the life-form subclass and the second indicated its percent of the total vascular flora. Abbreviations used for different life forms were tabulated below:

An	... Angisperms	MeP	... Mesophanerophyte
b	... bulb or tuber	MiP	... Microphanerophyte
bi	... biennial	nrb	... without basal rosette
C	... Cryptophyte	nrd	... non-rooted
c	... caespitose	nst	... without stolons
Ch	... Chamaephyte	P	... Nanophanerophyte
Cv	... vascular cryptogam	P	... Phanerophyte
d	... erect dwarf shrub	pa	... passive
em	... emergent	PrH	... Protohemicryptophyte
er	... perennating bud on fibrous roots	r	... prostrate, creeping
		rb	... basal rosette
G	... Gymnosperm	rd	... rooted
H	... Hemicryptophyte	rh	... rhizame
he	... Herbaceous	rp	... semi-rosette
Hy	... Hydrophyte	st	... stolons, runners, s. lat
im	... submerged		
li	... woody	Th	... Therophytes
MP	... Megaphanerophyte	v	... vascular

PHANEROPHYTES: perennating bud at least 0.3 m above the ground, vascular plants only.

125. Mesophanerophytes (8-30 m), Gymnosperms: MeP.G. (4, 0.1%)

Larix laricina
Picea glauca
P. marinana
Pinus banksiana

126. Mesophanerophytes 8-30 m), Angiosperms: MeP. An. (3, 0.1%)

Betula paprifera
Populus balsamifera
Populus tremuloides

135. Micropnanerophytes (2-8 m), Gymnosperms: MiP. G (young trees)

137. Microphanerophytes (2-8 m), woody Angiosperms: MiP.An.Ii (11, 3.5%)

Alnus crispa
A. incana
Betula glandulosa (NP, Cn)
Cornus stolonifera
Salix arbusculoides
S. bebbiana
S. discolor
S. glauca (NP)
S. maccaliana
S. padopnylla
S. planifolia

145. Nanophanerophytes (0.3-2 m), Gymnosperms: NP.An. (22, 7.0%)

Juniperus communis

147. Nanophanerophytes (0.3-2 m), Angiosperms: NP.An.

Amelancnief alnifolia (MiP.)
Chamaedapnne calyculata
Ledum decumbens
L. groenlandicum
Lonicera dioica (MiP, vine)
Myrica gale
Potentilla fruticosa
Prunus pennsylvanica (Ms)
Ribes glandulosum
R. hudsonianum
R. lacustre
R. oxyacantnoides
R. triste
Rosa acicularis
Salix athabascensis
S. candida
S. nova-angliae
S. pedicellaris
S. serissima
Snepherdia canadensis
Vaccinium uliginosum
Viburnum edule

CHAMAEPHYTES: perennating buds not more than 0.3 m above the ground.

215. Chamaephytes, erect dwarf-shrubs, Gymnosperms: Ch.v.d.G. (young shrubs and trees)

216. Chamaephytes, erect drwarf-shrubs, Angiosperms: Ch.v.d.An. (young shrubs and trees; 2, 0.1%)

Andromeda polifolia
Kalmia polifolia

224. Chamaephytes, prostrate vascular cryptogams: Ch.v.r.Cv. (3. 0.1%)

Lycopodium annotinum
L. complanatum
Selaginella selaginoides

225. Chamaephytes, prostrate Gymnosperms: Ch.v.r.G. (1. 0.1%)

Juniperus horizontalis

227. Chamaephytes, prostrate woody Angiosperms: Ch.v.r.An.li. (11, 3.5%)

Arctostaphylos rubra
A. uva-ursi
Dryas drummondii
Empetrum nigrum
Linnaea borealis
Oxycoccus microcarpus
O. quadripetalous
Salix myrtillifolia (NP,MiP)
S. arctophylla
S. reticulata
Vaccinium vitis-idaea

228. Chamaephytes, prostrate herbaceous Angiosperms: (passive): (20, 6.3%) Ch.v.r.An.li.

Antennaria campestris
A. nitida
A. rosea
A. pulcherrima (Hrp.nst/Ch)
Arenaria dawsonensis
A. humifusa
A. rubella
Astragalus yukonis
Cerastium arvense
Draba glabella
D. lanceolata
D. oligosperma
D. oligosperma
Lesquerella arctica
Oxytropis varians (Hrb.nst/Ch)
Potentilla multifida
P. nivea
Rubus pubescens (PrH. st/Ch)
Saxifraga tricuspidata
Stellaria longifolia
C. longipes

HEMICRYPTOPHYTES: perennating buds at soil level, in the soil surface (litter).

316. Protohemicrypotophytes with stolons: PrH.v.An.st. (19, 6.0)

Apocynum androsaemifolium (Crh.PrH.nst/PrH.st)
Arenaria lateriflora
A. junciformis
A. sibiricus
Cornus canadensis
Epilobium angustifoloum (PrH.nst.Ch/PrH.st)
E. palustre
Galium labradoricum (PrH/nst/PrHst)
Lathyrus ochroleucus
Rubus acaulis
R. chamaemorus (Pr.H. nst/PrH.st)
Scutellaria galericulata
Stellaria calycantha
S. crassifolia
Urtica gracilis
Vicia americana (PrH.nst/Prh.st)

316. Photohemicryptophytes without stolons: PrH.v.An.nst. (10, 3.2%)

Astragalus americanus (PrH.st/PrH.nst)
Castilleja raupii
Epilobium glandulosum (PrH.st/PrH.nst)
Erigeron hyssopifolius (PrH.st/PrH.nst)
Gentiana affinis
Hedysarum alpinum
H. mackenzii
Hieracium scabriusculum
Linum lewisii
Rubus strigosus

326. Hemicryptophytes, caespitose: H.v.c.An. (16, 5.1%)

Carex atrataformis (Crh/Hrp.nst)
C. capillaris (Hrp.nst)
C. capitata (Hrb.st)
C. concinna (Hrb.st)
C. diandra (Hrp.nst)
C. filifolia (Hrp.nst.
C. rossii (Crh/Hrp.nst)
C. viridula (Hrp.nst)
Deschampsia caespitosa (Hrp.nst)
Eriophorum vaginatum (Hrp.nst)
Festuca saximontana (Hrp.nst)
Kobresia simpliciuscula (Hrb.nst)
Poa alpina (Hrp.nst)
P. glauca (Hrp.nst)
Rhynocospora alba (Hrp.nst)
Scirpus caespitosus (Hrb.nst/Hrp.st)

336. Hemicryptophytes with semi-rosette and stolons: H.v.rp.st. (29, 9.0%)

Achillea lanulosa
Anemone parviflora
Arctagrostis arundinacea
Aster alpinus (Hsr.nst,Ch/Hsr.st)
A. ciliolatus (PrH.st/Hrp.st)
Calamagrostis canadensis
C. inexpansa
C. lapponica
C. purpurascens
Campanula rotundifolia
Carex chordorrhiza
C. interior (Hrp/nst/Hrp.st)
C. leptalea
C. media
C. tenuiflora
Elymus innovatus
Glyceria striata (Hrp.nst/Hrp.st)
Hierochloe odorata
Mitella nuda (Hrb.st/Hrp.st)
Muhlenbergia glomerata
Ranunculus macounii (Hrp/nst/Hrp.st)
Scheuchzeria palustris
Senecia lugens
Smilacina trifolia
Solidago decumbens
Thalictrum venulosum (Hrp.nst/Hrp.st)
Tofieldia glutinosa (Hrb.nst, Crh/Hrp.st)
T. pusilla (Hrb.nst/Hrp.st)
Viola adunca

336. <u>Hemicryptophytes with semi-rosette and without stolons</u>: (36, 11.7%) H.v.rp.nst.

Agropyron trachycaulum
A. violaceum
Agrostis scabra
Anenome multifida
Aquilegia brevistyla
Arnica alpina
Artemesia canadensis
Carex aenea
C. cannescens

Cicuta bulbifera
C. mackensieana
Dracocephalum parviflorum
E. glabellus
Eriophorum brachyantherum
Erysimum cheiranthoides
E. inconspicuum
Hordeum jubatum
Juncus albescens

Koeleria cristata
Lepidium densiflorum
Lobelia kalmii
Melandrium ostenfeldii
Melilotus alba
M. officinalis
Mertensia paniculata
Parnassia palustris
Pedicularia labradorica
Phleum pratense
Potentilla arguta
Ranunculus abortivus
Rorripa islandica
Rumex occidentalis
Senecio cymbalarioides
S. indecorus
S. pauperculus

346. <u>Hemicryptophytes with basal rosette and with stolons</u>: (9, 2.8%) H.v.rb.An.st.

Fragaria virginiana
Geum triflorum (Hrp.nst/Hrb.st)
Goodyera repens
Pyrola asarifolia

P. grandiflora

P. minor
P. secunda
P. virens
Triglochin palustre (Hrb.nst,Crh/Hrb.st)

346. <u>Hemicryptophytes with basal rosette and without stolons</u>: (14, 3.8%) H.v.rb.An.nst.

Dodecatheon pauciflorum
Drosera anglica
D. rotundifolia
Pinguicula villosa
P. vulgaris
Plantago major
P. septata

Primula mistassinica
Sarracenia purpurea
Taraxacum officinale
Trifolium hybridum
Triglochin maritimum
Viola nephrophylla
V. renifolia

386. <u>Hemicryptophytes, biennial</u>: H.bi.An. (11, 3.5%)

Androsace septentrionalis (T/Hrp.nst/T,bi)
Arabis divaricarpa (Hrp.nst//bi)
A. hirsuta

Corydalis aurea (T, Hrp.nst/T,bi)
C. sempervirens Hrp.nst,T//T,bi)
Geranium bicknellii

(Hrp.nst//bi)
A. holboellii
(Hrp.nst//bi)
Artemisia biennis
(Hrp.nst//T,bi)

(T/Hrp.nst//bi)
Placelia franklinii
(Hrp/nst//T,bi)
Senecio congestus
(Hrp.nst//T,bi)

CRYPTOPHYTES: perennating buds clearly in the soil

416. Cryptophytes with bulbs or tubers and with rosettes: (3, 0.1%) C.v.b.An.rb.

Habenaris obtusata
Orchis rotundifolia
Zygadernus elegans

416. Cryptophytes with bulbs or tubers and without rosettes: 6, 1.9%) C.v.b.An.nrb.

Allium schoenoprasum
Calypso bulbosa
Eleocharis pauciflora
romanzoffiana
Habenaris hyperborea
Polygonum vivaparum
Spiranthes

424. Cryptophytes with rhizomes and rosettes, vascular:

(2, 0.1%) cryptogams: C.v.rh.Cv.rb.

Cystopteris fragilis
(Hrb.nst)
Woodsia glabella
(Hrb.nst)

424. Cryptophytes with rhizomes and without rosettes, vascular: (8, 0.3%) cryptogams C.v.rh.Cv.nrb.

Botrychium virginianum
Cystopteris montana
Equisetum arvense
E. palustre
E. pratense
E. scirpoides
E. variegatum
Polypodium vulgare

426. Cryptophytes with rhizomes and rosettes, Angiosperms:
(8, 2.5%) C.v.rh.An.rb.

Carex aurea
C. disperma
C. eburnea
C. garberi
C. richardsonii
(Hrp.st)
C. vaginata
Eriophorum
angustifolium
E. viridicarnatum

426. Cryptophytes with rhizomes and without rosettes:

(26, 8.2%) Angiosperms: C.v.rh.An.nrb.

Actaea rubra
Carex aquatalis
C. foena (Hrp.nst/Crh)
C. gynocrates
C. lasiocarpa
C. limosa
C. livida
C. paupercula
C. physocarpa
C. scirpoidea
Corallorhiza trifida
Cypripedium calceolus
C. guttatum
C. passerimum
Eleocharis compressa
Geocaulon lividum
Juncus alpinus
J. balticus
Listera borealis
Oryzopsis asperifolia
O. pungens
Petasites palmatus
P. sagittalus
P. vitifolius
Poa pratensis
Ranunculus lapponicus

436. Cryptophytes, root: C.v.er.An.
(1. 0.1%)

Moneses uniflora (Hrb.nst/Cer)

THEROPHYTES: continuity assured by seeds; perennating buds are entirely contained in the seeds; annuals

616. Therophytes, Angiosperms without rosettes):
Th.v.d.An.nrb. (14, 3.8%)

Bechmannia syzigachne
Capsella bursa-pastoris
Chenopodium album
C. capitatus
Crepis tectorum
Descuriana sophia
Gentiana acuta
Lappula echinata
Matiricaria matricoides
Pedicularis parviflora
Polygonum norvegica
Potentilla norvegica
Ranunculus scleratus
Rhinanthus borealis

HYDROPHYTES: rooted plants with floating vegetative organs or plants which float freely in the water.

814. Hyrdophytes, emergent vascular cryptogams: Hy.em.Cv.
(1, 0.1%)

Equisetum fluviatile

818. Hydrophytes, emergent herbaceous Angiosperms:
(9, 2.8% Hy.em.An.ne.

Carex rostrata
Eleocharis palustris
Hippuris vulgaris
Lysimachia thyrsiflora
Menyanthes trifolia
Potentilla palustris
Scirpus validus
Sium suave
Typha latifolia

836. <u>Hydrophytes, rooted floating, Angiosperms</u>:
(5, 1.6%) Hy.v.rd.fl.An.

Nuphar variegatum
Ranunculus purshii
Sparganium angustifolium
S, minimum
S. multipedunculatum

846. <u>Hydrophytes, rooted submerged, Angiosperms</u>:
(7, 2.2%) Hy.v.rd.im.An.

Potamogenton filiformis
P. gramineus
P. natans P. vaginatus
P. praelongus
P. Pusillus
P. richardsonii

856. <u>Hydrophytes, non-rooted floating, Angiosperms</u>:
1, 0.1%) Hy.v.nrd.fl.An.

Lemna minor

866. <u>Hydrophytes, non-rooted submerged, Angiosperms</u>:
(3, 0.1%) Hy.v.nrd.im.An.

Myriophyllum verticillatum
Utricularia intermedia
U. vulgaris

APPENDIX III. Matrix of index of similarity values in percent for 20 upland phytocoenoses.

PHYTOCOENOSE	PHYTOCOENOSE 17	31	32	34	22	1	2	3	4	5	6	7	8	9	10	12	13	14	15	16
17	X																			
31	31.9	X																		
32	29.1	32.0	X																	
34	66.4	30.7	32.0	X																
22	60.3	32.1	41.8	65.7	X															
1	29.4	7.7	13.8	28.3	23.1	X														
2	38.2	11.5	28.8	31.4	31.7	67.5	X													
3	50.8	16.4	37.3	43.0	42.4	50.6	71.9	X												
4	59.6	19.3	25.3	46.8	43.3	51.5	62.8	66.3	X											
5	67.7	28.0	31.2	54.9	54.5	40.3	48.7	62.9	66.7	X										
6	57.6	24.7	31.6	67.0	62.4	19.1	26.6	37.0	43.8	49.4	X									
7	38.8	40.5	39.1	42.9	49.1	5.6	19.4	26.4	24.4	32.9	48.0	X								
8	58.1	46.7	40.0	44.7	49.7	13.8	19.2	34.8	38.6	53.2	40.8	47.8	X							
9	33.9	49.0	35.9	39.1	44.0	8.0	19.9	27.7	26.9	36.5	25.5	53.1	52.4	X						
10	60.4	44.2	28.9	60.3	59.0	33.5	37.6	43.8	50.5	57.7	54.2	43.8	52.2	41.1	X					
12	49.4	24.4	42.5	42.2	52.5	30.5	39.5	49.1	40.7	58.7	43.0	41.7	43.8	34.4	37.6	X				
13	50.3	14.8	28.8	40.4	35.2	48.6	57.9	56.3	58.2	54.9	34.4	24.8	36.0	16.7	38.0	46.9	X			
14	76.8	28.4	34.9	63.4	61.1	31.6	39.5	52.4	55.2	70.0	59.6	41.5	55.4	30.4	61.2	58.1	54.5	X		
15	47.8	35.4	44.6	47.1	44.3	19.6	29.9	43.8	40.2	51.9	48.7	54.8	54.1	35.3	44.7	45.5	34.0	48.3	X	
16	29.7	30.1	62.9	28.6	36.7	16.2	26.8	36.6	27.2	28.0	29.7	39.7	32.2	29.7	32.8	43.0	31.0	35.5	39.7	X

APPENDIX IV. Matrix of index of similarity values in percent for 19 lowland phytocoenoses.

PHYTOCOENOSE	18	19	20	21	23	24	25	26	27	28	29	33	35	37	38	39	40	41	11
18	X																		
19	58.1	X																	
20	21.5	26.5	X																
21	23.4	25.3	81.3	X															
23	1.3	16.6	6.6	3.3	X														
24	2.3	22.1	6.0	4.4	62.3	X													
25	0.0	12.5	1.6	0.0	51.5	35.4	X												
26	0.0	19.9	4.5	1.5	52.8	64.4	47.8	X											
27	1.5	2.7	4.1	0.0	31.0	26.5	7.7	24.1	X										
28	4.1	10.2	5.5	0.0	34.1	29.8	20.2	25.5	54.2	X									
29	13.2	17.7	4.2	1.4	12.0	14.0	11.3	12.4	12.8	26.7	X								
33	42.8	45.3	10.2	5.6	12.0	19.8	10.2	18.5	6.3	15.9	30.1	X							
35	31.1	37.6	17.7	15.3	24.7	32.5	14.9	24.1	0.0	7.0	11.3	31.4	X						
37	13.6	24.7	5.8	5.7	28.8	39.0	22.0	37.4	0.0	8.1	7.5	20.4	50.3	X					
38	32.0	44.5	50.8	51.4	15.6	19.3	6.2	16.9	6.1	9.9	13.6	33.3	35.5	17.5	X				
39	15.6	28.6	5.7	1.4	31.6	49.2	21.5	54.0	15.4	15.7	13.1	30.6	35.6	42.7	25.3	X			
40	24.9	27.8	70.5	69.5	3.6	1.6	0.0	1.6	0.0	0.0	1.5	4.8	16.3	3.1	40.7	1.5	X		
41	38.7	56.6	12.4	8.9	22.5	31.9	13.9	36.8	6.3	14.4	21.8	45.4	37.0	35.7	35.1	57.3	9.5	X	
11	49.6	63.3	32.3	25.8	21.8	24.9	16.3	22.6	2.8	11.8	18.1	41.6	44.0	27.5	41.8	32.4	29.5	47.7	X

APPENDIX V. Classification of phytocoenoses according to the Ceska-Roemer (1973) program. For comparative purposes each phytocoenose was shown in relation to its position in the "C" classification of Figure 7.

Phytocoenose	"C" Phytocoenon	SPECIES GROUP NUMBER*																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	II A	x	x	x																	
2	II B	x	x	x																	
3	VI B	x	x	x																	
13	VI B			x																	
4	II B	x	x	x						x											
5	III A			x			x														
12	III B			x		x	x		x												
34	III C		x	x	x		x		x	x											
22	III C			x			x	x	x												
6	III C			x	x				x	x											
16	IV					x			x												
17	III A			x			x		x	x											
14	III A			x			x		x	x											
32	IV					x		x	x												
10	III D			x				x	x	x											
8	V B						x		x												
7	V A								x												
15	V A								x												
31	V C							x	x			x									
18	VII A						x		x	x	x	x									
9	V B								x			x									
40	VI A									x					x						
20	VI A									x			x		x						
21	VI A									x			x		x						
33	VII B								x			x		x		x					
19	VII A										x	x		x				x	x		

APPENDIX V. Continued

Phytocoenose	"C" Phytocoenon	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
		SPECIES GROUP NUMBER*																			
38	VI B											x	x	x	x	x	x				
11	VII A											x									
35	XI C											x						x	x		
41	VII B											x		x	x	x		x	x	x	
39	VII B											x				x	x	x	x		
37	XI C															x	x	x	x		
24	VIII B														x			x	x	x	
26	VIII B														x	x		x	x		x
23	VIII B														x			x	x		x
28	IX B														x			x	x	x	x
25	VIII A																		x		
27	IX B																	x	x		x
29	IX A																				
30	I																				
36	X																				

* Composition of species groups. Mean similarity of phytocoenoses in percent was given after the last species in each group. Group number:

1, Brachythecium albicans, Achillea lanulosa, Solidago decumbens, Cerastium arvense, Poa glauca, Festuca saximontana, Draba lanceolata, Geum triflorum, Aster alpinus, 69.5, 2, Carex richardsonii, Senecio cymbalarioides, 53.7), 3, Peltigera canina, Cetraria ericetorum, Arctostaphylos uva-ursi, Anemone multifida, 49.5 4, Alnus crispa, Empetrum nigrum, Cladonia crispata, Polytrichum juniperinum, Calamagrostis purpurascens, 69.3 5, Populus balsamifera, Ceratodon purpureus, Ribes oxyacanthoides 52.0 6, Zygadenus elegans, Aster sibiricus, 44.5 7, Dicranum fuscescens, Cornus stolonifera, 42.2 8, Viburnum edule, Cornus canadensis, Ptilidium pulcherrimum, 49.9 9, Cetraria nivalis, Cladonia alpestris, 38.9 10, Orchis rotundifolia, Pedicularis labradorica, Carex scirpoides, Tofieldia pusilla, Senecio lugens, 55.3 11, Mitella nuda, Salix myrtillifolia, Arctostaphylos rubra, 36.5, 12, Cladonia pleurota, Drosera rotundifolia, Mylia anomala, Ledum decumbens, Polytrichum strictum, Cladonia amaurocraea, Chamaedaphne calyculata, Sphagnum fuscum, Rubus chamaemorus, Sphagnum capillaceum, Icmadophila ericetorum, Pinguicula villosa, Pohlia sphagnicola, 37.6, 13, Habenaria hyperborea, Carex gynocrates, 35.0, 14, Andromeda polifolia, Oxycoccus microcarpus, 32.6, 15, Smilacina trifolia, Carex capillaris, 34.2, 16, Rubus acaulis, Catoscopium nigritum, Carex vaginata, Parnassia palustris, Carex leptalea, Carex aurea, 38.5, 17, Scorpidium scorpioides, Triglochin maritima, Cinclidium stygium, 36.6, 18, Bryum pseudotriquetrum, Betula glandulosa, Campylium stellatum, Drepanocladus revolvens, Salix candida, 31.3, 19, Scirpus caespitosus, Drosera anglica, 41.4, 20, Salix pedicellaris, Carex limosa, Menyanthes trifoliata, 64.5.

APPENDIX VI. Comparison of the life-form spectrum at Heart Lake and the subzone spectra of Scoggan (1978) using chi-square tests for goodness of fit. Expected values are shown in parentheses. No comparison is shown for the High Arctic, because the expected frequency for Phanerophytes is less than one. A visual inspection indicates that the High Arctic is very different from Heart Lake.

REGION	LIFE-FORM CLASS Phanerophyte	Chamaephyte	Hemicryptophyte	Cryptophyte	Therophyte	Total	Chi-square
Heart Lake	42	34	145	70	12	303	-
High Arctic	0	38	74	24	1	137	-
Low Arctic	22 (12)	108 (61)	268 (152)	116 (66)	20 (11)	534 (303)	82.60**
High Subarctic	73 (24)	141 (47)	446 (148)	208 (69)	44 (15)	912 (303)	17.07**
Low Subarctic	117 (29)	159 (39)	594 (147)	284 (70)	70 (17)	1224 (303)	8.27
High Temperate	303 (36)	193 (23)	1217 (144)	600 (71)	250 (30)	2563 (303)	17.00**
Low Temperate	361 (37)	205 (21)	1377 (140)	678 (69)	355 (36)	2976 (303)	25.32**

** 1% significance level with 4 df equals 13.28.

Appendix VII. Tree population analysis. Population structure of trees in phytocoenoses by phytocoena. Figures represent the number of living (L) and dead (D) arborescent individuals per 1000 m^2. Abbreviations: Be p, Betula papyrifera; La l, Larix laricina; Pc g, Picea glauca; Pc m, Picea mariana; Pn b, Picea banksiana; Po b, Populus balsamifera; and Po t, Populus tremuloides.

Phytocoenon Phytocoenose	Species	Stems Live/ Dead	Diameter (at breast height) classes in inches and cm									
			1 2.5- 5	2 5- 7.6	3 7.6- 10	4 10- 12.7	5 12.7- 15.2	6 15.2- 17.8	7 17.8- 20.3	8 20.3- 22.9	9 22.9- 25.4	10-16 25.4- 27.9
II B:2	Po t	L	17	.	1	1	.	.	.	.	.	.
		D	4	3	.	1	.	.	.	.	.	.
	Pc g	L	5	3	2	.	.	.	.	.	.	.
		D	.	.	.	.	.	.	.	.	.	.
:3	Po t	L	53	27	18	4	.	.	.	.	.	.
		D	8	10	3	3	.	.	.	.	.	1
	Pc g	L	17	11	5	6	1	.	1	1	.	.
		D	.	1	5	.	.	.	1	.	.	.
	Pn b	L	.	.	1	.	.	1	1	1	.	.
		D	.	.	.	1	.	.	.	.	.	.
:4	Po t	L	6	3	4	2	.	.	.	.	.	.
		D	2	2	1	1	2	.	.	.	.	.
	Pc g	L	14	10	13	11	12	4	1	.	1	4
		D	.	1	.	1	.	.	1	.	.	.
	Pn b	L	1	2	2	1	1	4	3	.	2	.
		D	.	.	.	.	.	.	.	.	.	.
:13	Po t	L	3	3	.	.	.	.	.	.	.	.
		D	.	.	.	.	.	.	.	.	.	.
	Pn b	L	1	7	3	5	1	3	1	.	.	.
		D	.	1	.	.	.	.	.	.	.	.
III A:17	Pc g	L	11	16	11	5	3	5	1	.	1	.
		D	.	.	.	.	.	.	.	.	.	.
	Pn b	L	1	34	88	75	23	2	2	.	.	.
		D	42	43	9	1	.	.	.	.	.	.
:14	Po t	L	1	.	.	.	.	.	.	.	.	.
		D	.	.	.	.	.	.	.	.	.	.

Appendix VII. Continued

Phytocoenon Phytocoenose	Species	Stems Live/ Dead	Diameter (at breast height) classes in inches and cm									
			1 2.5- 5	2 5- 7.6	3 7.6- 10	4 10- 12.7	5 12.7- 15.2	6 15.2- 17.8	7 17.8- 20.3	8 20.3- 22.9	9 22.9- 25.4	10-16 25.4- 27.9
	Pn b	L	3	72	142	76	132	.	.	.	.	.
		D	56	40	9	.	.	.	.	.	.	.
	Be p	L	.	1	.	1	.	.	.	.	.	.
		D	.	.	.	.	.	.	.	.	.	.
:5	Pc g	L	3	8	7	9	2	5	4	2	.	.
		D	2	.	1	.	.	.	.	.	.	.
	Pn b	L	1	7	14	23	32	19	4	1	.	.
		D	7	13	6	8	1	1	.	.	.	.
III B:12	Pn b	L	205	1	.	.	.	.	.	.	.	.
		D	.	.	.	.	.	.	.	.	.	.
III C:22	Po t	L	1	.	.	.	.	.	.	.	.	.
		D	.	.	.	.	.	.	.	.	.	.
	Pc g	L	6	.	.	1	.	.	.	.	.	.
		D	.	.	.	.	.	.	.	.	.	.
	Pn b	L	2	5	22	40	58	37	9	3	.	.
		D	8	11	17	2	3	.	.	.	.	.
:6	Po t	L	.	.	1	1	.	.	.	.	.	.
		D	.	.	.	.	.	.	.	.	.	.
	Pn b	L	3	15	35	31	14	5	4	.	.	.
		D	12	14	3	2	1	2	.	.	.	.
:34	Po t	L	.	.	2	.	4	4	2	.	.	.
		D	2	.	2	.	.	.	.	.	.	.
	Pc g	L	10	2	2	.	2	.	.	.	.	.
		D	.	.	.	.	.	.	.	.	.	.
	Pc m	L	2	4	.	.	.	.	.	.	.	.
		D	.	.	.	.	.	.	.	.	.	.
	Pn b	L	.	.	.	.	.	2	.	.	.	.
		D	.	.	.	.	.	.	2	.	15	1
	Po b	L	2	.	.	.	.	.	.	.	.	.
		D	.	.	2	.	.	.	.	.	.	.

Appendix VII. Continued

Phytocoenon Phytocoenose	Species	Stems Live/ Dead	Diameter (at breast height) classes in inches and cm									
			1 2.5- 5	2 5- 7.6	3 7.6- 10	4 10- 12.7	5 12.7- 15.2	6 15.2- 17.8	7 17.8- 20.3	8 20.3- 22.9	9 22.9- 25.4	10-16 25.4- 27.9
III D:10	Pc g	L	46	18	35	28	17	10	3	4	.	1
		D	4	9	5	3	.	.	.	.	.	.
	Pc m	L	1	11	6	7	5	1	.	.	.	.
		D	.	2	.	.	.	.	.	.	.	.
	Pn b	L	.	.	1	3	1	2	.	.	.	.
		D	.	20	16	13	3	.	.	.	.	.
	Be p	L	5	1	4	.	1	.	.	.	.	.
		D	.	1	2	.	.	.	.	.	.	.
IV:32	Po t	L	5	6	11	19	26	22	13	19	11	10
		D	2	3	7	8	3	1	.	.	.	.
	Po b	L	1	.	1	2	3	10	8	2	.	2
		D	.	.	1	1	3	.	.	.	1	.
	Pc g	L	1	1	1	.	1	1	.	.	.	.
		D	.	.	.	.	.	.	.	.	.	.
	Pc m	L	1	.	.	.	.	.	.	.	.	.
		D	.	.	.	.	.	.	.	.	.	.
IV:16	Po t	L	2	4	12	10	12	8	9	8	4	1
		D	9	8	2	.	.	.	.	.	.	.
	Po b	L	2	.	1	2	3	8	12	8	1	4
		D	.	1	.	1	1	.	.	.	.	.
	Be p	L	2	2	.	2	2	3	2	1	.	.
		D	.	.	.	.	.	.	.	.	.	.
	Pn b	L	.	.	.	.	.	.	.	2	.	1
		D	.	.	.	.	.	.	.	.	.	.
	Pc g	L	.	2	.	.	.	.	.	.	.	.
		D	.	.	.	.	.	.	.	.	.	.

Appendix VII. Continued

Phytocoenon Phytocoenose	Species	Stems Live/ Dead	Diameter (at breast height) classes in inches and cm 1 2.5-5	2 5-7.6	3 7.6-10	4 10-12.7	5 12.7-15.2	6 15.2-17.8	7 17.8-20.3	8 20.3-22.9	9 22.9-25.4	10-16 25.4-27.9
V A:7	Po t	L	.	14	47	44	22	5	1	.	.	.
		D	3	10	2	1	1	.	.	.	.	.
	Pc m	L	24	31	18	2	.	.	.	.	.	.
		D	1	3	.	.	.	.	.	.	.	.
	Pn b	L	2	2	6	8	12	16	2	1	.	.
		D	4	3	.	1	.	.	.	.	.	.
	Pc g	L	.	1	1	.	1	1	1	.	.	.
		D	.	.	.	.	.	.	.	.	.	.
:15	Po t	L	4	34	48	46	24	5	.	.	1	.
		D	12	11	.	.	.	.	1	.	1	.
	Pn b	L	.	.	2	7	8	7	5	3	2	.
		D	.	.	3	.	1	.	[illegible]	1	.	.
	Pc g	L	1	7	.	.	1	.	[illegible]	.	.	1
		D	.	.	.	.	.	.	.	.	.	.
V B:8	Po t	L	.	.	1	.	.	2	.	.	.	.
		D	1	.	.	.	.	.	.	.	.	.
	Pc g	L	294	265	52	34	2	4	.	.	.	.
		D	36	18	.	.	.	.	.	.	.	.
	Pn b	L	1	31	81	59	18	3	.	.	.	.
		D	78	102	37	2	1	.	.	.	.	.
:9	Pc g	L	15	23	22	11	10	24	20	13	10	25
		D	4	5	5	4	3	2	1	.	.	.
	Pc m	L	1	5	6	7	5	.	.	.	.	.
		D	1	1	1	.	2	1	.	.	.	.
	Po b	L	.	.	.	.	.	.	.	.	.	.
		D	.	.	.	.	1	1	.	.	.	.

Appendix VII. Continued

Phytocoenon Phytocoenose	Species	Stems Live/ Dead	Diameter (at breast height) classes in inches and cm									
			1 2.5- 5	2 5- 7.6	3 7.6- 10	4 10- 12.7	5 12.7- 15.2	6 15.2- 17.8	7 17.8- 20.3	8 20.3- 22.9	9 22.9- 25.4	10-16 25.4- 27.9
V C:31	Pc g	L	28	15	13	8	3	6	4	3	7	9
		D	.	3	2	1	.	.	.	1	.	.
	Pc m	L	1	1	.	1	3	.	.	.	.	.
		D	.	.	.	.	.	.	.	.	.	.
	Be p	L	6	3	7	.	.	.	.	.	.	.
		D	.	1	.	.	.	.	.	.	.	.
VI A:20	Pc m	L	135	49	26	6	2	.	.	.	.	.
		D	1	1	1	.	.	.	.	.	.	.
	Pn b	L	.	1	.	.	.	.	.	.	.	.
		D	.	3	.	.	.	.	.	.	.	.
	Pc m	L	121	43	7	.	.	.	.	.	.	.
		D	14	7	.	.	.	.	.	.	.	.
:40	Pc m	L	115	65	43	6	5	.	.	.	.	.
		D	7	1	4	.	.	.	.	.	.	.
VI B:38	Pc m	L	29	12	5	1	.	.	.	.	.	.
		D	1	1	.	.	.	.	.	.	.	.
	La l	L	3	4	.	.	.	.	.	.	.	.
		D	.	.	.	.	.	.	.	.	.	.
VII A:18	Pc m	L	128	165	73	17	2	1	.	.	.	.
		D	124	54	22	6	.	1	.	.	.	.
	Pc g	L	14	27	28	13	10	5	1	1	1	.
		D	5	8	4	.	1	.	.	1	.	.
	La l	L	.	2	3	1	.	.	.	.	.	.
		D	.	4	.	2	2	.	.	.	.	.
:19	Pc m	L	33	41	27	18	3	4	.	.	.	.
		D	11	5	2	.	.	.	.	.	.	.
	Pc g	L	21	16	13	12	6	4	.	.	.	.
		D	1	.	.	.	.	.	.	.	.	1
	La l	L	4	15	6	3	1	.	.	.	.	.
		D	12	13	2	3	.	.	.	.	.	.
:11	Pc m	L	111	122	32	6	1	.	.	.	.	.
		D	9	1	.	.	.	.	.	.	.	.

Appendix VII. Continued

Phytocoenon Phytocoenose	Species	Stems Live/ Dead	Diameter (at breast height) classes in inches and cm									
			1 2.5-5	2 5-7.6	3 7.6-10	4 10-12.7	5 12.7-15.2	6 15.2-17.8	7 17.8-20.3	8 20.3-22.9	9 22.9-25.4	10-16 25.4-27.9
	Pn b	L	1	9	6	7	2	1	.	.	.	.
		D	13	11	11	4	1	1	.	.	.	.
	La I	L	2	.	.	.	.	.	.	.	.	.
		D	.	.	.	.	.	.	.	.	.	.
VII B:33	Pc g	L	23	20	25	32	17	17	4	8	5	10
		D	8	11	1	3	1	.	.	.	.	.
	Pc m	L	7	1	4	5	2	1	.	.	.	.
		D	1	5	2	1	.	.	.	.	.	.
	La l	L	.	.	.	.	4	2	.	1	1	.
		D	.	.	.	.	5	1	.	.	.	.
:41	La l	L	30	6	7	1	1	.	.	.	.	.
		D	5	3	.	.	.	.	.	.	.	.
	Pc m	L	33	2	.	.	.	.	.	.	.	.
		D	2	.	.	.	.	.	.	.	.	.
:39	La l	L	2	1	.	.	.	.	.	.	.	.
		D	.	.	.	.	.	.	.	.	.	.

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PHYTOCOENOSES AND PHYTOCOENOSES

	I	II					III								IV		V					VI				VII			
		A		B				A		B		C		D			A		B		C		A		D		A		
	30	1	2	3	4	13	17	14	5	12	20	6	34	10	32	16	7	15	8	9	31	20	21	40	36	18	19	11	33
Total Number of Species	19	51	46	56	40	40	54	50	55	51	56	42	68	72	42	41	32	53	46	40	62	35	34	26	30	71	58	74	60
X̄ Number of Species per Quadrat	8.4	19.0	20.0	21.0	18.8	17.5	27.2	25.1	19.8	25.0	20.4	15.7	23.0	30.7	14.3	13.3	14.8	15.2	14.2	15.3	17.0	17.3	18.7	12.2	23.8	29.0	22.6	28.7	23.6
Homogeneity Coefficient (HC)	72.3	41.0	57.7	56.7	48.1	40.1	67.6	53.6	44.7	48.8	50.5	46.5	56.2	58.4	58.4	48.4	62.8	46.7	44.4	58.0	52.9	66.5	77.5	73.0	55.0	52.6	56.1	41.8	58.0
SPECIES																													
Cladonia arbuscula		+ 1	II 1	+ 1	III 3		III 3	IV 6	III 2		III 2	II 5	V 6	III 4				+ 1	+ 1			I 1	+ 1	II 4	III 3	IV 3	II 3	III 3	
Cetraria pinastri		I 1	+ 1	II 1	+ 1	III 1	II 1	III 1	+ 1	+ 1	II 1	+ 1	II 1	II 1	I 1	+ 1		II 1				I 1	II 1		I 1	+ 1	+ 1	II 1	
Cladonia mitis	+ 1	I 1	+ 1	I 2	III 4	+ 1	III 3	I 1	III 2		+ 2	III 5	I 3	II 2				+ 2	+ 1			V 7	IV 3	V 4	III 3	II 2	II 2	IV 3	
Cladonia gracilis	I 1	I 1			+ 1	II 1	IV 2	IV 1	+ 1		III 1	II 1	II 1	II 1		+ 1		II 1	+ 1				I 1	II 1	II 1	I 1	+ 1		
Cladonia pyxidata	IV 3	V 7	V 5	IV 2	IV 1	V 4	III 1	II 1	III 1	III 3			+ 1	II 2		+ 1									+ 1	III 1	+ 1	+ 1	
Galium boreale		I 1	IV 2	V 2	III 1	V 1	IV 1	II 1	III 1	III 1	IV 2		V 1	III 1	I 1	+ 1			III 1	IV 2						IV 1	I 1	II 1	IV 1
Picea glauca			II 2	V 5	V 6	+ 1	V 5	+ 1	V 5	II 1	III 3		V 3	V 6	II 2	I 1	II 1	IV 4	V 7	V 7	V 6					V 6	V 5		V 6
Hylocomium splendens				I 1	II 2	+ 1	IV 6	IV 5	II 3		V 7	II 2	IV 5	V 6	I 1		V 7	V 4	V 6	III 7	V 8	+ 1			+ 2	IV 6	II 3	IV 4	V 5
Rosa acicularis		II 1	IV 1	IV 3	V 3	III 1	V 4	V 4	V 3	V 3	V 5	V 5	V 5	IV 3	V 5	V 5	V 5	V 5	IV 3	IV 4	I 2					V 4	V 2	II 1	III 1
Shepherdia canadensis			III 2	V 5	V 3	V 2	V 4	V 4	V 3	V 4	V 4	V 5	V 3	II 1	IV 2	V 5	I 1	+ 1	II 1	IV 2						V 2	I 1	I 1	+ 1
Juniperus communis		II 2	IV 4	V 5	V 6	V 5	V 6	V 5	V 5	+ 1	II 1		IV 3	IV 3	+ 1	+ 1		III 1	II 1	II 1	II 1					II 1	+ 1	III 1	
Ditrichum flexicaule	V 1	V 3	V 4	IV 1	IV 5	IV 2	IV 2	I 1	IV 3	V 3				II 4				+ 1	+ 1		II 1						IV 5	III 1	
Juniperus horizontalis		V 6	III 5	IV 5	III 4				+ 1		+ 1		+ 1	+ 1						+ 1						II 2	I 1	III 2	
Pinus banksiana		+		II 2	III 5	III 4	V 6	V 7	V 6	V 7	V 6	V 6	II 2	II 2		I 1	III 5	III 4	V 6			+ 1						IV 4	
Ptilidium ciliare					I 1	+ 1	IV 5	V 4	III 1		V 2	III 2	V 5	V 2			III 1	+ 1	IV 2				+ 1			+ 1	I 1	II 1	
Dicranum undulatum						+ 1	II 2	III 1	I 1		+ 1		III 1	III 1				II 1	II 1		+ 2	II 1	+ 1	+ 1	IV 3			III 3	+ 1
Cladonia rangiferina					II 1		IV 3	II 1	+ 1		III 1	V 4	III 2	IV 1				+ 1	I 1			V 4	IV 5	V 4	III 1	II 1	I 4	III 4	
Vaccinium vitis-idaea							+ 1				III 6	V 5	V 5	I 3			V 3	II 1	+ 1	II 3	III 2	V 2	V 3	V 4	V 4	II 1	III 2	V 3	
Cladonia cornuta				I 1			V 2	IV 1	I 1	+ 1	III 1	I 1	II 1	I 1			+ 1	I 1				II 1	I 1	III 2	I 1	I 1	+ 1		
Pleurozium schreberi						+ 1	II 1	III 2		+ 1	V 6	I 5	IV 4	IV 6			I 2		I 2			+ 1					I 1	+ 1	
Cetraria nivalis		II 1	II 1		+ 1	II 1	I 1	I 1				I 1	+ 1	I 1								IV 2	V 4	IV 4		II 1			
Cladonia alpestris					+ 1		III 3	+ 1				III 2	II 2	II 2								III 5	IV 5	IV 5		II 4	+ 3	II 1	
Hypnum cupressiforme	V 4																				+ 1								
Encalypta procera	III 1																				I 1								
Saxifraga tricuspidata	I 1	II 1	III 1		+ 1	III 2															+ 1								
Brachythecium albicans		II 1	+ 1	+ 1	II 1				+ 1									I 1											
Achillea lanulosa		I 1	V 1	II 1	I 1																					I 1			+ 1
Solidago decumbens			I 1	II 1	+ 1				+ 1																	I 1			
Cerastium arvense		IV 1	IV 1	I 1	+ 1																								
Poa glauca		I 1	II 1	I 1	+ 1																								
Festuca saximontana		V 2	I 1	II 1		+ 1																							
Draba lanceolata		II 1	II 1		I 1	I 1																							
Geum triflorum		II 1	II 1	I 1																									
Aster alpinus		III 1	I 1	I 1																									
Encalypta vulgaris		I 1		+ 1		+ 1																							
Bryum argenteum		I 1		+ 1		+ 1																							
Prunus pensylvanica		+ 1	III 2			II 1																							
Senecio cymbalarioides		IV 1	IV 1	III 1	III 1	II 1				I 1			+ 1																
Cladonia cariosa		II 1	II 1	I 1	III 1	II 1			I 1	+ 1	+ 1				+ 1														
Tortella fragilis	V 2	II 3	II 1	III 1	III 2			I 1	II 1					I 1															
Carex richardsonii		II 1	IV 2	V 2	IV 4		V 2	V 2	III 3				III 1	IV 2															
Campanula rotundifolia		I 1		II 1	III 1	III 1		+ 1	II 1				+ 1																
Fragaria virginiana			II 1	IV 1	+ 1				I 1	I 1	I 1									II 1									
Arctostaphylos uva-ursi		II 5	V 6	V 6	V 6	IV 6	V 6	V 6	V 5	II 2	III 7	V 5	V 7	II 4				I 1											
Peltigera canina		V 5	IV 2	II 1	III 3	III 2	III 1	II 1	III 1	IV 2	+ 1	+ 1	+ 1	I 1		+ 1													
Cetraria ericetorum		III 2	III 1	II 1	IV 1	IV 1	V 2	III 1	V 2	+ 1	+ 1	I 1	I 1	I 1										+ 1					
Anemone multifida		II 1	V 2	I 1	I 1	IV 1	I 1			+ 1	+ 1		+ 1																
Elymus innovatus			IV 3	V 3	III 1	III 1	V 1	V 2	V 2	V 4	V 4	V 3	IV 1	III 1	V 2	I 1	IV 3	II 1	II 1	V 4						II 1			
Eurhynchium pulchellum			+ 1	II 1	I 1	I 1	V 1	II 1	I 1	+ 1				+ 1	+ 1	+ 1		I 1	+ 1	+ 1									
Salix bebbiana						+ 1			+ 1	IV 2			+ 1		+ 1	III 3	IV 5	IV 3	+ 1	I 1	II 1								II 1
Populus tremuloides			V 6	V 6	IV 4	IV 4	I 1	I 1		I 1	I 1	+ 1	II 1		V 7	V 6	V 6	V 6	I 1										
Drepanocladus uncinatus		I 1	I 1	I 1		+ 1	I 1	II 1	+ 1	+ 1		+ 1		I 1	+ 1	+ 1	+ 1	I 1	I 1		I 1								
Campylium hispidulum		II 1	+ 1	+ 1	I 1			I 1	+ 1	I 1	+ 1	+ 1		+ 1	+ 1	+ 1				+ 1					+ 1			I 1	+ 1
Brachythecium salebrosum				I 1			II 1		+ 1	+ 1		I 1	II 1		+ 1	II 1	I 1	II 1	+ 1	+ 1	+ 1					II 1			
Campylium chrysophyllum				+ 1				I 1		+ 1						I 1	II 1	+ 1	+ 1	+ 1									
Populus balsamifera										+ 1			+ 1		IV 5	V 5													
Ribes oxyacanthoides										+ 1					+ 1	III 1													
Ribes lacustre														+ 1		I 1													
Lathyrus ochroleucus											II 1				II 1	I 1													
Viola americana															II 1	+ 1													
Rubus pubescens															III 3	II 2			+ 1		+ 1								
Linnaea borealis					+ 1		V 3	V 3	III 3	III 5	V 5	II 1	V 4	IV 2	I 1	II 1	IV 2	IV 1	V 2	IV 4	I 1					III 1		II 1	I 1
Peltigera aphthosa				+ 1			IV 1	II 2	I 1	II 1	II 1	+ 1	I 1	+ 1	+ 1			+ 1	II 1		IV 5				I 1	II 1		I 1	+ 1
Pyrola secunda							III 1	I 1	I 1	I 1	V 2	+ 1	IV 2	II 1	III 2	II 1	IV 1	I 1	+ 1	+ 1	I 1					II 1			
Viburnum edule							III 1	II 1		I 1	V 5	II 1	II 1	III 1	V 5	V 6	II 2	IV 2	III 1	II 2	I 1					+ 1			
Cornus canadensis								+ 1		+ 1	+ 1			+ 1	V 4	II 1	II 1	II 1	IV 3	II 2	+ 1					III 1		+ 1	+ 1
Ptilidium pulcherrimum							II 1	II 1			II 1	I 1	+ 1	II 1	+ 1		II 1	II 1	+ 1		+ 1		+ 1			+ 1			+ 1
Epilobium angustifolium								+ 1		I 1	III 3	I 1			II 1	II 1	II 1												
Sphagnum fuscum																						V 7	V 8	+ 1	V 8				
Cladonia pleurota											+ 1											III 1	IV 3	II 1	I 1				
Drosera rotundifolia																						+ 1	IV 1		III 1				
Mylia anomala																						V 2	V 3	I 1	V 2			I 1	
Ledum decumbens																						V 5	V 5	IV 3	IV 2				
Polytrichum strictum																						I 1	II 1	+ 1	III 2				
Cladonia amaurocraea																					+ 1	+ 1	III 1		I 1				
Chamaedaphne calyculata																						V 4	V 3	IV 2	II 2				
Rubus chamaemorus																						V 3	V 3	V 3	III 1				
Sphagnum nemoreum																						+ 1	+ 1	I 1					
Icmadophila ericetorum																						II 1	III 1	I 1					
Pinguicula villosa																						III 1	II 1		II 1				
Pohlia sphagnicola																						II 1	III 1		II 1				
Cladonia furcata																							+ 1		+ 1				
Andromeda polifolia																						III 1	V 3	+ 1	IV 2				
Oxycoccus microcarpus																						V 2	V 2	+ 1	IV 4				
Picea mariana													I 1	IV 5	+ 1		V 6			V 5	II 3	V 6	V 6	V 6	V 5	V			
Ledum groenlandicum													+ 1				+ 1			II 1	V 4	V 4	V 4	V 7	V 5				
Potentilla fruticosa		II 1													II 1					+ 1					+ 1	V 4			IV 2
Selaginella selaginoides																										+ 1	II [illegible]		
Arctostaphylos rubra																					+ 1					IV 3	II 2	[illegible]	
Salix myrtillifolia																				+ 1					+ 1	V 5	IV 4	V 4	
Mitella nuda																	+ 1			+ 1	IV 5				+ 1	IV 1	III 1	III 1	V 2
Equisetum pratense																				IV 6							II 1	V 2	V 7
Tomenthypnum nitens	+ 1			I 2	+ 2		II 1	I 1	III 1	II 1				I 1				+ 1	+ 1						III 5	V 6	III 6	III 4	V 5
Aulacomnium palustre									+ 1	IV 4											III 1				III 3	III 1	+ 4	III 2	III 5
Equisetum scirpoides												I 1	II 1				II 1	+ 1		IV 3						V 2	IV 2	IV 2	I 1
Larix laricina													+ 1												V 4	V 4	V 5	+ 1	V 5
Betula glandulosa																						+ 1			V 2		IV 3	V 3	V 3
Campylium stellatum																											III 5	II 3	V 4
Drepanocladus revolvens																											II 1	II 4	II 2
Bryum pseudotriquetrum																									+ 1		IV 2	II 1	IV 2
Salix candida																									+ 1		I 1	+ 1	
Myrica gale																									IV 4		II 2		
Scorpidium scorpioides																												I 4	
Triglochin maritima																												+ 1	
Cinclidium stygium																											+ 1	+ 1	

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PHYTOCOENON AND PHYTOCOENOSES

III					IV		V					VI				VII								VIII				IX			X
[illegible]	[illegible]	C		D			A		B		C		A		B		A			B			C		A		B	A		B	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	36	7	15	6	9	31	20	21	40	36	18	19	11	33	41	39	35	37	26	34	23	21	29	28	27	36
[illegible]																															

Juniperus communis		II 2 IV 4 V 1 V 6 V 5	V 6 V 5 V 5 + 1 II 1 IV 5 IV 5	+ 1 + 1	III 1 II 1 II 1 II 1		II 1 + 1 III 1
Ditrichum flexicaule	V 1	V 5 V 4 IV 1 IV 5 IV 2	IV 2 I 1 IV 3 V 5 II 4		+ 1 + 1 II 1		IV 4 III 1
Juniperus horizontalis		V 6 III 5 IV 5 III 4 V	+ 1 + 1 + 1 + 1		+ 1 II 1		II 2 I 1 III 2
Pinus banksiana		II 2 III 5 III 6	V 6 V 7 V 6 V 7 V 6 V 6 V 5 II 2	I 1	III 5 III 4 V 6	+ 1	IV 4
Ptilidium ciliare		I 1 + 1	IV 3 V 4 III 1 V 2 III 3 V 5 V 2		III 1 + 1 IV 2		+ 1 I 1 II 1
Dicranum undulatum		+ 1	II 2 III 1 I 1 + 1 III 1 III 1		II 1 II 1 + 2	II 1 + 1 + 1 + 1 IV 3	III 3 + 1 + 1
Cladonia rangiferina		II 1	IV 3 II 1 + 1 III 1 V 4 III 3 IV 1		+ 1 I 1	V 4 IV 3 V 4 III 1	II 1 I 4 III 4
Vaccinium vitis-idaea			+ 1 III 6 V 5 V 5 I 5		V 5 II 1 + 1 II 5 III 2	V 2 V 3 V 4 V 4	II 1 III 3 V 3
Cladonia cornuta		I 1	V 2 IV 1 I 1 + 1 III 1 I 1 II 1 I 1		+ 1 I 1	II 1 I 1 III 1 I 1	I 1 + 1
Pleurozium schreberi		+ 1	II 1 III 2 + 1 V 6 I 5 IV 4 IV 6		I 1 I 1	+ 1	I 1 + 1
Cetraria nivalis		II 1 II 1 + 1 II 1	I 1 I 1 I 1 + 1 I 1			IV 2 V 4 IV 4	II 1
Cladonia alpestris		+ 1	III 3 + 1 III 2 II 2 II 2			III 5 IV 5 IV 5	II 4 + 5 II 1
Hypnum cupressiforme	V 4				+ 1		
Encalypta procera	III 1				I 1		
Saxifraga tricuspidata	I 1	II 1 III 1 + 1 III 2			+ 1		
Brachythecium albicans		II 1 + 1 + 1 II 1	+ 1		I 1		
Achillea lanulosa		I 1 V 1 II 1 I 1					I 1 + 1
Solidago decumbens		I 1 II 1 + 1	+ 1				I 1
Cerastium arvense		IV 1 IV 1 I 1 + 1					
Poa glauca		I 1 II 1 I 1 + 1					
Festuca saximontana		V 2 I 1 II 1 + 1					
Draba lanceolata		II 1 II 1 I 1 I 1					
Geum triflorum		II 1 II 1 I 1					
Aster alpinus		III 1 I 1 I 1					
Encalypta vulgaris		I 1 + 1 + 1					
Bryum argenteum		I 1 + 1 + 1					
Prunus pensylvanica		+ 1 III 2 II 1					
Senecio cymbalarioides		IV 1 IV 1 III 1 III 1 II 1	I 1 I 1				
Cladonia cariosa		II 1 II 1 I 1 III 1 II 1	I 1 + 1 + 1	+ 1			
Tortella fragilis	V 2	II 3 II 1 III 1 III 2	I 1 II 1 I 1				
Carex richardsonii		II 1 IV 2 V 2 IV 4	V 2 V 2 III 5 III 1 IV 2				
Campanula rotundifolia		I 1 II 1 III 1 III 1	+ 1 II 1 + 1				
Fragaria virginiana		II 1 IV 1 + 1	I 1 I 1 I 1		II 1		
Arctostaphylos uva-ursi		II 5 V 6 V 6 V 6 IV 6	V 6 V 6 V 5 II 2 III 7 V 5 V 7 III 4		I 1		
Peltigera canina		V 5 IV 2 II 1 III 3 III 2	III 1 III 1 III 1 IV 2 + 1 + 1 + 1 I 1	+ 1			
Cetraria ericetorum		III 2 III 1 II 1 IV 1 IV 1	V 2 III 1 V 2 + 1 I 1 I 1 I 1		+ 1		
Anemone multifida		II 1 V 2 I 1 I 1 IV 1	I 1 + 1 + 1 + 1				
Elymus innovatus		IV 3 V 3 III 1 III 1	V 1 V 2 V 2 V 4 V 4 V 3 IV 1 III 1	V 2 I 1	IV 3 II 1 II 1 V 4		II 1
Eurhynchium pulchellum		+ 1 II 1 I 1 I 1	V 1 II 1 I 1 + 1 + 1	+ 1 + 1	I 1 + 1 + 1		
Salix bebbiana		+ 1	+ 1 IV 2 + 1	+ 1 III 3	IV 5 IV 5 + 1 I 1 II 1		II 1
Populus tremuloides		V 6 V 6 IV 4 IV 4	I 1 I 1 I 1 I 1 + 1 III 1	V 7 V 6	V 6 V 6 I 1		
Drepanocladus uncinatus		I 1 I 1 I 1 + 1	I 1 II 1 + 1 + 1 + 1 I 1	+ 1 + 1	+ 1 I 1 I 1 II 1		
Campylium hispidulum		II 1 + 1 + 1 I 1	I 1 + 1 I 1 + 1 + 1 + 1	+ 1 + 1	+ 1	+ 1	I 1 + 1
Brachythecium salebrosum		I 1	II 1 + 1 + 1 I 1 III 1	+ 1 II 1	I 1 III 1 + 1 + 1 + 1		III 1
Campylium chrysophyllum		+ 1	I 1 + 1	I 1	II 1 + 1 + 1 + 1		
Populus balsamifera			+ 1 + 1	IV 5 V 5			
Ribes oxyacanthoides			+ 1	+ 1 III 1			
Ribes lacustre			+ 1	I 1			
Lathyrus ochroleucus			II 2	II 1 I 1			
Viola americana				II 1 + 1			
Rubus pubescens				III 3 II 2			
Linnaea borealis		+ 1	V 3 V 3 III 3 III 5 V 5 II 1 V 4 IV 2	I 1 II 1	IV 2 IV 1 V 2 IV 4 I 1		III 1 II 1 I 1
Peltigera aphthosa		+ 1	IV 1 II 2 I 1 II 1 II 1 + 1 I 1 + 1	+ 1	+ 1 II 1 IV 5	I 1	II 1 I 1 + 1
Pyrola secunda			III 1 I 1 I 1 I 1 V 2 + 1 IV 2 III 1	III 2 II 1	IV 1 I 1 + 1 + 1 I 1		II 1
Viburnum edule			III 1 II 1 I 1 V 5 II 1 II 1 III 1	V 5 V 6	II 2 IV 2 III 1 II 2 I 1		+ 1
Cornus canadensis			+ 1 + 1 + 1 + 1	V 4 II 1	II 1 II 1 IV 3 II 2 + 1		III 1 + 1 + 1
Ptilidium pulcherrimum			II 1 II 1 II 1 I 1 I 1 III 1	+ 1	II 1 II 1 + 1 II 1	+ 1	+ 1 + 1
Epilobium angustifolium			+ 1 I 1 III 3 I 1	II 1 II 1	III 1		
Sphagnum fuscum						V 7 V 8 + 1 V 8	
Cladonia pleurota						III 1 IV 3 II 1 I 1	
Drosera rotundifolia			+ 1			+ 1 IV 1 III 1	
Mylia anomala						V 2 V 3 I 1 V 2	I 1
Ledum decumbens						V 5 V 5 IV 5 IV 2	
Polytrichum strictum						I 1 II 1 + 1 III 2	
Cladonia amaurocraea					+ 1	+ 1 III 1 I 1	
Chamaedaphne calyculata						V 4 V 3 IV 2 II 2	
Rubus chamaemorus						V 3 V 3 V 3 III 1	
Sphagnum nemoreum						+ 1 + 1 I 1	
Icmadophila ericetorum						II 1 III 1 I 1	
Pinguicula villosa						III 1 II 1 II 1	
Pohlia sphagnicola						II 1 III 1 II 1	
Cladonia furcata						+ 1 + 1	
Andromeda polifolia						III 1 V 3 + 1 IV 2	
Oxycoccus microcarpus						V 2 V 2 + 1 IV 4	
Picea mariana			I 1 IV 5	+ 1	V 6 V 5 II 3	V 6 V 6 V 6 V 8	V 7 V 5 V 6 II 3 V
Ledum groenlandicum			+ 1		+ 1 II 1 V 4	V 4 V 4 V 7 V 5	V 5 V 3 +
Potentilla fruticosa		II 1		II 1	+ 1	+ 1	V 4 V 5 V 4 IV 2 V
Selaginella selaginoides							+ 1 III 1 + 1 III
Arctostaphylos rubra					+ 1		IV 3 II 2 II 1 II 4 III
Salix myrtillifolia					+ 1	+ 1	V 5 IV 4 V 4 III 4 IV
Mitella nuda					+ 1 + 1 IV 5	+ 1	IV 1 III 1 III 1 V 2 I
Equisetum pratense					IV 6		II 1 V 2 V 7 V
Tomenthypnum nitens	+ 1	I 2 + 2	II 1 I 1 III 1 II 1 I 1		+ 1 + 1	III 5	V 8 III 6 III 4 V 5 V
Aulacomnium palustre			+ 1 IV 4		III 1	III 3	III 1 + 4 III 2 III 5 III
Equisetum scirpoides			I 1 II 1		II 1 + 1 IV 3		V 2 IV 2 IV 2 I 1 IV
Larix laricina			+ 1			V 4	V 4 V 5 + 1 V 5 V
Betula glandulosa						+ 1 V 2	IV 3 V 3 V 3 V
Campylium stellatum							III 5 II 3 V 4 V
Drepanocladus revolvens							II 1 II 4 II 2 V
Bryum pseudotriquetrum						+ 1	IV 2 II 1 IV 2 V
Salix candida						+ 1	I 1 + 1 II
Myrica gale						IV 4	II 2
Scorpidium scorpioides							I 4 +
Triglochin maritimum							+ 1
Cinclidium stygium							+ 1 + 1 IV
Lobelia kalmii							
Moerkia hibernica							
Pinguicula vulgaris							
Kobresia simpliciuscula							
Primula mistassinica							
Carex limosa						+ 1	I 1
Salix pedicellaris							
Menyanthes trifoliata							
Drepanocladus fluitans							
Carex chordorrhiza							
Carex lasiocarpa							
Calliergon trifarium							
Rorippa islandica							
Salix planifolia							
Carex rostrata							
Cicuta mackenzieana							
Scutellaria galericulata							
Eriophorum angustifolium							+ 1
Triglochin palustre							

*Quadrat Frequency Classes: + = 1-10, I = 11-20, II = 21-40, III = 41-60, IV = 61-80, V = 100%
Quadrat Cover Classes: 1 = <, 2 = 1-1.9, 3 = 2-2.9, 4 = 3-4.9, 5 = 5-12.9, 6 = 13-25.9, 7 = 26-50.9, 8 = 51-75.9, 9 = 76-100%

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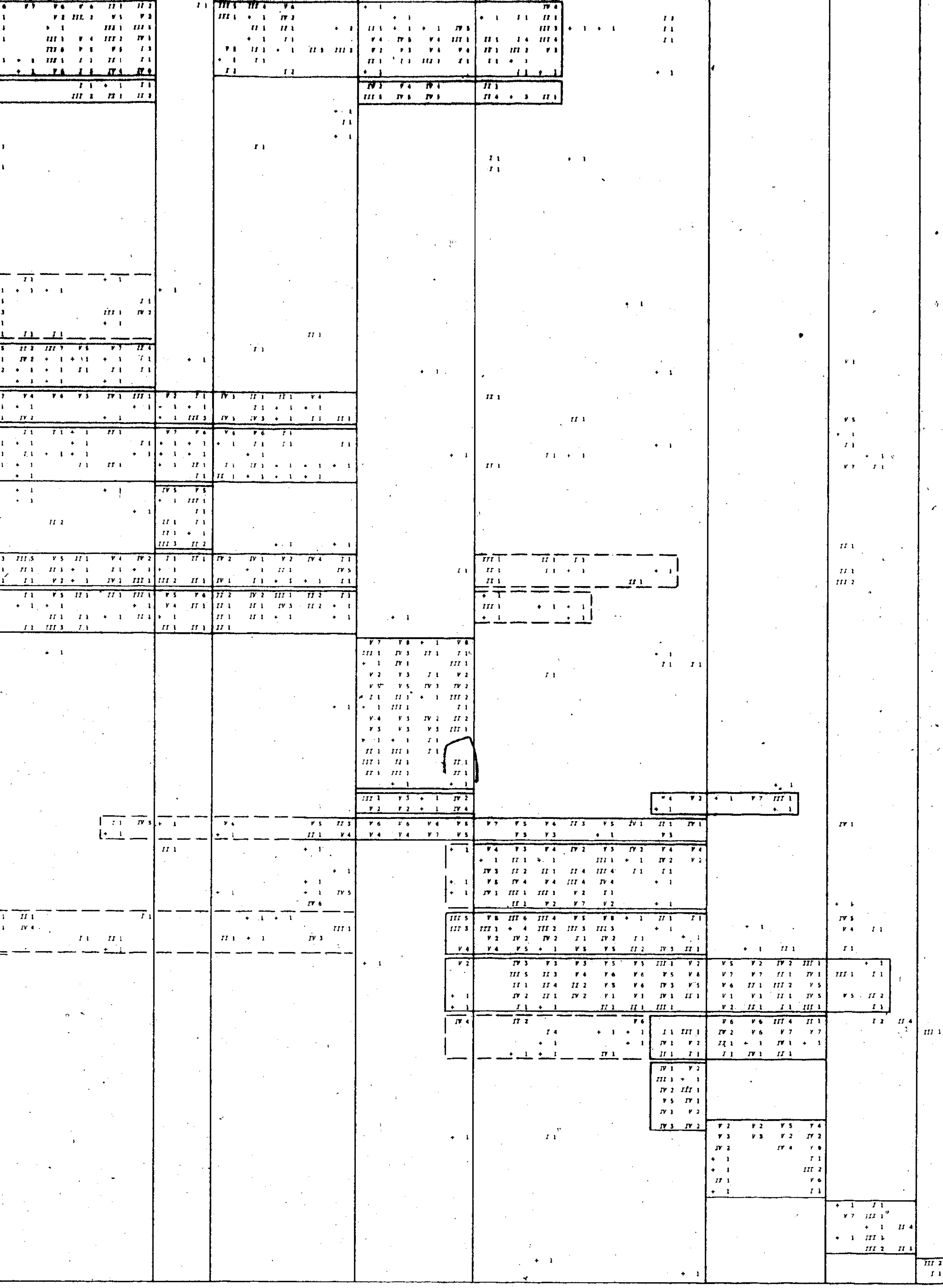

0.9, 8 = 51-75.9, 9 = 76-100%

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Table 5. Classification of phytocoenoses based on species composition and abundance. For inclusion a species must occur in at least two phytocoenoses. Solid lines delimit distinct groups and dashed lines characterize weaker groups.

Table 5. (Continued). Classification of phytocoenoses based on species composition and abundance. For inclusion a species must appear in at least two phytocoenoses. Dashed lines characterize weak species groups.

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Hypnum bambergeri

Dicranum groenlandicum

Moneses uniflora

Stellaria longipes

Marchantia polymorpha

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PHYTOCOENON AND PHYTOCOENOSE

III					IV		V						VI				VII								VIII				IX			X
B		C		D				A		B		C			A	B		A				B		C		A		B	A		B	
2	22	6	34	10	32	16	7	15	8	9	31	20	21	40	38	18	19	11	33	41	38	35	37	26	24	23	21	29	28	27	36
[illegible]																																

Species
[illegible]
[illegible]
[illegible]
[illegible] flagellare
Trillium [illegible]
Tofieldia glutinosa
[illegible] uliginosa
Sphagnum [illegible]
[illegible] sp.
Salix [illegible]
[illegible]
Juncus balticus
Anemone parviflora
[illegible]
[illegible] rotundifolia
[illegible] labradorica
Carex [illegible]
Tofieldia pusilla
[illegible]
Carex eburnea
[illegible]
Carex capillaris
Salix [illegible]
[illegible]
[illegible]
Carex [illegible]
[illegible]
[illegible]
[illegible]
Carex [illegible]
Parnassia palustris
Carex [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
Carex [illegible]
[illegible]
Aster [illegible]
[illegible]
Carex [illegible]
[illegible]
[illegible]
Carex [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
Salix [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
Aster [illegible]
Cladonia fimbriata
[illegible]
[illegible]
[illegible]
Cladonia [illegible]
[illegible]
Cladonia [illegible]
[illegible]
[illegible]
Carex [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
Cladonia [illegible]
Betula [illegible]
[illegible]
Bryum [illegible]
Cladonia [illegible]
Stereocaulon tomentosum
Cladonia [illegible]
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Cladonia [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
Dicranum groenlandicum
Moneses uniflora
Carex [illegible]
Stellaria longipes
Marchantia polymorpha
[illegible]
[illegible]
[illegible] canadensis
[illegible] trifida
Calypso bulbosa
Bryum [illegible]

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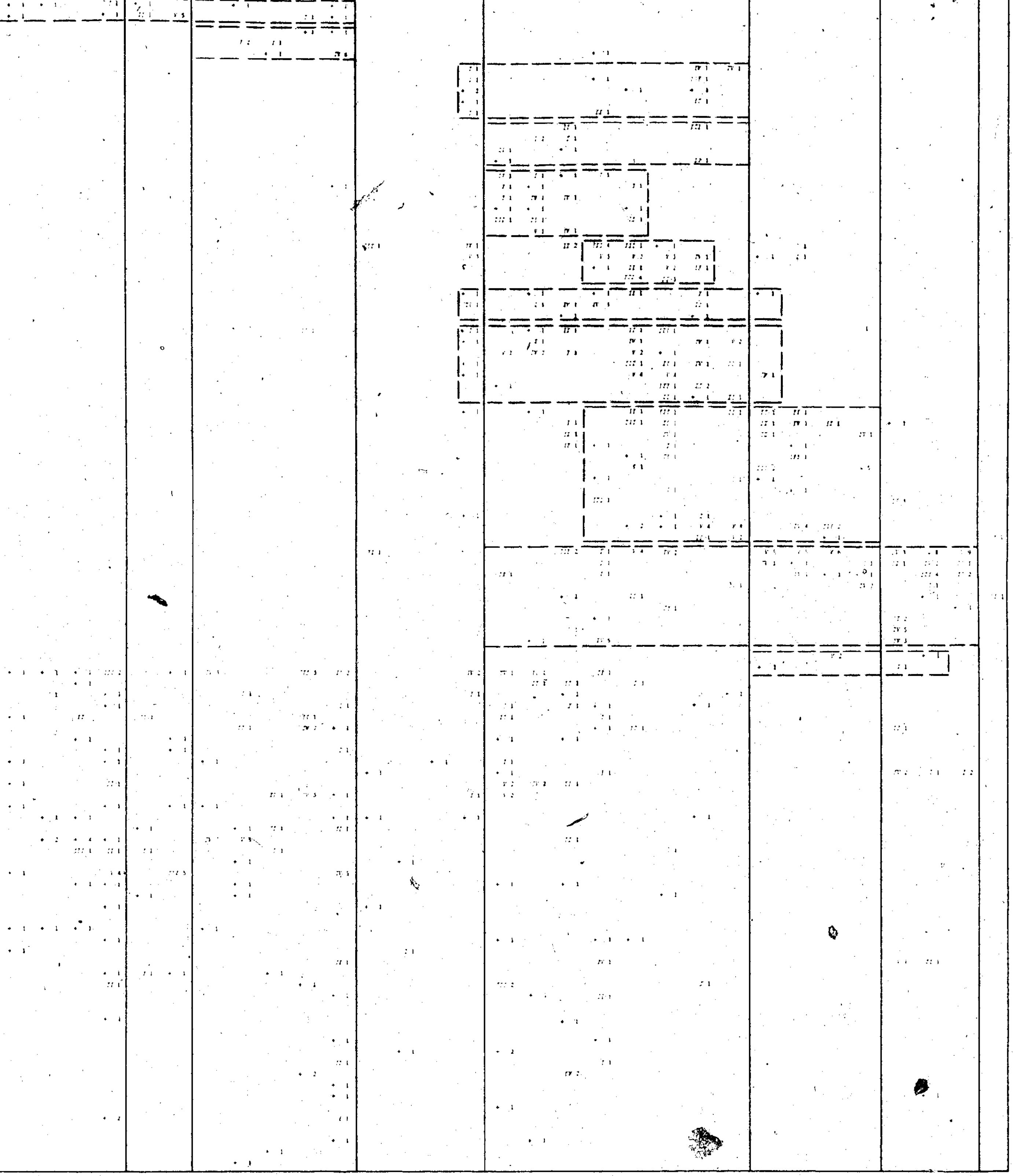

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Table 9. Classification of phytocoenoses based on dominant life-forms of component vascular strata.

CODE	PHYTOCOENON AND PHYTOCOENOSE	I	II				III				IV	V							
			A	B										A	B				
		30	36	27	28	25	23	26	24	39	37	1	35	29	38	11	41	19	33
FE-FORM CLASSES																			
0	Mesophanerophytes														1.1	1.7	0.2	13.3	25.0
0	Microphanerophytes							0.2		1.5			0.7	8.7	5.4	19.9	7.8	10.5	6.9
0	Nanophanerophytes			4.3	2.0	1.8	2.7	9.7	4.2	8.2	0.4	2.2	3.3	36.8	8.6	20.9	16.7	12.9	5.8
0	Chamaephytes	0.2				1.1	9.2	27.4	52.8	30.6	7.1	30.4	42.8	1.8	19.6	12.5	19.0	13.2	6.9
0	Hemicryptophytes		0.4	1.7	4.5	2.2	2.1	3.2	4.8	10.1	73.6	5.7	21.4	7.2	5.4	2.4	8.7	1.9	8.5
0	Cryptophytes		3.7	83.0	62.8	17.8	20.8	10.4	12.0	3.0	1.7	1.3	6.4	4.1	2.9	9.3	10.5	11.1	51.7
0	Hydrophytes		0.9	4.7	9.2	18.1	1.2	1.1	0.8		0.7								
0	Therophytes				0.1														
FE-FORM SUBCLASSES																			
6	Rhizome cryptophytes without rosettes		*IV** 0.7	*V* 83.0	*V* 62.8	*V* 17.8	*V* 20.8	*V* 10.3	*V* 12.0	*V* 2.3	*V* 1.6	*I* 0.2	*V* 5.2	*V* 3.6	*V* 2.7	*V* 5.6	*V* 7.1	*V* 7.9	*V* 15.8
8	Emergent herbaceous hydrophytes		+ 0.1	*III* 4.7	*IV* 8.7	*V* 16.9	+ 0.1	*IV* 1.1	*IV* 0.8										
6	Non-rooted submerged hydrophytes		*II* 0.4		*I* 0.3	*IV* 1.2	*V* 1.1				*IV* 0.7								
6	Caespitose hemicryptophytes						*III* 1.3	+ 0.1	*V* 4.2	*V* 2.7	*V* 64.7	*V* 2.6	*V* 14.0		*V* 2.8		*V* 2.6	*V* 1.3	*V* 2.4
6	Basal rosette hemicryptophytes without stolons		*I* 0.2			+ 0.1	*IV* 0.8		+ 0.1	+ 0.1	*V* 5.0	+ 0.1	*V* 3.6	*III* 2.2	*IV* 1.0	+ 0.1		+ 0.1	
4	Prostrate cryptogamic chamaephytes									+ 0.1	*V* 1.0		*I* 1.4			+ 0.3	*III* 0.5	*II* 0.4	
6	Protohemicryptophytes without stolons									*III* 0.5			*II* 1.5	*III* 0.6					
5	Prostrate gymnospermous chamaephytes											*V* 22.5	*IV* 30.3			*III* 1.8		*I* 0.6	
6	Semi-rosette hemicryptophytes without stolons				*III* 0.9					*II* 0.4	*V* 2.0	*V* 1.5	+ 1.6	+ 0.2	+ 0.1		*III* 0.7	+ 0.1	*II* 0.6
8	Prostrate (passive) herbaceous chamaephytes	*I* 0.2										*V* 2.3	*I* 0.2	*II* 0.7					
6	Bulbous or tuberous cryptophytes without rosettes		*IV* 0.8					+ 0.1					*I* 0.3		+ 0.1	+ 0.1	*II* 0.4	+ 0.1	+ 0.1
24	Rhizome cryptogamic cryptophytes without rosettes		*II* 0.5							*I* 0.2	+ 0.1		+ 0.1	*II* 0.5		*V* 2.3	*V* 2.6	*V* 1.4	*V* 35.2
25	Gymnospermous mesophanerophytes														*III* 1.1	*V* 1.7	*I* 0.2	*V* 13.3	*V* 25.0
16	Bulbous or tuberous cryptophytes											*II* 0.5	*I* 0.6			+ 0.1		*I* 0.2	*I* 0.2
26	Rhizome cryptophytes without rosettes		*III* 1.7							*II* 0.5		*II* 0.6	*I* 0.2		+ 0.1	*II* 1.2	*V* 0.4	*IV* 1.5	
35	Gymnospermous microphanerophytes									*II* 0.9			+ 0.7	*V* 8.7	*V* 5.4	*V* 19.9	*V* 7.8	*V* 10.5	*V* 5.0
45	Gymnospermous nanophanerophytes						*I* 0.2				+ 0.1	*II* 1.4	*IV* 1.1	*I* 0.4	*V* 2.3	*V* 3.6	*V* 7.1	*V* 3.9	*II* 1.7
27	Prostrate woody chamaephytes						*II* 0.6	+ 0.1	*V* 39.1	*III* 2.9	*V* 1.0	*II* 5.0	*III* 4.0		*V* 8.6	*V* 6.9	*IV* 12.5	*V* 6.1	*III* 4.2
15	Gymnospermous erect chamaephytes						+ 0.1		+ 0.1	*IV* 1.0	*IV* 1.3		*I* 1.4	*III* 0.6	*V* 2.5	*III* 1.0	*V* 3.3	*IV* 1.1	*V* 1.9
47	Angiospermous nanophanerophytes			*III* 4.3	*IV* 2.0	*IV* 1.8	*V* 2.5	*V* 9.7	*V* 4.2	*V* 8.2	*I* 0.3	*II* 0.8	*III* 2.2	*V* 36.4	*V* 6.3	*V* 17.3	*V* 9.6	*V* 9.0	*IV* 4.1
16	Angiospermous erect chamaephytes					*III* 1.1	*V* 8.5	*V* 27.3	*V* 13.6	*V* 26.6	*V* 3.8	*II* 0.6	*III* 5.5	*II* 0.5	*V* 8.5	*V* 2.5	*V* 2.7	*IV* 5.0	*III* 0.8
16	Protohemicryptophytes with stolons			*III* 0.6	*V* 3.3	*I* 0.2		*IV* 1.1	+ 0.1	*III* 0.9	*IV* 1.2	*I* 0.2	*IV* 0.7	*III* 0.5	*IV* 1.0	*III* 0.1	*IV* 1.0	*I* 0.3	*IV* 1.3
36	Semi-rosette hemicryptophytes with stolons			*I* 1.1	*I* 0.2	*III* 1.9		*IV* 1.3	*II* 0.4	*V* 4.9	*I* 0.3	*III* 0.9		*IV* 1.9	*I* 0.5	*IV* 1.3	*V* 4.0	*IV* 1.4	*V* 3.7
46	Basal rosette hemicryptophytes with stolons		*I* 0.2							*III* 0.6	*II* 0.4	*II* 0.4		*III* 2.2			*II* 0.4	+ 0.1	*III* 0.5
26	Angiospermous mesophanerophytes																		
37	Angiospermous microphanerophytes							*I* 0.2		*III* 0.6						*II* 0.5			*IV* 1.9
36	Root cryptophytes																		*I* 0.4
46	Rooted submerged hydrophytes		*II* 0.4																
56	Non-rooted floating hydrophytes				+ 0.1														
36	Rooted floating hydrophytes				+ 0.1														
16	Therophytes without rosettes				+ 0.1														
86	Biennial hemicryptophytes				+ 0.1														
	OTAL NUMBER OF LIFE-FORMS	1	9	5	11	8	10	11	10	17	15	15	19	13	15	18	17	18	18
	NUMBER OF LIFE-FORMS PER QUADRAT	-	3.7	4.7	4.7	4.9	5.8	5.8	6.3	9.5	10.2	7.2	10.1	7.5	10.3	11.4	13.1	11.2	12.6
	OMOGENEITY COEFFICIENT (bH)	-	40.5	21.3	70.2	69.4	77.6	87.9	90.5	57.9	90.2	51.4	75.2	50.7	90.3	75.4	84.7	88.4	81.0

* QUADRAT FREQUENCY CLASSES: + = 1-9, *I* = 10-20, *II* = 21-40, *III* = 41-60, *IV* = 61-80, *V* = 81-100%.

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VI										VII	VIII									IX			
C		D									A					B				A		B	
3	9	4	18	5	14	10	17	31	8	6	2	3	13	22	34	12	21	20	40	7	15	16	32
.0	36.7	15.7	16.4	20.5	21.8	15.8	24.0	15.7	27.5	20.4		2.8		17.6	3.5			0.4		28.1	24.9	35.5	50.8
.9	7.5	8.3	23.0	4.6	6.4	8.2	7.7	46.2	40.2	2.2	21.1	27.4	7.9	2.5	4.3	36.7	10.1	15.2	11.7	28.5	79.8	2.6	2.8
.8	5.4	17.0	14.5	12.9	12.6	7.9	16.0	6.4	1.4	6.8	10.1	24.3	10.5	8.3	7.4	23.7	15.2	7.1	32.8	11.1	5.0	27.0	12.8
.9	9.0	26.1	15.9	14.3	21.6	9.6	25.0	4.5	4.9	20.7	26.2	29.1	34.8	67.8	49.4	12.4	19.2	13.7	12.6	8.8	8.7	18.0	22.2
.5	12.7	5.1	6.6	2.9	2.6	2.8	2.8	10.5	4.9	2.6	8.9	7.5	4.2	11.1	4.8	5.4	3.7	3.1	2.5	4.8	2.0	3.0	10.2
.7	21.9	3.3	4.1	3.6	1.6	3.5	3.2	2.5	0.2	0.5	1.6	1.9		0.4	3.3	0.1		0.8		2.9	0.1	0.3	
V ,8	+ 3.0		IV 1.0	+ 0.1		III 1.4	IV 0.8	III 2.1						+ 0.3	II 0.5			III 0.8		IV 2.5		+ 0.3	
V 3.4	IV 2.1	II 2.1						+ 0.1	II 0.3		II 0.6	III 0.6	I 0.2										
			II 0.4				III 0.5	IV 1.3			II 0.3			V 2.0			IV 1.1	III 0.7					
			+ 0.1																	I 0.4			
	I 0.6		+ 0.1				+ 0.1																
	+ 0.3	III 3.5	II 1.2	+ 0.1		+ 0.3					III 7.2	IV 8.3		+ 0.1	+ 0.1								
II 0.6	I 0.4	II 0.7	II 0.5				I 0.2	+ 0.1			V 2.1	IV 1.0	IV 1.0	+ 0.1	+ 0.4	I 0.4							
		II 0.6	II 0.3					II 0.3	+ 0.1		IV 1.7	II 0.3	IV 1.5			II 0.3						II 1.9	III 2.0
+ 0.1							+ 0.1		+ 0.1														
V 5.2	V 18.8		V 1.0							I 0.2					II 0.4					II 0.4	+ 0.1		
V 5.0	V 36.7	V 14.8	V 16.4	V 20.5	V 21.8	V 14.2	V 24.0	V 15.7	V 26.9	V 20.1		IV 2.8		V 17.6	II 2.1			II 0.4		V 9.7	IV 5.4	I 1.2	II 0.9
I 0.2	+ 0.1		III 0.5	II 0.6	III 0.5	III 0.5	IV 0.7	+ 0.1	+ 0.1			I 0.2		+ 0.1	V 1.9	+ 0.1							
		IV 3.3	V 1.6	III 2.9	V 1.1	IV 1.6	V 1.6			+ 0.3	IV 1.6	V 1.7			III 0.5								
V 5.0	V 7.3	IV 5.3	V 23.0	IV 4.5	V 5.8	V 6.2	V 7.7	V 5.1	V 40.2	II 1.2	II 1.9	V 6.9	III 4.2	IV 2.2	III 1.6	V 36.7	V 10.1	V 15.2	V 11.7	V 9.6	III 2.8		+ 0.4
II 1.7	III 1.6	V 17.0	IV 6.2	V 9.9	V 7.7	V 4.5	V 10.8	V 3.2	I 0.2		IV 3.3	V 11.8	V 6.4	II 0.4	IV 2.9	V 14.6	V 12.3	V 2.6	V 1.5	IV 3.9	III 0.9	+ 0.3	+ 0.1
III 4.2	V 5.7	V 17.7	V 10.0	V 11.0	V 16.8	V 6.5	V 15.9	IV 1.4	V 1.4	V 17.8	V 13.3	V 16.7	IV 24.3	V 54.8	V 43.6	III 6.3	V 6.9	V 3.1	V 3.7	V 4.2	IV 1.8	II 0.5	I 0.2
V 1.9	I 0.2	III 1.2	III 0.9	V 1.2	II 1.5	II 1.2	V 6.1	II 0.3	II 0.3		III 0.9	IV 0.9	II 3.4	+ 0.1	I 0.2	+ 0.1	III 1.2	II 0.5	III 0.7	II 1.6	II 0.3		+ 0.1
IV 4.1	V 3.8	V 3.3	V 8.3	V 3.0	V 4.9	IV 3.4	V 5.2	IV 3.2	III 1.2	V 6.8	V 6.8	V 12.5	V 4.1	V 7.9	V 4.5	IV 8.1	V 2.9	V 4.5	V 31.3	V 7.2	V 4.1	V 26.7	V 12.7
III 0.8	IV 2.8	IV 3.1	V 3.4	V 2.0	V 3.3	IV 1.6	V 3.0	III 2.5	V 3.1	IV 2.9	V 3.1	III 2.9	V 5.6	V 12.8	V 5.5	V 5.7	V 11.1	V 10.1	V 8.2	IV 2.6	V 6.6	V 15.6	V 19.9
IV 1.3	IV 3.5	III 0.5	V 1.9	III 0.7	IV 1.1	III 0.6	IV 1.0	+ 0.1	V 3.8	I 0.2	IV 1.2	V 1.6	V 1.0	V 4.8	V 1.6	III 1.2	V 2.6	V 2.4	V 2.5	III 1.3	II 0.5	III 2.4	V 6.8
V 3.7	V 3.6	IV 1.7	V 2.4	V 1.7	V 1.3	IV 1.1	V 1.0	IV 8.9	II 0.5	V 2.3	V 3.5	V 3.3	V 2.0	V 4.2	V 1.2	V 3.2				V 2.8	II 0.4	II 0.3	V 1.5
III 0.5	IV 2.5	+ 0.1	II 0.4	II 0.5	I 0.2	IV 1.1	III 0.5	IV 1.3	II 0.3	+ 0.1	IV 1.1	IV 1.0		V 2.0	V 1.6	II 0.6				IV 0.7	I 1.1	II 0.3	III 1.9
		II 0.9				II 1.6		III 2.4	I 0.6	+ 0.3					I 0.5					V 18.4	V 19.5	V 34.3	IV 49.9
IV 1.9	+ 0.3	III 3.0		+ 0.1	I 0.6	III 2.0		IV 3.1		+ 1.0	V 19.2	V 20.5	III 3.7	I 0.3	I 3.6					V 18.9	V 77.4	V 2.6	V 2.4
I 0.4								II 0.3															
											+ 0.1												
18	18	17	20	15	13	16	16	18	14	12	16	17	12	15	18	12	8	10	7	15	13	12	13
12Ↄ6	10.5	10.8	13.8	9.8	10.0	10.6	12.1	8.7	7.3	5.9	11.9	12.9	8.8	8.7	10.3	7.2	7.3	7.8	6.3	11.2	7.9	6.3	7.8
81.0	85.7	65.7	81.2	77.6	87.0	72.6	92.6	34.5	65.7	79.7	80.7	86.8	79.5	88.5	71.8	69.4	91.8	76.9	92.1	87.5	68.4	65.6	75.6

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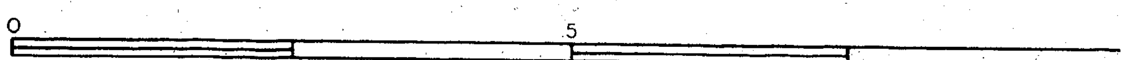

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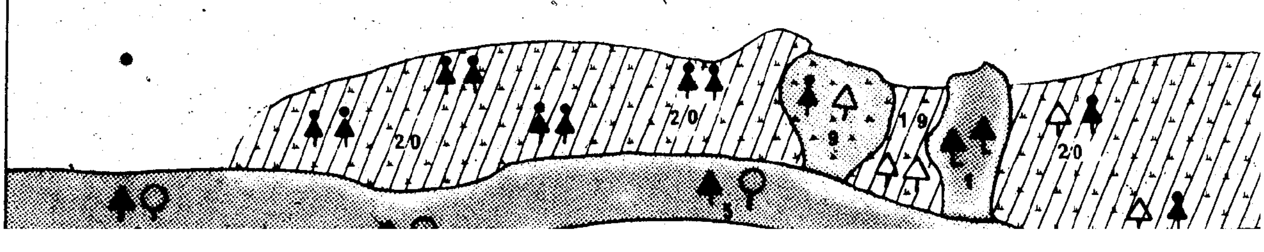


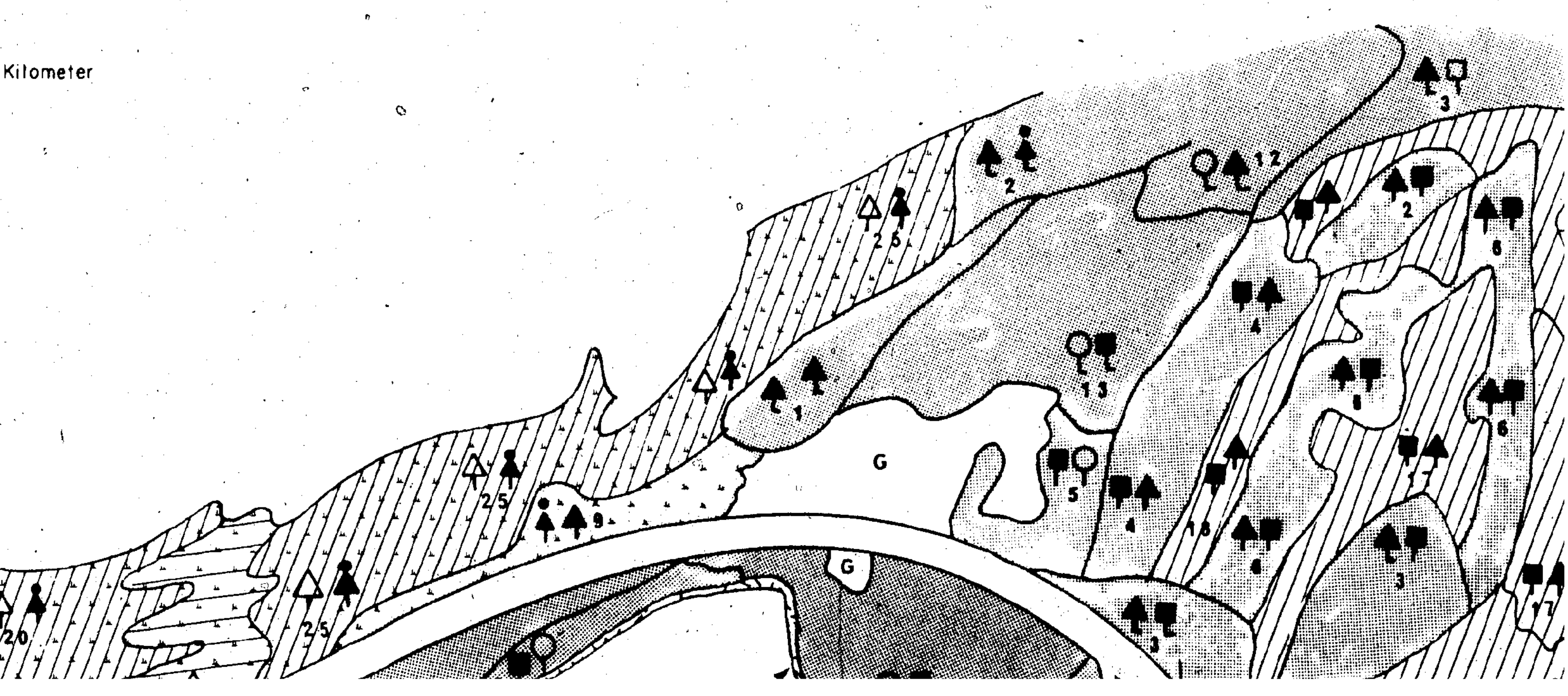
Vegetation Map of the Heart L
Southern Mackenzie District

by

Stephen Talbot

2 of

1971 - 1972



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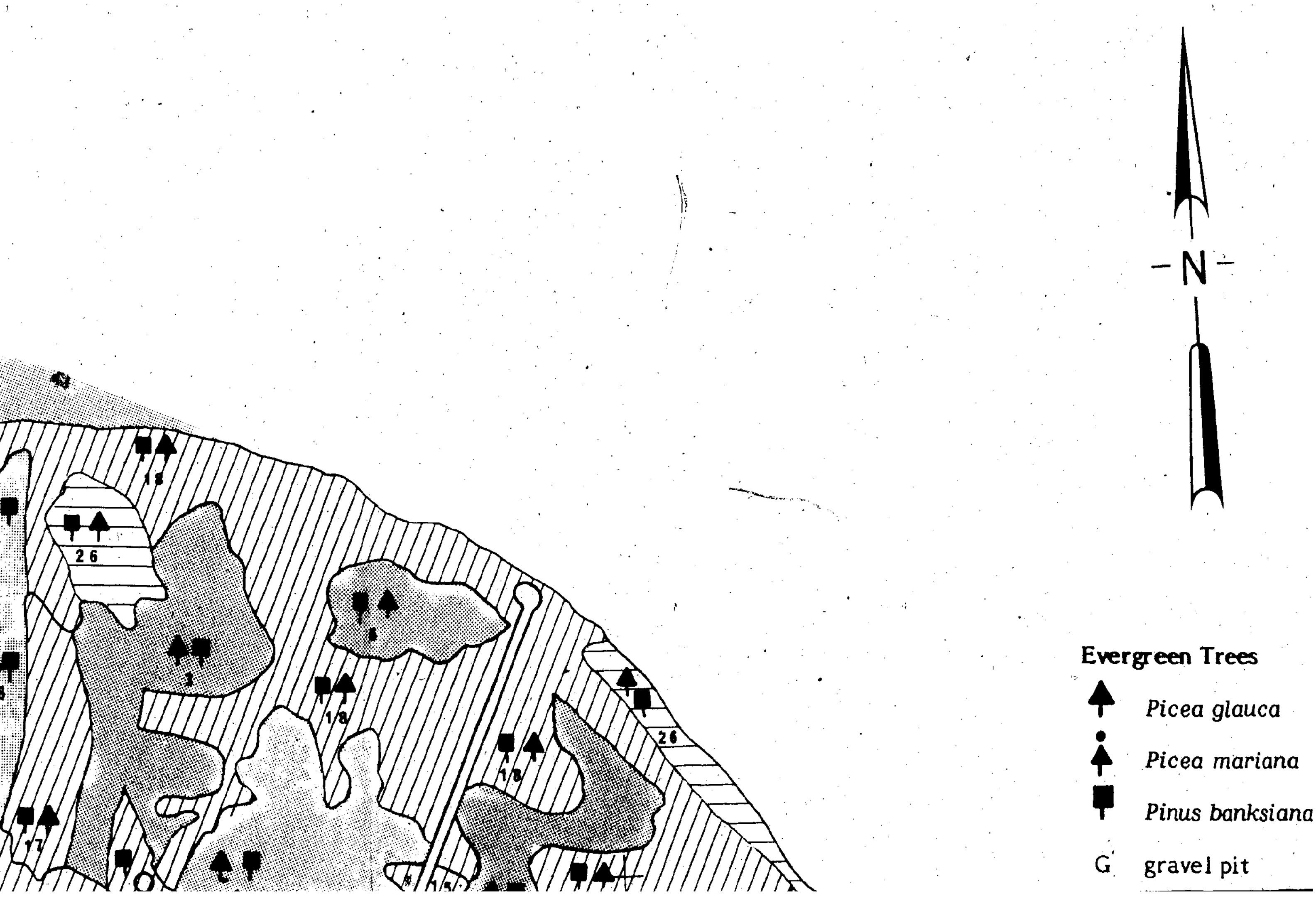

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E

Picea glauca -(Picea
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Picea glauca -Pinus b
with tall deciduous
P. balsamifera, Betu

Picea glauca -Pinus b
deciduous shrubs (Ro

Pinus banksiana - Pice
forest with tall decic

Pinus banksiana - Pice
forest with low de
canadensis)

Pinus banksiana - Pice
forest with low everg

Picea mariana moss
(Rosa acicularis)

Picea glauca -Larix l

Picea mariana -(Larix
dwarf shrubs (Arctost

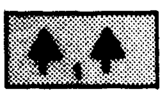
Symbols

Trees	Deciduous Trees
glauca	Larix laricina
mariana	Populus tremuloides
banksiana	Populus balsamifera
pit	Betula papyrifera

5 of

EXPLANATION

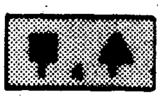
FOREST



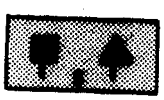
Picea glauca -(*Picea mariana*) moss forest with deciduous dwarf shrubs (*Arctostaphylos rubra, Salix myrtillifolia*)

Picea glauca -*Pinus banksiana* -(*Populus tremuloides*) moss forest with tall deciduous shrubs (*Alnus crispa, Populus tremuloides, P. balsamifera, Betula papyrifera, Cornus stolonifera*)

Picea glauca -*Pinus banksiana* moss-lichen forest with low deciduous shrubs (*Rosa acicularis, Shepherdia canadensis*)

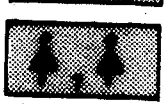


Pinus banksiana - *Picea glauca* -(*Populus tremuloides*) moss-lichen forest with tall deciduous shrubs (*Alnus crispa*)

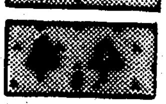


Pinus banksiana - *Picea glauca* -(*Populus tremuloides*) moss-lichen forest with low deciduous shrubs (*Rosa acicularis, Shepherdia canadensis*)

Pinus banksiana - *Picea glauca* -(*Populus tremuloides*) lichen-moss forest with low evergreen shrubs (*Juniperus communis*)



Picea mariana moss-lichen forest with low deciduous shrubs (*Rosa acicularis*)



Picea glauca -*Larix laricina* moss swamp forest

Picea mariana -(*Larix laricina*) moss swamp forest with deciduous dwarf shrubs (*Arctostaphylos rubra, Salix myrtillifolia*)

Picea mariana moss swamp forest with low evergreen shrubs (*Ledum groenlandicum*)

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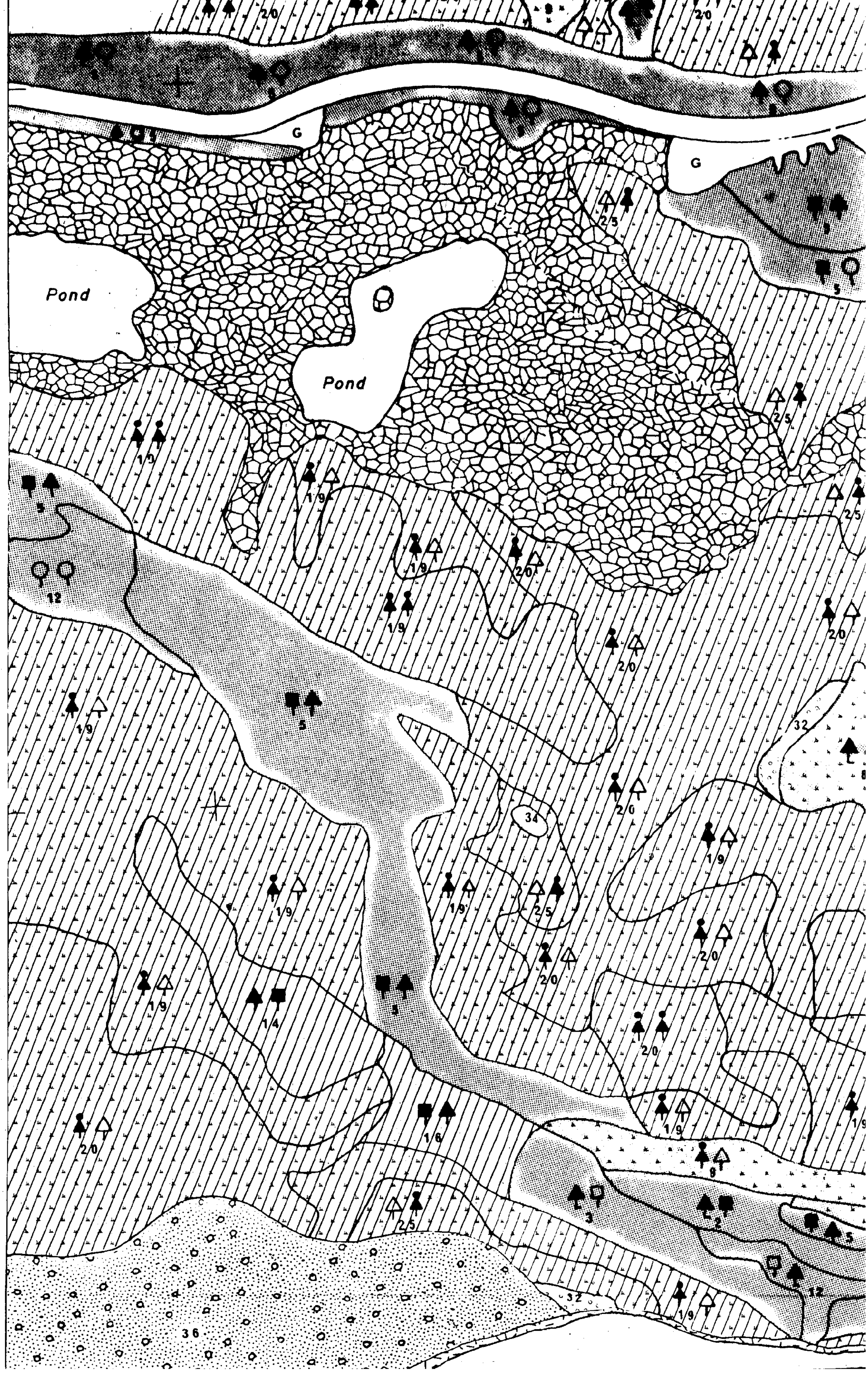

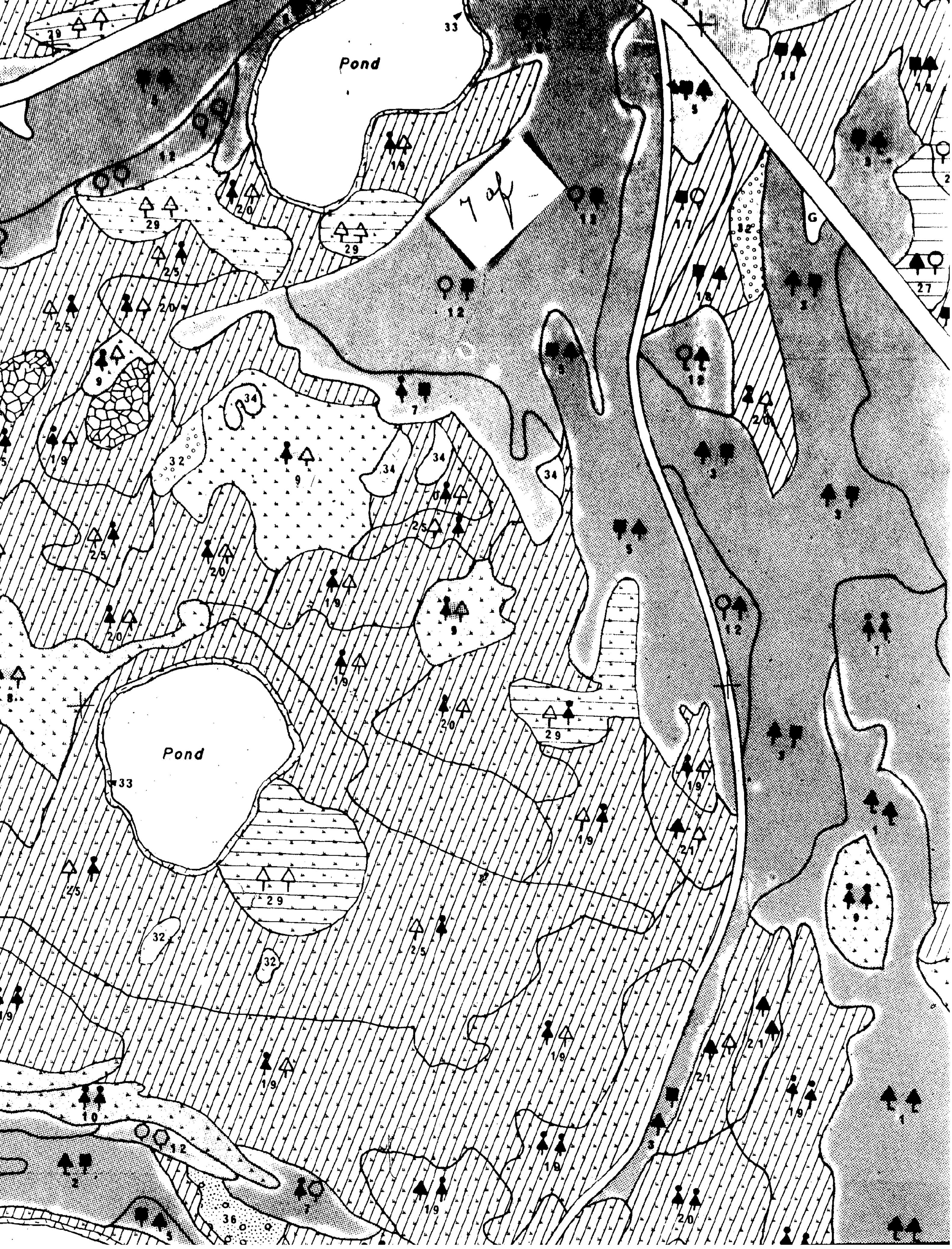

Pond
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Pond
G

G gravel pit

Betula papyrifera

dwarf shrubs (*Arctostap*

Picea mariana moss sw
(*Ledum groenlandicum*)

Picea mariana moss sw
(*Betula glandulosa*)

Populus tremuloides-Pic
shrubs (*Rosa acicularis,*
Cornus stolonifera)

Populus tremuloides-(Pic
tall deciduous shrubs (*Al*

Picea glauca-Pinus bank
woodland with low decid
canadensis, Potentilla fr

Picea glauca-Pinus bank
woodland with low everg

Pinus banksiana-(Populus
with tall deciduous shrub

Pinus banksiana-(Populus
low deciduous shrubs
Potentilla fruticosa, Pop

Pinus banksiana-Picea
papyrifera) lichen-moss
(*Juniperus communis*)

Picea mariana-(Larix l
moss swamp woodland w
landicum)

Picea mariana-(Larix l
swamp forest with decid
Salix myrtillifolia)

Picea glauca-(Larix lari
uous dwarf shrubs (*Arcto*

Populus tremuloides-Pin
uous shrubs (*Alnus crispa*

Populus tremuloides-Pin
deciduous shrubs (*Rosa*
herdia canadensis)

Populus tremuloides-Pin
land with low evergreen

Larix laricina-Picea mar
deciduous shrubs (*Betula*

Pinus banksiana-Picea g
shrubs (*Juniperus commu*

Picea glauca-Pinus bank

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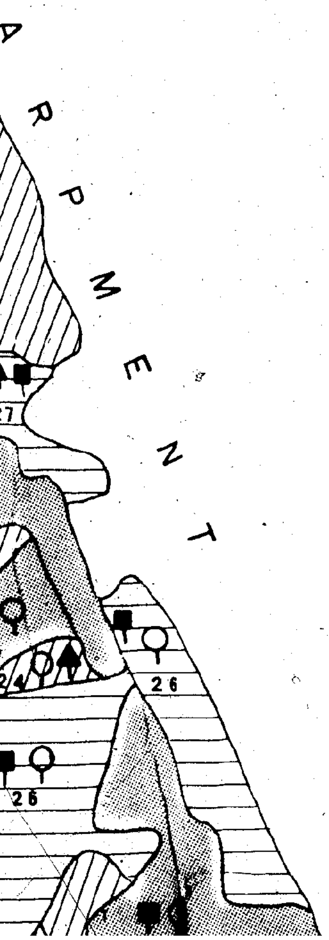


Picea mariana moss swamp forest with low evergreen shrubs (*Ledum groenlandicum*)

Picea mariana moss swamp forest with tall deciduous shrubs (*Betula glandulosa*)

Populus tremuloides-Picea glauca forest with low deciduous shrubs (*Rosa acicularis, Shepherdia canadensis, Viburnum edule, Cornus stolonifera*)

Populus tremuloides-(Picea glauca, Pinus banksiana) forest with tall deciduous shrubs (*Alnus crispa*)

WOODLAND

Picea glauca -Pinus banksiana-(Populus tremuloides) moss-lichen woodland with low deciduous shrubs (*Rosa acicularis, Shepherdia canadensis, Potentilla fruticosa*)

Picea glauca -Pinus banksiana-(Populus tremuloides) lichen-moss woodland with low evergreen shrubs (*Juniperus communis*)

Pinus banksiana-(Populus tremuloides-Picea glauca) woodland with tall deciduous shrubs (*Alnus crispa*)

Pinus banksiana-(Populus tremuloides) moss-lichen woodland with low deciduous shrubs (*Rosa acicularis, Shepherdia canadensis, Potentilla fruticosa, Populus balsamifera*)

Pinus banksiana -Picea glauca-(Populus tremuloides) (Betula papyrifera) lichen-moss woodland with low evergreen shrubs (*Juniperus communis*)

Picea mariana -(Larix laricina)-(Betula glandulosa)-(Sphagnum) moss swamp woodland with low evergreen shrubs (*Ledum groenlandicum*)

Picea mariana -(Larix laricina)-(Ledum groenlandicum) moss swamp forest with deciduous dwarf shrubs (*Arctostaphylos rubra, Salix myrtillifolia*)

Picea glauca -(Larix laricina) moss swamp woodland with deciduous dwarf shrubs (*Arctostaphylos rubra, Salix myrtillifolia*)

Populus tremuloides-Pinus banksiana woodland with tall deciduous shrubs (*Alnus crispa*)

Populus tremuloides-Pinus banksiana lichen woodland with low deciduous shrubs (*Rosa acicularis, Amelanchier alnifolia, Shepherdia canadensis*)

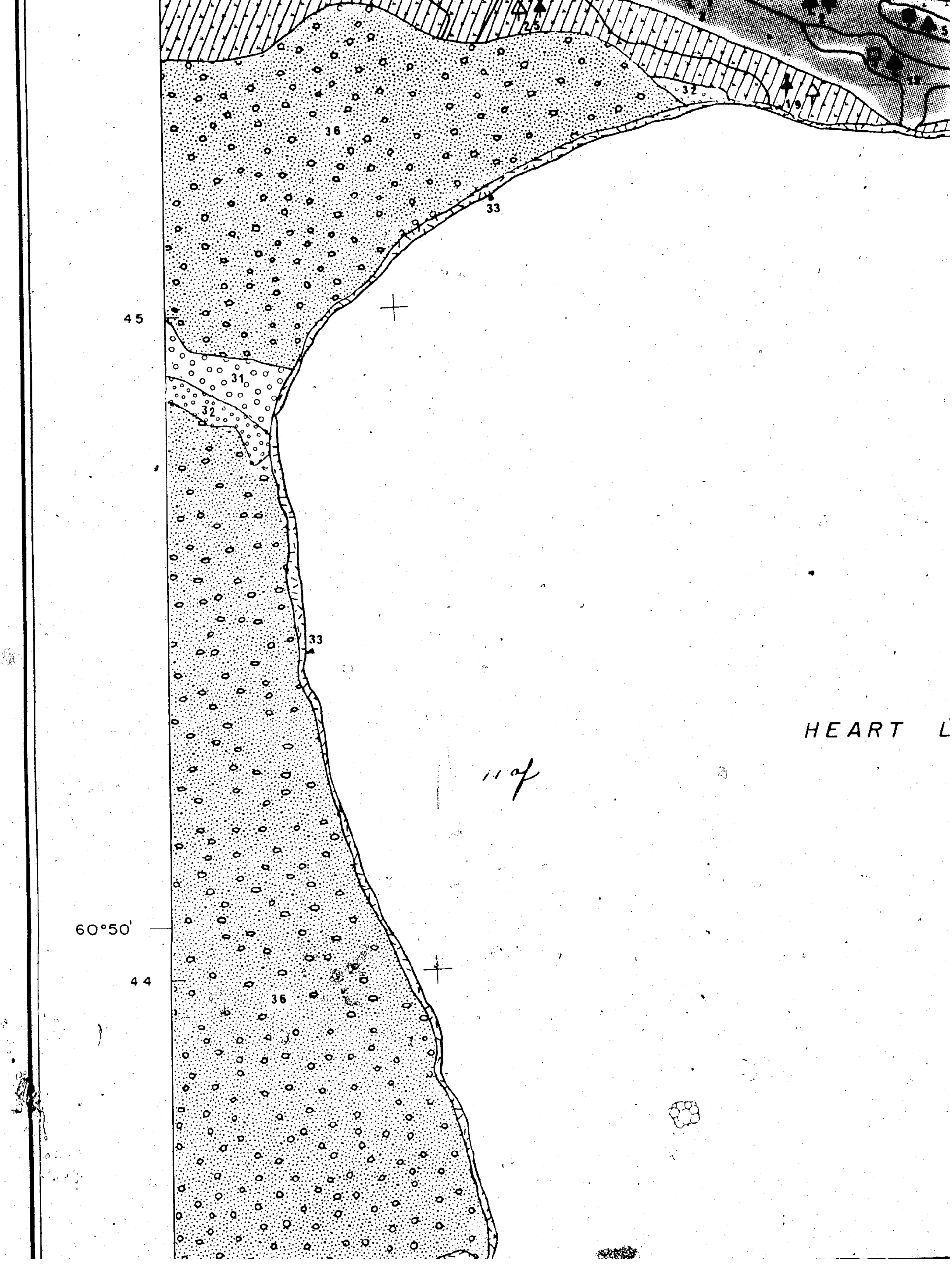
Populus tremuloides-Pinus banksiana-(Picea glauca) lichen woodland with low evergreen shrubs (*Juniperus communis*)

Larix laricina-Picea mariana moss swamp woodland with tall deciduous shrubs (*Betula glandulosa*)

SAVANNA

Pinus banksiana-Picea glauca lichen savanna with low evergreen shrubs (*Juniperus communis*)

Picea glauca -Pinus banksiana -(Populus tremuloides) lichen



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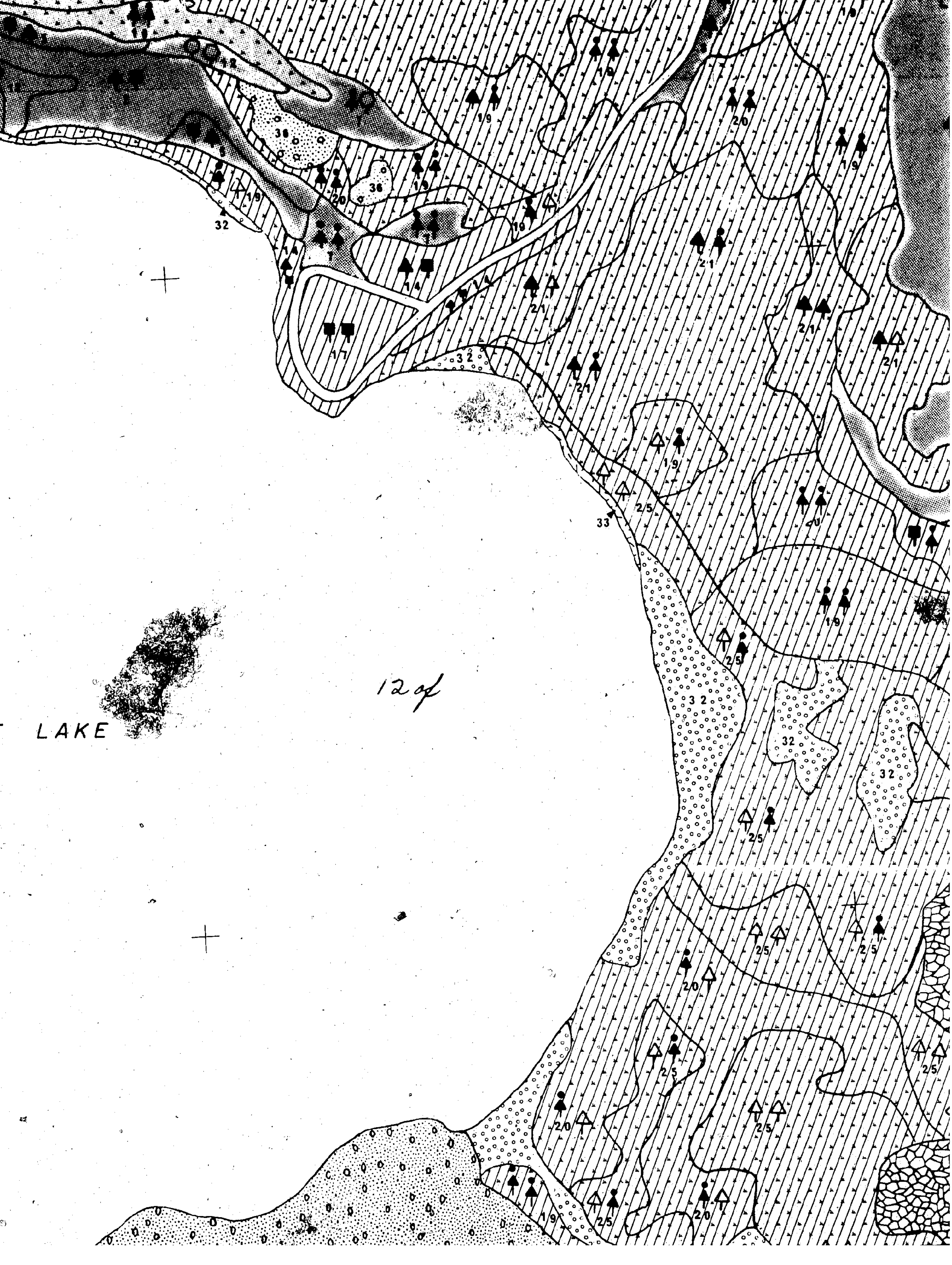
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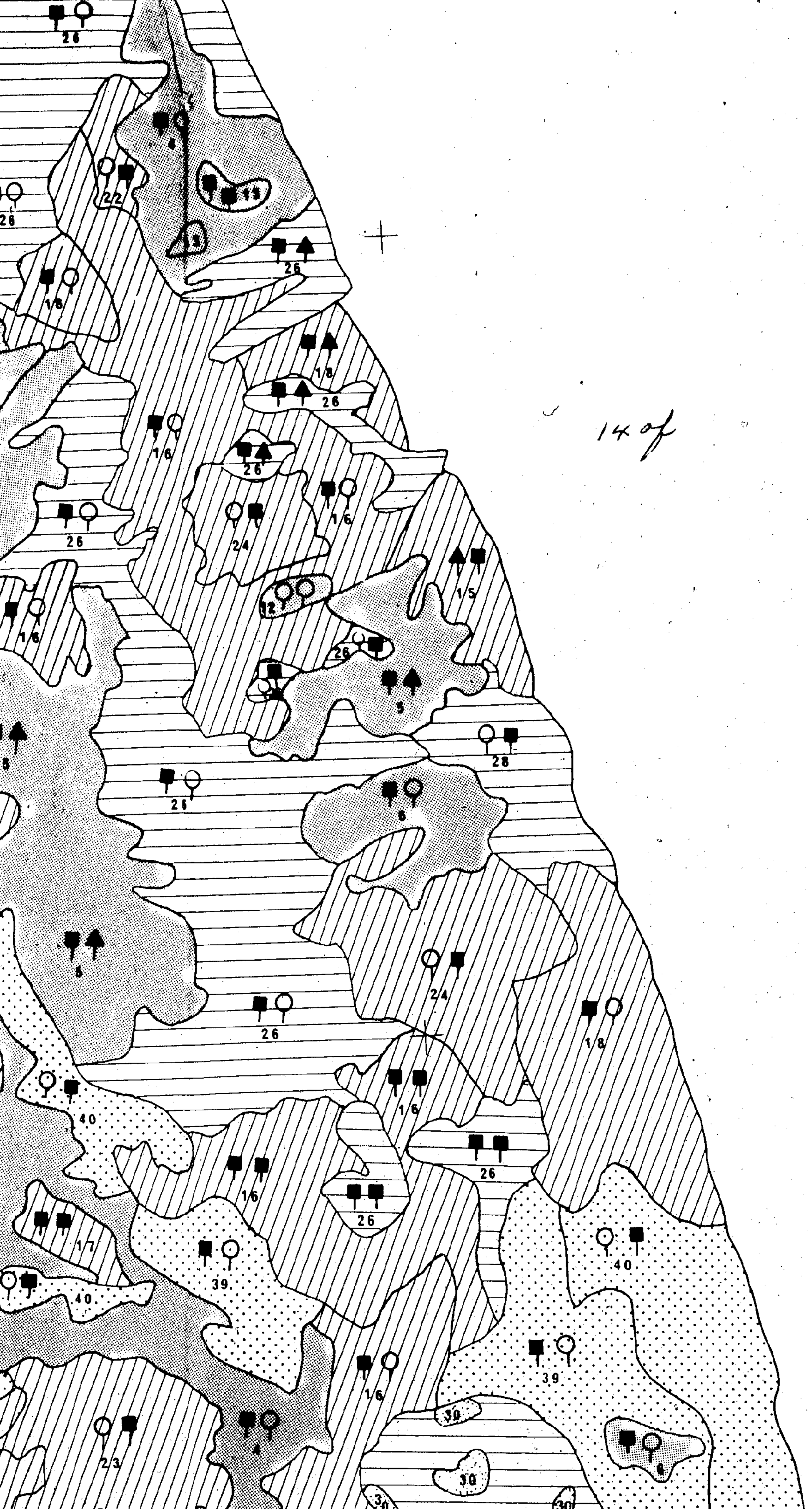
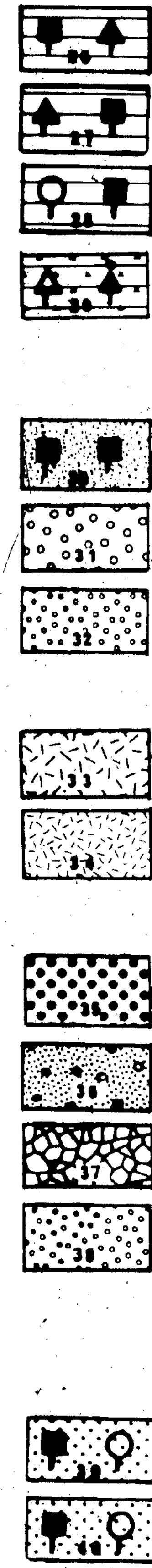




Pinus banksiana - *F*
shrubs (*Juniperus*

Picea glauca -*Pinu*
savanna with low

Populus tremuloid
savanna with low

Larix laricina -(*Pic*
(*Betula glandulosa*

Pinus banksiana th

Salix planifolia all

Betula glandulosa -

Carex aquatilis - C

Scirpus caespitosu

DWARF S

Arctostaphylos uv

Raised ombrotroph

Reticulate pattern

Low evergreen shr

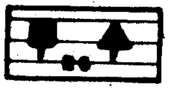
Pinus banksiana - *F*
low evergreen shr

Populus tremuloid
low evergreen shr

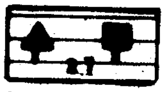
Note: Tree symbols in
Other possible combinati

For each treed phytoco

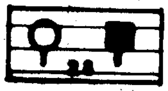
SAVANNA



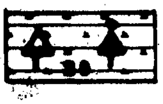
Pinus banksiana - Picea glauca lichen savanna with low evergreen shrubs (*Juniperus communis*)



Picea glauca - Pinus banksiana -(*Populus tremuloides*) lichen savanna with low evergreen shrubs (*Juniperus communis*)

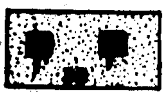


Populus tremuloides - Pinus banksiana -(*Picea glauca*) lichen savanna with low evergreen shrubs (*Juniperus communis*)

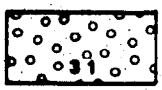


Larix laricina -(*Picea mariana*) moss swamp savanna with tall (*Betula glandulosa*) and low (*Myrica gale*) deciduous shrubs.

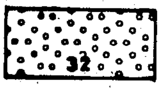
SCRUB



Pinus banksiana thicket (fire regeneration)

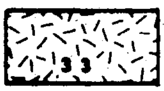


Salix planifolia alluvial moss thicket



Betula glandulosa - Myrica gale moss swamp scrub

GRAMINOID

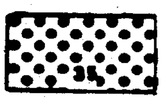


Carex aquatilis - Carex rostrata shore fen

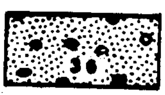
15 of

Scirpus caespitosus fen (marl)

DWARF SCRUB AND RELATED PHYTOCOENA

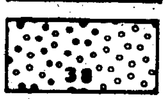


Arctostaphylos uva-ursi - Juniperus horizontalis dwarf scrub



Raised ombrotrophic plateau bog (mozaic complex)

Reticulate patterned fen (aapamire)



Low evergreen shrub (*Ledum groenlandicum*) bog

STEPPE SCRUB

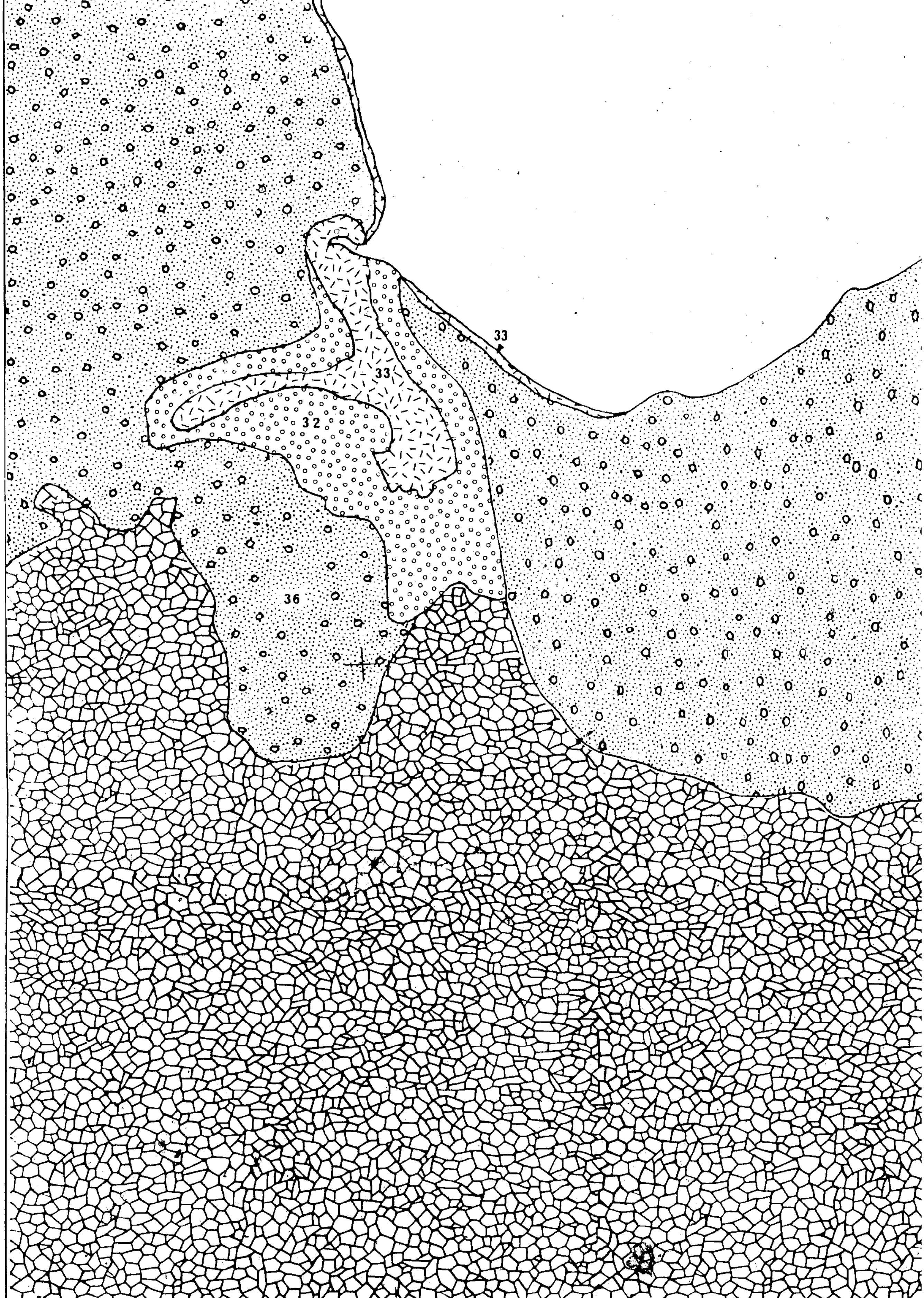
Pinus banksiana - Populus tremuloides lichen steppe scrub with low evergreen shrubs (*Juniperus communis*)

Populus tremuloides - Pinus banksiana lichen stepp[illegible]b with low evergreen shrubs (*Juniperus communis*)

* * * *

Note: Tree symbols in "Explanation" represent modal type. Other possible combinations are indicated in parentheses.

For each treed phytocoenose 2 symbols are given: the first



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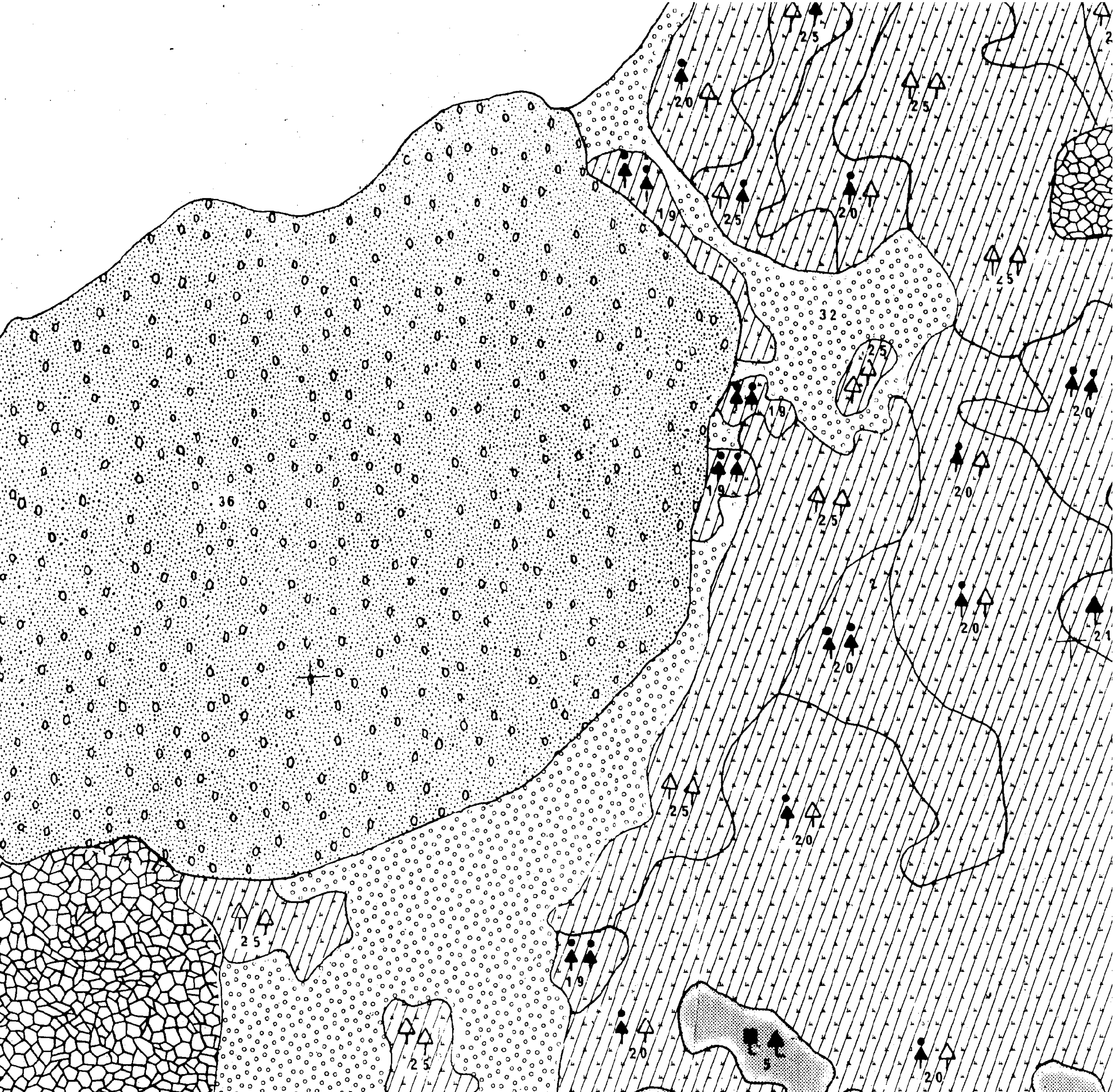

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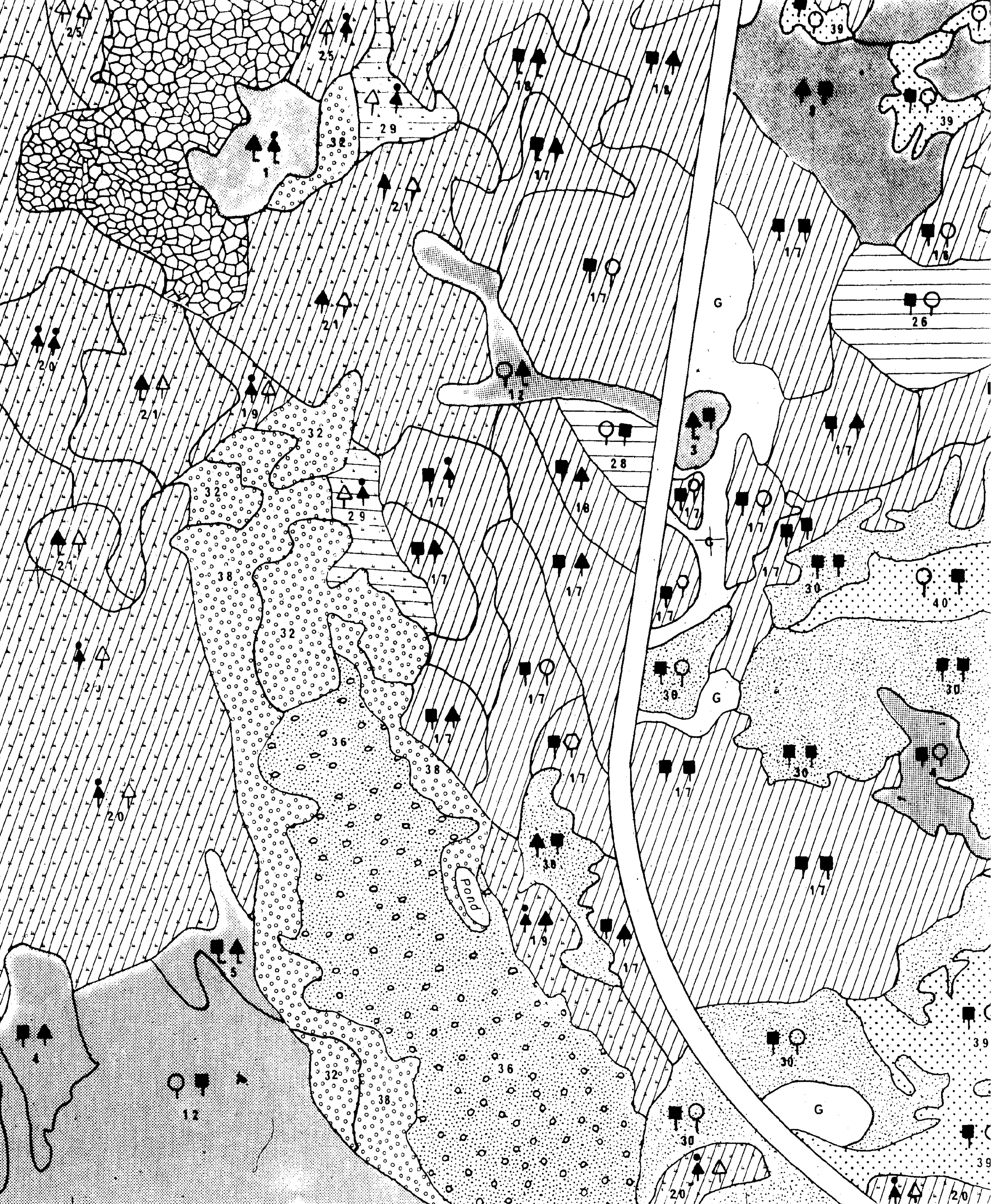

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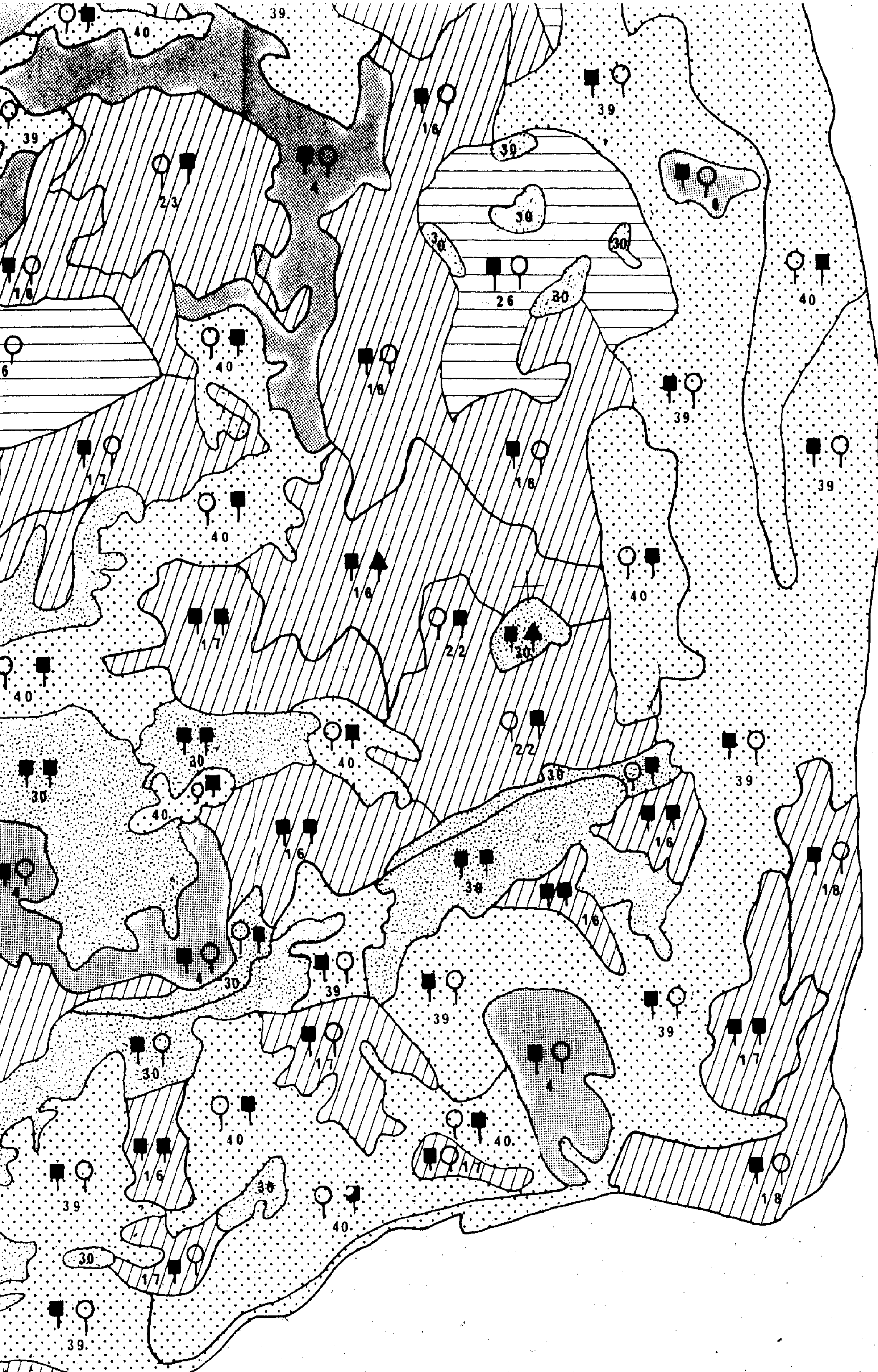

Note: Tree symb
Other possible con

For each treed p
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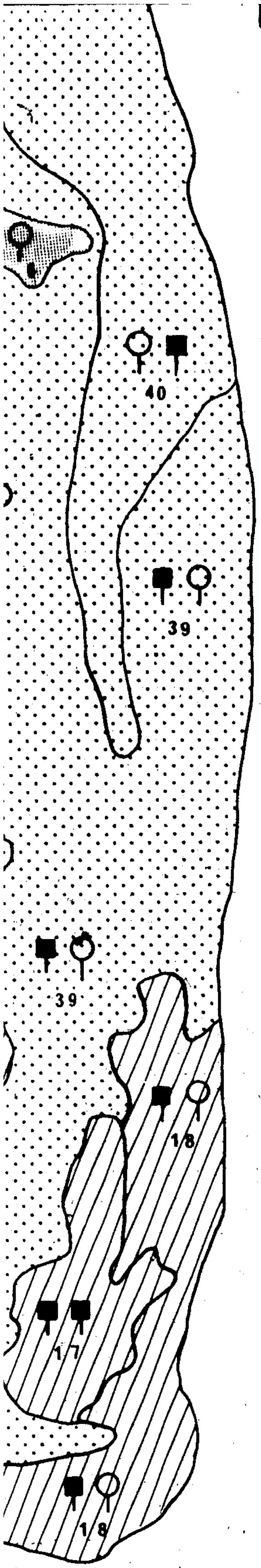
... steppe scrub with
low evergreen shrubs (*Juniperus communis*)



* * * *

Note: Tree symbols in "Explanation" represent modal type. Other possible combinations are indicated in parentheses.

For each treed phytocoenose 2 symbols are given: the first indicates the dominant species and the second, the subdominant species; if the phytocoenose is dominated by only one species, the first is repeated.

A phytocoenose with trees > 15 m are indicated by a "bar" at the tree symbol base, e.g.