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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

After carrying out extensive field studies and examining previous moss collections from northern Ellesmere Island, I undertook a comprehensive revision of northern Ellesmere Island mosses. As a result, the mosses of that area are now more completely studied than for any other area of comparable size in the Canadian Arctic.

One hundred fifty moss species have been verified from northern Ellesmere Island; new data clarifying the taxonomy, biology and ecology of these arctic species are included in a detailed annotated list.

This present investigation and my studies on mosses from other localities in the Canadian High Arctic have led me to consider the bryogeography of the Queen Elizabeth Islands, a field of research until now completely neglected in Arctic Canada. The results indicate that studies on the geographical distributions of arctic mosses, when combined with similar studies on vascular plants, provide data vital to a complete understanding of the glacial history of the Canadian High Arctic. Botanical evidence strongly supports the hypothesis that there existed a refugium on northern Ellesmere Island at least during the Wisconsin Glaciation.

RESUME

Trois étés de travail dans le nord de l'île Ellesmere et l'étude des collections de mousses déjà existantes de cet endroit me permettent de présenter ici une revision complète des mousses de cette partie du grand nord. Les mousses y sont maintenant mieux connues que celles d'aucun autre endroit de superficie comparable dans l'arctique canadien.

Cent cinquante mousses ont été vérifiées pour le nord de l'île Ellesmere; une liste descriptive présente de nouvelles données qui clarifient la taxonomie, la biologie et l'écologie de ces espèces arctiques.

Mes études sur les mousses de l'île Ellesmere et sur celles de nombreuses autres régions arctiques me conduisent à considérer la bryogéographie des îles Queen Elizabeth. Les résultats indiquent que l'étude de la distribution des mousses arctiques ainsi que celle des plantes vasculaires est essentielle pour saisir de façon significative le passé géologique. Les données botaniques appuient fortement l'hypothèse qu'il y a eu refuge dans la partie nord de l'île Ellesmere, et ce, durant la dernière glaciation (Wisconsin).

CHAPTER 1

INTRODUCTION

Location of the study area

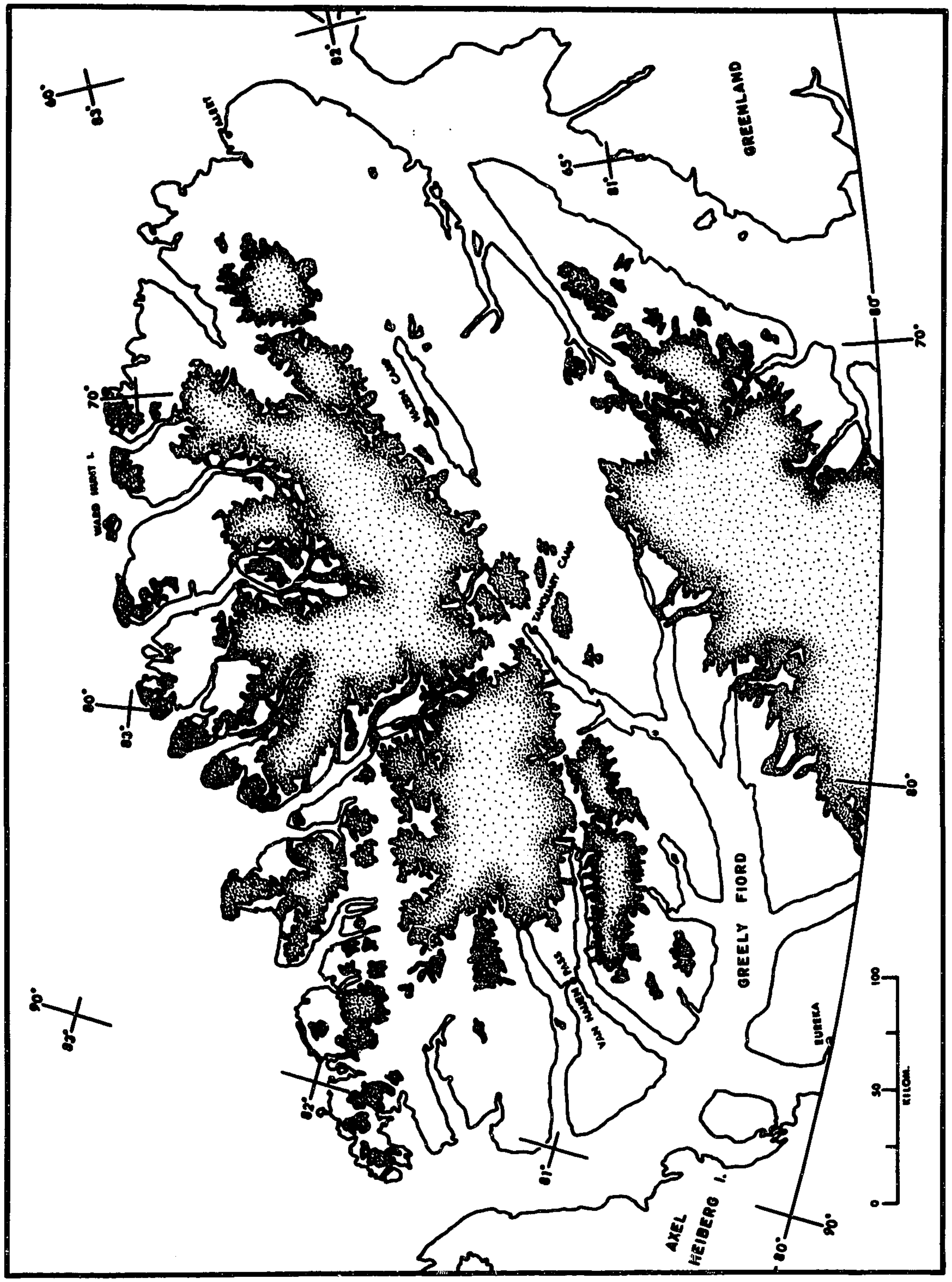
Ellesmere Island is the northernmost and third-largest island in the Canadian Arctic, and extends from 76°08' to 83°08' N and from 61°01' to 92°05' W. It has an area of 200,000 km^2 (Dunbar and Greenaway 1956), of which 83,000 km^2 (40%) are covered by permanent ice caps and glaciers (Sharp 1956). It is the highest land mass in North America east of the Rocky Mountains, rising to about 2,400 m. Its coasts are almost everywhere strongly dissected by fiords or fiord systems penetrating deep into the interior. Rivers are generally short and directly glacier-fed. Large lakes are few, except for Lake Hazen, the second-largest lake in the Arctic Archipelago.

For the purposes of this study, northern Ellesmere Island (Fig. 1) is defined as that part of Ellesmere Island lying north of the line joining the east end of Greely Fiord to the west end of Archer Fiord (Beatrix Bay). Northern Ellesmere Island has an area of about 80,000 km^2, about one-third of which is ice covered.

Botanical exploration on Ellesmere Island

The first botanical collections of importance from

Figure 1. Map of Ellesmere Island above 80° N, showing the extent of permanent ice (stippled) and the five principal localities where mosses have been collected (Van Hauen Pass, Tanquary Camp, Hazen Camp, Alert, Ward Hunt Island). Hazen Camp is on the north shore of Lake Hazen. The position of the Eureka weather station is also shown.


GREENLAND
GREELY FIORD
AXEL HEIBERG I.
EUREKA

Ellesmere Island were made during the British Polar Expedition of 1875-76 (Mitten 1878, Hart 1880). The United States Lady Franklin Bay Expedition of 1881-83 (based at Fort Conger for three years) yielded few botanical results since most of the botanical specimens were abandoned during the hasty retreat and only Greely's personal collection was salvaged (Greely 1886, 1888); the cryptogams have never been located despite attempts by W. C. Steere and myself, and the list of mosses published (Lehnert and Greely 1886) is so full of obvious misdeterminations that none of the records can be accepted until the specimens are located (Steere 1948).

The Second Norwegian Expedition in the "Fram", 1898-1902, gathered such significant and massive botanical data and collections from Ellesmere Island that they have not since been equalled. The credit rests with the botanist of the expedition, H. G. Simmons, whose important papers (Simmons 1903, 1906, 1909, 1913) are the foundation of Canadian Arctic botany. The bryophytes which Simmons collected were published in extremely detailed form (Bryhn 1906-07), and a list of corrections to Bryhn's important contribution was later included in a paper by Simmons (1909).

Captain R. Peary's several attempts to reach the North Pole yielded few botanical studies, but results from small collections made by members of his expeditions were published (Bryhn 1908, Britton 1909, Rydberg 1911-12, Williams 1918). The next report dealing with the botany of Ellesmere Island was by Harmsen and Seidenfaden (1932), and not much later (in 1936) Polunin spent a few days on Ellesmere's south coast making detailed studies which were eventually incorporated into later works (Polunin 1940, 1948, 1948a).

With the establishment of permanent weather stations at Eureka (in 1947) and at Alert (in 1950) many scientists began to use the facilities available, and many of them collected plants, even in the course of non-botanical studies. In 1953 (Holmen 1953) some bryophytes were reported from Fosheim Peninsula. The same year a work appeared on the vascular flora of Alert (Bruggemann and Calder 1953), and Schuster, Steere and Thomson (1959) later reported on the terrestrial cryptogams of the same region.

The Defence Research Board of Canada opened semi-permanent field stations at Lake Hazen (in 1957) and at Tanquary Fiord (in 1963) and several works on the botany of these two localities have appeared (Powell 1961, Savile 1964, Brassard and Beschel 1968), as well as others more specialized in nature (Radforth 1965, Oliver and Corbet 1966, Powell 1967, Brassard 1967, 1967a, 1968, 1968a, 1969, Brassard and Longton 1969, Brassard 1970).

Bryological exploration on northern Ellesmere Island

Many of the botanical works mentioned above deal with bryophytes from northern Ellesmere Island. Until 1964, when I first collected bryophytes in that area, the only reports mentioning mosses from northern Ellesmere Island were those of Mitten (1878), Lehnert and Greely (1886), Bryhn (1908), Britton (1909), Williams (1918), Steere (1948), Schuster et al. (1959). Many of the moss collections made near the weather station or near other field camps by non-botanists or non-bryologists were not published, yet these collections add considerably to our knowledge of the moss flora of northern Ellesmere Island. The various scientists who took time off from their own studies to collect mosses must be commended for their efforts.

In 1964 I collected vascular plants and bryophytes at Tanquary Fiord (Brassard 1967, Brassard and Beschel 1968). I returned to the Tanquary area in 1967, and in the same summer I was able to collect in the Van Hauen Pass area (Brassard and Longton 1969). I spent a third field season on northern Ellesmere Island in 1969, when I was based at Ward Hunt Island (just off the north coast of Ellesmere Island) and from which I was able to collect bryophytes at numerous localities on the north coast and in the northeastern part of Ellesmere Island.

Present status of knowledge of the mosses of northern Ellesmere Island

Figure 2 shows all the localities on northern Ellesmere Island where mosses have been collected. The regions and localities at which mosses have been collected are listed below. The abbreviations of localities are the same as in Fig. 2, and will also be used in the annotated list of mosses (Chapter 3).

Region 1 (west coast):

OF Otto Fiord
VH Van Hauen Pass

Region 2 (central):

TF Tanquary Fiord
BP Barbeau Peak
LH Lake Hazen
GG Gilman Glacier
HL Heintzelman Lake

Region 3 (east coast):

FC Fort Conger
WB Wrangle Bay
LB Lincoln Bay
AL Alert

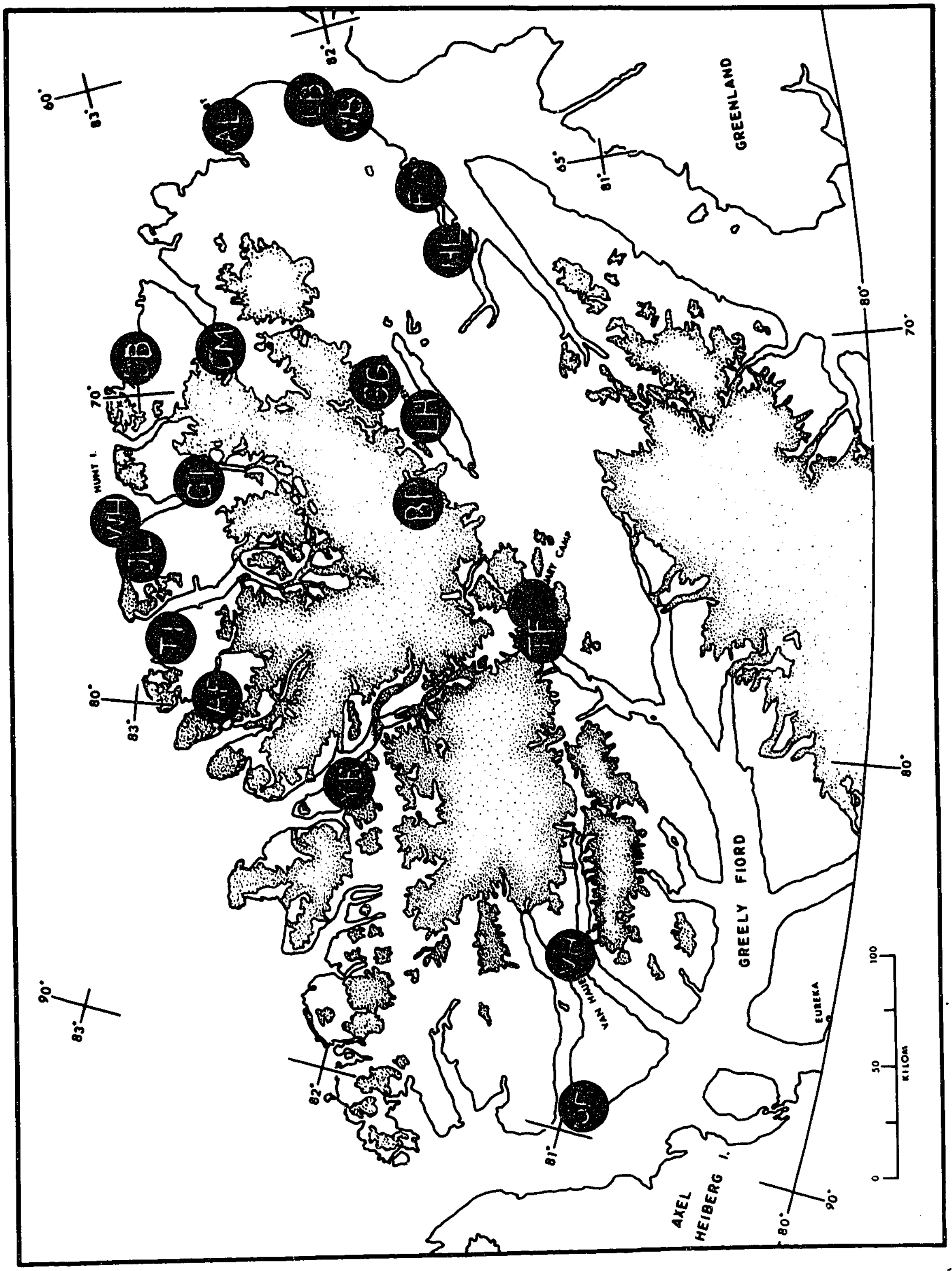
Region 4 (north coast):

CM Clements Markham Inlet
DB Doidge Bay
GI Garlic Island
WH Ward Hunt Island
JL Jasper Lake
TI Taconite Inlet
AF Ayles Fiord

Region 5 (northwest coast):

YB Yelverton Bay

Figure 2. The localities (abbreviated as on page 6) at which mosses have been collected on northern Ellesmere Island.


GREENLAND
GREELY FIORD
AXEL HEIBERG I.
EUREKA
HUNT I.

For each of the 19 northern Ellesmere localities at which mosses have been collected the collectors and year of collection, and published reports (if any) are listed below. Localities are abbreviated as on page 6.

Locality abbreviation	Collector, year	Reference
OF	Harington 1961	Unpublished
	Hattersley-Smith 1964	Unpublished
VH	Brassard 1967	Partly published (Brassard 1968a, 1970, Brassard and Longton 1969)
	Longton 1967	Unpublished
TF	Brassard 1964	Partly published (Brassard 1967a)
	Brassard 1967	Partly published (Brassard 1969)
	Brassard 1969	Unpublished
	Haight 1963	Hattersley-Smith (1964)
	Longton 1967	Unpublished
BP	Hattersley-Smith 1967	Unpublished
LH	Brassard 1964	Partly published (Brassard 1967a)
	Brassard 1969	Unpublished
	Corbet 1963	Unpublished
	Harington 1961	Unpublished
	Longton 1967	Unpublished
	Oliver 1961	Unpublished
	Powell 1957-59	Powell (1967)
	Richards 1967-68	Unpublished
	Savile 1962	Partly published (Savile 1964)
GG	Powell 1959	Powell (1967)
HL	Brassard 1969	Unpublished
FC	Brassard 1969	Unpublished
	Greely 1881-83	Lehnert and Greely (1886)
	Hart 1875-76	Mitten (1878)
	Peary 1902	Bryhn (1908)

Locality abbreviation	Collector, year	Reference
WB	Wolf 1906	Bryhn (1908)
LB	Wolf 1906	Bryhn (1908)
AL	Brassard 1969	Unpublished
	Davis 1950	Unpublished
	Feilden 1875-76	Mitten (1878)
	Harington 1959	Unpublished
	Schuster 1955	Schuster et al. (1959)
	Wolf 1906	Williams (1918)
CM	Brassard 1969	Unpublished
DB	Brassard 1969	Unpublished
GI	Brassard 1969	Unpublished
WH	Brassard 1969	Unpublished
	Christie 1954	Partly published (Brassard 1967a)
	Hattersley-Smith 1954	Partly published (Brassard 1967a)
	Kingston 1959	Unpublished
	Lenton 1960	Partly published (Powell 1967)
	Serson 1964	Partly published (Brassard 1967a)
	Walker 1959	Unpublished
JL	Brassard 1969	Unpublished
	Christie 1954	Unpublished
TI	Brassard 1969	Unpublished
AF	Brassard 1969	Unpublished
YB	Brassard 1969	Unpublished

I have examined material from each of the 19 sites, and collected mosses at 14 of them. Although five of the localities can be considered as well investigated (Van Hauen Pass, Tanquary Fiord, Lake Hazen, Alert, Ward Hunt), even these need more field studies on mosses. For instance at Alert, where a bryologist had previously spent an entire summer (Schuster et al. 1959), during only three hours of collecting in June 1969 I was able to add three moss species to its flora. Our knowledge of the moss floras of 14 localities varies from mediocre to very poor; however, in four of the five main regions of northern Ellesmere Island at least one locality has been well investigated (the exception is Region 5 where only two small collections have been made at Yelverton Bay), and the data and specimens from under-collected sites add significantly to the known moss floras of the larger regions.

Further field studies in some of these poorly known localities, and in still others now inaccessible, will undoubtedly greatly increase our knowledge of northern Ellesmere mosses. The inaccessibility of much of northern Ellesmere Island still limits botanical studies there. It is no coincidence that the five well studied localities mentioned above are the only places on northern Ellesmere with airstrips.

Only in spring (before the melt-season) can landings be made on lakes or sea ice, but of course at this time most of the land is still snow-covered and unsuitable for detailed botanical studies. Nevertheless, even under such adverse circumstances one can gather moss specimens since the mosses remain virtually unchanged under the light snow cover, which in many places is only a few centimeters deep.

A bryologist who knows moss habitats in the Arctic can accomplish much even under normally **poor field** conditions. However, a thorough knowledge of the moss flora of any area is only possible after at least three or four weeks of **intensive field** studies after the thaw.

Scope and objectives of the present study

The northern Ellesmere Island localities at which I collected mosses were, of necessity, primarily those where facilities for carrying out field work existed (in particular the Defence Research Board field camps at Tanquary Fiord and Lake Hazen, and the camp at Ward Hunt Island). When the opportunity arose I collected in outlying, and often unexplored regions by travelling with non-botanists who were carrying out scientific research in these areas.

At any one locality, whenever time permitted (e.g. when I was able to spend several days or weeks collecting) I tried to obtain representative mosses from as many different habitats as possible. Habitats known to possess more diverse moss floras (e.g. seepage slopes or wet heaths) or those unique at a particular locality (e.g. brackish shoreline lagoons) were either visited several times or in as many different sites as possible.

When time (or weather conditions) did not permit detailed investigation of several habitats at one locality, I then concentrated on collecting in habitats where previous experience indicated that the greatest number of moss species would be growing in close proximity (e.g. enriched bird perches). This was especially true in late May 1969, when I was able to visit several localities on the north coast for only a few hours.

A habitat with a diverse flora was often investigated in great detail (sometimes for one hour or more in a site less than 10 m^2), and I collected as many different species as I found in the field. Notes on vegetation (especially associated vascular plants) were compiled in the field.

The presence of one moss species would often indicate the possible (or likely) occurrence of other species in the same place; for instance, whenever I found Pogonatum capillare I always searched for the rarer Polytrichum piliferum, which grows in similar habitats. I made a special effort to find fruiting specimens of mosses which rarely produce sporophytes in these high latitudes, especially where gametophytes of these species were abundant.

More specimens of taxonomically difficult genera or species were collected to increase the chance of obtaining most of the species present at any one locality. Since most mosses are quite small, a thorough search of a habitat included gathering the vascular plants among which the mosses grew or sometimes the soil surface which served as substrate. Microscopic examination of specimens in the laboratory often revealed species not noticed in the field; *Fissidens arcticus*, for instance, is hardly ever seen in the field but some plants are invariably found admixed with other species. Some moss admixtures, although no larger than a handful, contain up to 15 species.

During my studies almost all the specimens of mosses collected recently on northern Ellesmere Island have passed through my hands. The most important collections which I have examined are:

1) my own, some 1,500 specimens, collected in 1964, 1967, and 1969 from 14 localities throughout the area,

2) the collections of D. B. O. Savile and K. Richards made in 1962 and 1967-68 respectively at Lake Hazen,

3) the specimens reported by Powell (1967) collected in 1957-59 at Lake Hazen and Gilman Glacier,

4) critical specimens collected in 1967 by R. E. Longton at Van Hauen Pass and Lake Hazen,

5) most of the specimens gathered during the Peary expeditions (Bryhn 1908), and some of those cited by Mitten (1878), and,

6) miscellaneous specimens collected in the years 1950 to 1967 by several scientists at various northern Ellesmere localities.

Collections which I have been unable to locate or examine are:

1) Greely's specimens from Fort Conger, which do not appear to have been deposited in any herbarium,

2) most of the specimens reported by Mitten (1878), and,

3) R. M. Schuster's 1955 collection from Alert, which should have been deposited at the National Herbarium in Ottawa (Schuster et al. 1959) but is not at that institution (H. Crum, pers. comm.) nor at the New York Botanical Garden.

With few exceptions I have accepted the published reports of Mitten (1878) and Steere (1959) since the specimens reported were identified by reliable bryologists, but I have excluded reports by Lehnert and Greely (1886) because Greely's specimens were evidently largely misdetermined.

My own field studies, and examination of numerous specimens collected by others, enabled me to undertake a comprehensive monograph of the known moss flora of northern Ellesmere Island. As a result, the mosses of northern Ellesmere Island are now more completely studied than those of any other area of comparable size in the Canadian Arctic. My study, with that of Holmen (1960) for northernmost Greenland, make these most northerly lands among the best known bryologically.

This investigation of northern Ellesmere Island mosses, and my studies on mosses from many other localities in the Canadian High Arctic, have further led me to consider the bryogeography of the Canadian High Arctic (Queen Elizabeth Islands), a field of research until now completely neglected in Arctic Canada. The results indicate that studies on the geographical distributions of mosses yield data that are vital to a complete understanding of the botanical and geographical history of the Canadian High Arctic.

CHAPTER 2

DESCRIPTION OF NORTHERN ELLESMERE ISLAND

Physiography

Northern Ellesmere Island, as defined in this study, comprises two distinct physiographic areas. The Northern Mountains (Dunbar and Greenaway 1956) [= Grant Land Mountains (Christie 1964)] are largely ice-covered ranges (Fig. 3), the United States Range and other confluent smaller ranges, which reach 2,400 m altitude and extend from the north coast south to Greely and Tanquary Fiords, Lake Hazen, and Alert. The Northern Plateau (Dunbar and Greenaway 1956) [= Hazen Plateau (Christie 1964)] is an almost entirely ice-free plateau (Fig. 4) with a relatively uniform but deeply dissected terrain; its surface lies at about 300 m elevation in the south and at about 1,000 m along the northern edge (Christie 1964). A straight line drawn from the head of Tanquary Fiord to Alert almost exactly separates the two physiographic areas. Lake Hazen occupies a trough along the foothills of the Northern Mountains.

Van Hauen Pass lies between Otto and Hare Fiords on the west coast of northern Ellesmere, and is relatively low compared to the opposite shores of the two fiords. The northwest shore of Tanquary Fiord (Figs. 3, 5) is the

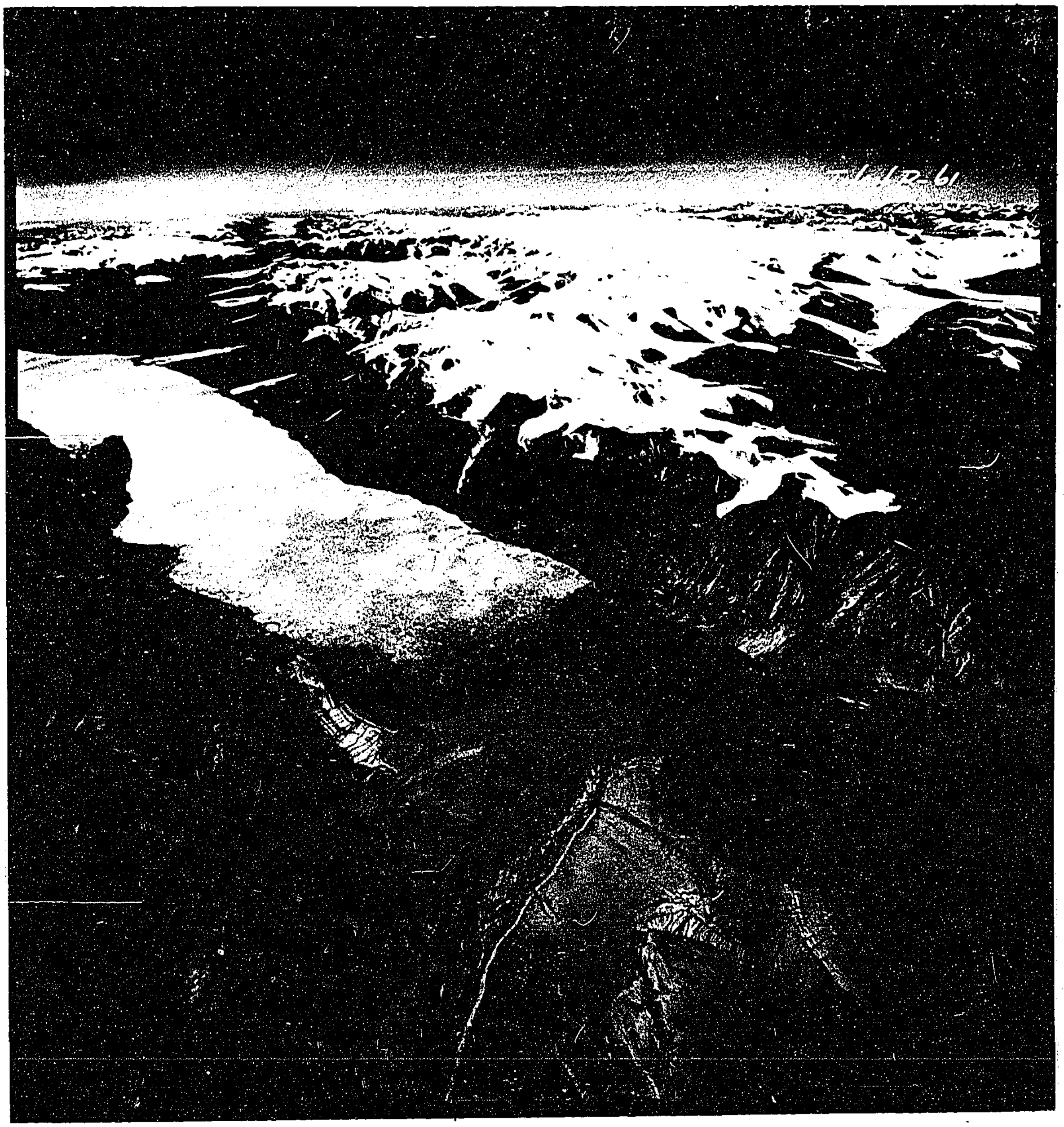


Figure 3. Northern Ellesmere Island. View from the head of Tanquary Fiord looking west across the western part of the Northern Mountains. Note the large ice cap with numerous valley glaciers. Oblique air photograph T404R-61, Dept. Energy, Mines and Resources, Canada.

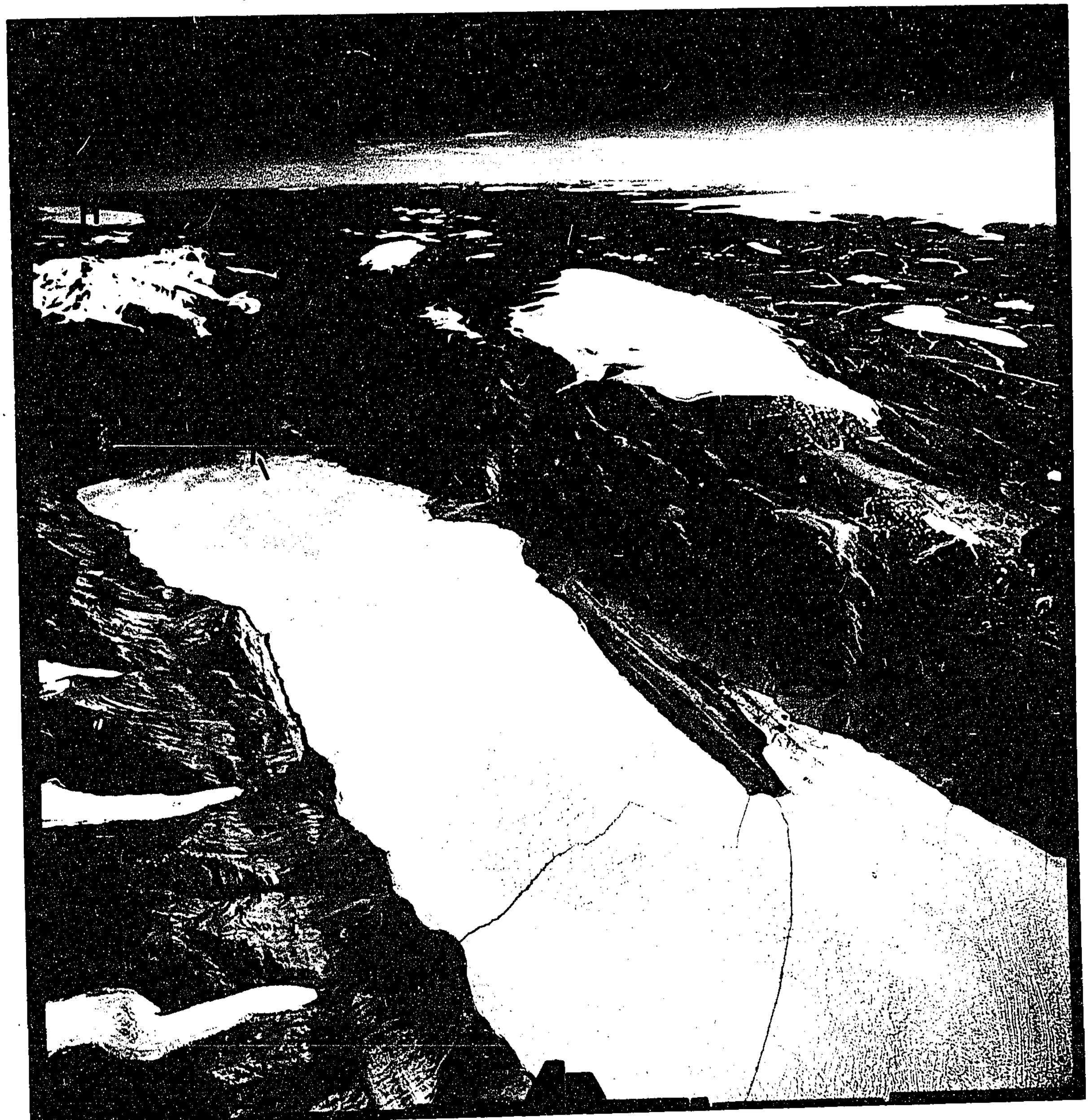
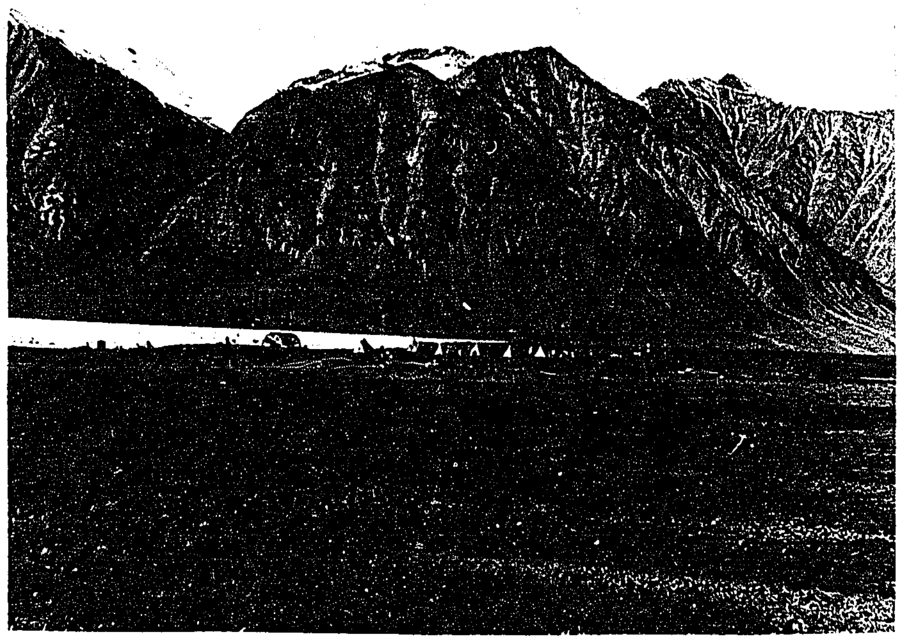


Figure 4. Northern Ellesmere Island. View looking east from Tanquary Fiord across the Northern Plateau. Tanquary Camp, the Defence Research Board field station, is indicated by the arrow. Lake Hazen (H) is visible at the upper left. Oblique air photograph T409L-61, Dept. Energy, Mines and Resources, Canada.

Figure 5. The northwest side of the head of Tanquary Fiord, showing the steep slopes which attain 1,500 m altitude. Tanquary Camp (in the foreground) is on the southeast shore of the fiord. 16 August 1964.

Figure 6. Rolling terrain on the southeast side of the head of Tanquary Fiord, showing the gentle slopes rising from sea level to about 600 m altitude. 26 June 1964.



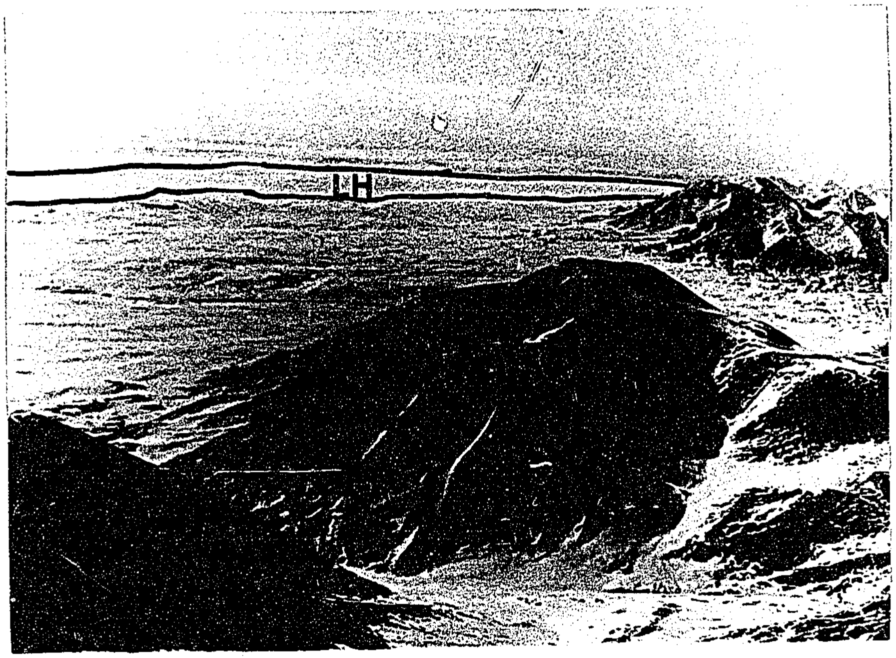
southern boundary of the Northern Mountains, and the Northern Plateau lies just south and east of the fiord (Figs. 4, 6). Four major glacial rivers flow into the head of Tanquary Fiord and some of these have formed extensive deltas (Fig. 3). One valley leads eastward from Tanquary Fiord to Lake Hazen (some 100 km distant) over a low pass (500 m); in 1964 I made this traverse on foot and found the terrain and vegetation along the valley and pass rather uniform. Lake Hazen (160 m elevation, 75 km long by about 10 km wide) is flanked on the north by the Northern Mountains and on the south by the Northern Plateau (Fig. 7).

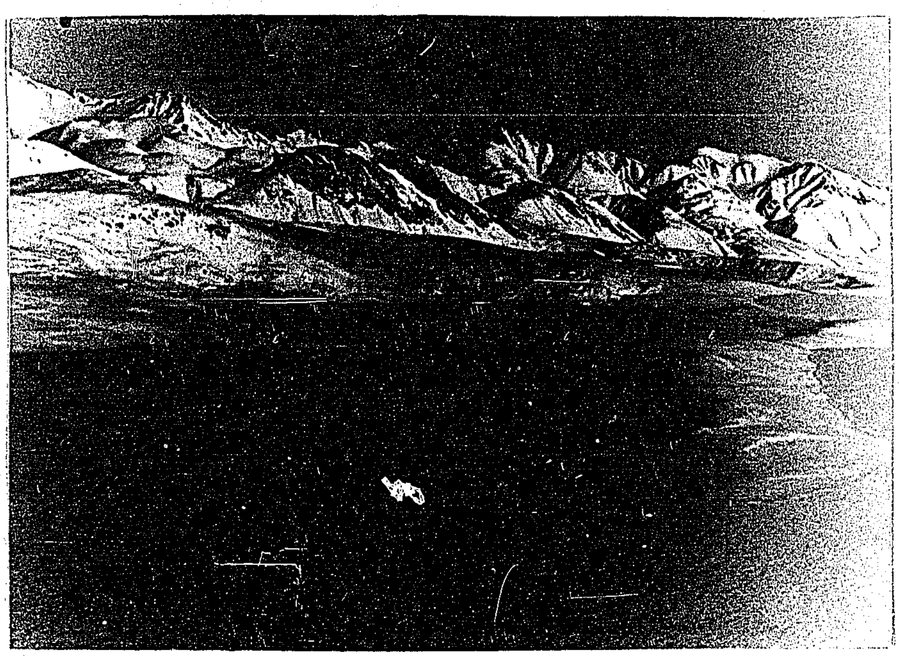
The Alert area has a rolling terrain quite different from the Northern Mountains which lie some 20 km to the west. The north coast of Ellesmere Island is deeply dissected by many large fiords (Fig. 1), and the northern 20 km or so of the peninsulas is mostly ice free. However, the mountains along the north coast (Fig. 8) rise very sharply to about 1,500-2,000 m. Ward Hunt Island (highest elevation 450 m) is a small rounded island surrounded by a permanent ice shelf. The northwestern part of Ellesmere Island is the least explored but its terrain is similar to that along the north coast.

The interior ice caps have numerous nunataks, the highest being Barbeau Peak (2,400 m +) on which one moss and a few lichens manage to grow.

Figure 7. The very sharp boundary between the Northern Mountains (right) and the Northern Plateau (upper left), looking west-southwest across the east end of Lake Hazen (LH). 25 May 1969.

Figure 8. Sharply dissected terrain east of Taconite Inlet (north coast) with more gentle slopes in the lowlands. 24 May 1969.


LH



Thus the five main regions of northern Ellesmere Island from which mosses have been collected differ in relief, ice cover, and other geomorphological features. More detailed information on the physiography of northern Ellesmere Island can be found in Gadbois and Laverdière (1954), Hattersley-Smith (1955), Dunbar and Greenaway (1956), Smith (1961), Hattersley-Smith (1961, 1963), Hattersley-Smith and Long (1967), Christie (1967), Hattersley-Smith (1969).

Geology

Northern Ellesmere Island as defined here comprises two geological provinces. A belt of metamorphic gneisses, schists, and granitic rocks, probably Precambrian in age, underlies (and is exposed along) the north coast and outcrops on Ward Hunt Island (Blackadar 1960; Christie 1964). These rocks (the Cape Columbia Group) are overlain by Permo-Carboniferous limestones and sandstones.

The second province embraces a broad belt of early- and middle-Palaeozoic bedded rocks which in the north consists largely of sandstones and Ordovician limestones; in the south the rocks underlying the mountains and plateau consist primarily of a sandstone-greywacke formation, in part Silurian in age (the Cape Rawson Group), and variably folded quartzites and limestones.

Sandstones, limestones, and conglomerates of Permo-Carboniferous age overlie the older rocks and form much of the present United States Range (Christie 1964).

Intrusives include granitic rocks of undetermined age in the Cape Columbia Group, and basalt dykes and sills which intrude the Permo-Carboniferous sandstones and limestones, especially near Tanquary Fiord and Lake Hazen (Hattersley-Smith 1963, Christie 1964).

Structural geology

The Cape Rawson beds trend uniformly northeast and are highly folded. The Cape Columbia gneisses on the north coast trend predominantly east.

A distinct fault separates the soft shales and sandstones north of Lake Hazen from the rocks of the Cape Rawson Group at the south edge of the Northern Mountains. The upper part of Tanquary Fiord also lies along a major fault zone.

Minerals

Few mineralogical studies have been made on northern Ellesmere. Coal occurs in the Lake Hazen and Fort Conger areas. More localized outcrops of other minerals occur at a few localities — gypsum near M'Clintock Fiord, quartz near Tanquary Fiord and Alert, amber nodules associated with the coal seams, and chalcopyrite near Doidge Bay.

Glaciology, oceanography

In addition to the ice caps and numerous large and small glaciers an extensive ice shelf has formed along the north coast within the last 3,000 years (Marshall 1961). Parts of the shelf occasionally break off and become large ice islands.

Otto Fiord is choked with icebergs calved from the large glacier at the head of the fiord, but most other fiords have only few icebergs. The ice on most fiords and large lakes breaks up in July but only in favourable summers does the floe ice melt completely from fiords such as Tanquary and Greely and from Lake Hazen. Around the small lakes and inlets of the north coast only a shore lead melts during most summers.

Rivers and creeks generally begin flowing in late May or early June, and the peak runoff period occurs in July.

Several lakes on northern Ellesmere Island are presumed to be landlocked arms of the sea since they contain salt water overlain by a layer of fresh water (Hattersley-Smith and Long 1967, Hattersley-Smith, Keys, Serson and Mielke 1970).

Climate

Only at Tanquary Fiord, Lake Hazen, and Alert have climatic data been recorded over several years (Jackson 1959, 1960, 1961, Barry 1964, Thompson 1967, Barry and Jackson 1969, Jackson 1969). Some data are available from other stations (Van Hauen Pass, Gilman Glacier, Ward Hunt Island) but only as incidental observations. The Eureka weather station (Fig. 1) is just southwest of northern Ellesmere Island, and detailed information is available about its climate (Thompson 1967). The main features of the northern Ellesmere climate are its variability from place to place and the unusually favourable summer regime at some localities.

Temperature

Parts of northern Ellesmere Island have remarkably warm summers for such high latitudes. The warmest summers undoubtedly occur at Tanquary Fiord and Lake Hazen, with mean frost-free seasons of 65 and 55 days respectively (Corbet 1967, Jackson 1969), and summer maxima from 15 to 18 °C (Brassard 1968). On the north and northeast coasts summer temperatures are substantially cooler than at north-central localities. At Van Hauen Pass summers also appear to be cooler than at Tanquary or Hazen, although warmer than on the extreme north coast.

Below are summarized mean monthly summer temperatures (in °C) for Eureka and several northern Ellesmere localities (Jackson 1959, Savile 1964, Thompson 1967, Barry and Jackson 1969).

Station	May	June	July	August	September
Eureka (1951-60)	-10.0	2.5	5.5	4.0	-7.0
Tanquary Fiord (1963-67; 1-23 Aug.)	--	3.2	5.9	(6.5)	--
Lake Hazen (1958, + June-July 1961-63)	-12.2	+0.9	6.0	--	-7.9
Alert (1951-60)	-11.5	-0.5	4.0	+0.5	-10.0

Mean daily summer temperatures at Tanquary Fiord are shown in Fig. 9. At Gilman Glacier (1,040 m elevation) the mean for July 1957-58 was + 1.7 °C (Lotz 1959). Barbeau Peak (2,400 m) had an ambient air temperature of - 6 °C but a rock surface temperature of 0 °C on 7 June 1967 (Hattersley-Smith, pers. comm.)

The difference between temperatures at screen level (1.25-2 m) and at ground level is most important since arctic plants, especially mosses, grow very close to the ground. At Hazen Camp, Powell (1961) found summer soil surface temperatures 8 to 16 C° higher than air temperatures on sunny days, and 2.5 to 5.5 C° higher on overcast days. He also found that soil surface temperatures rose above

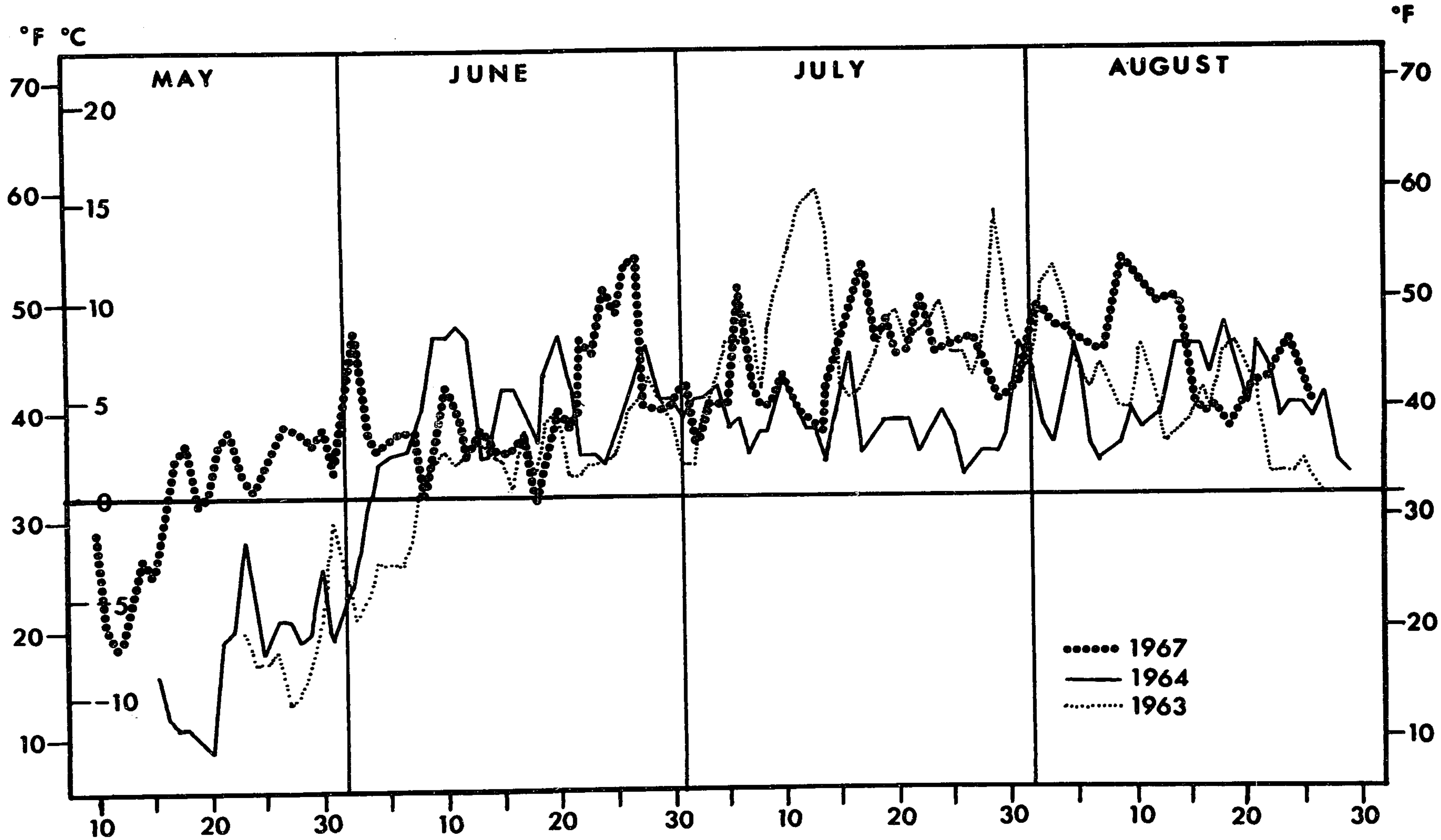


FIG. 9. MEAN DAILY SUMMER TEMPERATURES at TANQUARY FIORD, ELLESMERE I., N.W.T.

freezing about three weeks before screen temperatures did.

On 10 May 1969 at Tanquary Fiord (maximum screen temperature for that day: - 10 °C) I found several mosses on a wet south-facing gravel slope which had already thawed. Even on the extreme north coast, by 17 May 1969, when air temperatures were still well below freezing, the snow cover had already melted from favourable microhabitats, presumably enabling the mosses to resume physiological activity.

Winter temperatures are very low throughout northern Ellesmere. Lake Hazen is much colder in winter than either Alert or Eureka (Jackson 1959). Mean daily temperatures for January (1951-60) at Alert and Eureka are respectively - 32 and - 36 °C, but both stations have lower means for February and March (Thompson 1967).

Precipitation

Northern Ellesmere Island receives extremely little precipitation, and it is certainly the most arid part of the Canadian Arctic. Totals for June to August (in centimeters water equivalent) are 2.3 cm at Tanquary Fiord, less than 2 cm at Lake Hazen (1 June to 15 August only), 3.2 cm at Eureka, and 5.5 cm at Alert (Savile 1964, Thompson 1967, Barry and Jackson 1969). Total yearly precipitation at Eureka and Alert is 6.7 cm and 14.7 cm respectively (also in centimeters water equivalent).

Although no data are available from Van Hauen Pass, my observations indicate that it receives more snow in winter and more rain in summer than either Tanquary Fiord or Lake Hazen. The summer precipitation in the lowlands at Van Hauen Pass appears to be similar to precipitation above altitudes of 500 m at Tanquary and Hazen.

Winter snow cover is light, usually less than one-half meter deep except where packed by wind. Windblown sites are completely free of snow throughout winter. Snow disappears extremely rapidly; for instance at Tanquary Fiord in 1969, hardly any snow had melted by 10 May but well over half the total winter snow had disappeared two weeks later, despite the fact that screen temperatures had exceeded 0 °C for only six hours during those two weeks!

The most striking features of the precipitation regime on northern Ellesmere Island, and in the entire Queen Elizabeth Islands, are the small amount and the variability, which appears to increase with latitude (Jackson 1961).

Wind

Most northern Ellesmere localities have strong winds only infrequently, but local relief exerts strong influences on wind patterns. Van Hauen Pass periodically has severe windstorms lasting several days. At Tanquary Fiord the summers are very windy (Barry and Jackson 1969) with predominantly up-fiord winds; *föhn* winds which blow over Tanquary Camp from the ice caps north and northeast always substantially increase the temperature at the station. At Lake Hazen calm or near-calm conditions prevail in both summer and winter (Jackson 1959) and this undoubtedly contributes to the mild summer temperatures there.

Alert and Ward Hunt Island are more windy than the north-central areas, and mists and cold winds usually keep their summer temperatures close to freezing (Jackson 1961). In sheltered places on Ellesmere's north coast (e.g. Ayles Fiord) the winds in winter appear to be rather calm, judging from the depth of loose snow which I found on lakes at such localities.

Insolation

Since northern Ellesmere lies so far north the sun is continuously above the horizon from early April to early September. However, mountains often reduce the theoretical amount of radiation possible at individual localities since the sun's angle is relatively low at all times. Above 70° N the daily range of the sun's altitude above the horizon greatly decreases with latitude (Corbet 1969) resulting in a markedly more stable terrestrial micro-climate close to ground level in summer.

Both macro- and microrelief greatly affect the amount of radiation received by individual surfaces (and the plants growing on them). This influence of local topography was long ago noted (Hart 1880), "...it is due to the configuration of the land that northern slopes obtained the greatest amount of the sun's heat in Captain Feilden's latitudes [Alert area] . Eastern and southern slopes are the most favoured around Discovery Bay [Fort Conger]." At Lake Hazen, Powell (1961) found maximum solstitial irradiation on south-facing 30^{o} slopes, and he estimated that steep north-facing slopes receive less than half the amount of energy than horizontal surfaces. At high altitudes aspect becomes less deciding since there are fewer physical barriers to radiation near the summit of mountain peaks.

Localities which have high amounts of cloud cover in summer also receive considerably less radiation than localities with drier summer climates.

Vegetation and soils

Vast areas of northern Ellesmere Island are almost completely devoid of vegetation. These include, besides the ice caps themselves, active scree and talus slopes and dry, clay barrens. Most places, however, have sparse plant cover consisting of individual or small groups of plants with much bare ground in between (e.g. mesic slopes, gravel flats, wet deltas, solifluction slopes). Well-vegetated areas are the least common, and places with closed plant cover are still more rare.

Bruggemann and Calder (1953) estimated that in the Alert area, "...patches of closed vegetation occupy only a small fraction of one percent of the total land surface..." From my own field observations in the various regions of northern Ellesmere Island, I have found the proportion of land with closed plant cover on the north coast is no greater than at Alert, but in more favourable localities in the central part of northern Ellesmere (e.g. Van Hauen Pass, Tanquary Fiord, Lake Hazen) between one and five percent of the land is covered by vegetation. The only closed types of vegetation are:

1) lush, wet muskox meadows and pond margins,
2) _Dryas integrifolia_ or _Cassiope tetragona_ heaths,
3) _Dryas_ or _Cassiope_ hummock slopes,
4) late-lying snowbed vegetation, and,
5) gentle seepage slopes.

Local small patches of closed vegetation in some poorly-vegetated habitats are not, however, infrequent, especially around animal remains or bird perches.

The first comments on northern Ellesmere vegetation were those of Hart (1880) who described in detail the vegetation of the Fort Conger and Alert areas. His long discussions on the flora, vegetation development, and phytogeography near Fort Conger are still important since no more recent observations have been made there. Some of Hart's comments are particularly relevant to the present study; speaking of Fort Conger, he states (Hart 1880, pages 74-78),

> "The most luxuriant growth at this latitude is found on banks facing from south to east at from two to five hundred feet above sea-level,...
>
> "The snow-fall is, however, never of any great depth, and during the winter of our experience did not probably exceed a foot and a-half at the most, except where drifted,...
>
> "Up to the...highest altitudes [2,000 feet] two mosses (Tortula leucostoma [= Desmatodon leucostomus] and Orthothecium chryseum) occurred with the phanerogams."

Speaking of the Alert area Hart rightly noted the strong influence of topography on vegetation development at individual localities (Hart 1880, page 114),

"The richest vegetation occurred on the northern slopes, as these obtain the greatest amount of the sun's rays during the warm months."

Simmons (1906), who included northern Ellesmere in his flora, stressed the non-importance of altitude to vegetation, "The height is of little consequence, perhaps none at all, in these regions," and further, he stated that where soil and water conditions were suitable, lush vegetation would develop at any altitude. I fully concur with Simmons' statements on this matter since my observations on northern Ellesmere are identical to his. Some of the lushest sites which I found were at altitudes of 500 m or more.

Van Hauen Pass differs from all other northern Ellesmere localities in the lush development of vegetation in much of the lowlands, especially wet and dry heaths. At Tanquary Fiord, upland sites are often strikingly better vegetated than the lowlands, and although true heaths are rare, Dryas and Cassiope hummock slopes are common at all altitudes. At Tanquary many mountain slopes are very stable and often have substantial plant cover. Recent data on Lake Hazen vegetation are found in Soper (1959), Powell (1961) and Savile (1964). Its vegetation is similar to that at Tanquary, although marine habitats and stable rock slopes are lacking at Hazen and "Dryas tundra" is lacking at Tanquary (Brassard 1968).

Vegetation in the Alert region is dealt with at length by Bruggemann and Calder (1953) and Schuster et al. (1959). Vegetation on Ellesmere's extreme north coast has not yet been investigated in detail. Although my observations indicate that much of the north coast is poorly vegetated, localities near the heads of north coast fiords (e.g. Ayles Fiord) may have vegetation fully as lush as areas in north-central Ellesmere Island.

Peat

Sphagnum does not occur on northern Ellesmere, but peatlands composed mainly of sedges, grasses, and Drepanocladus species do develop. Radforth (1965) noted,

"...shallow peatland was discovered less than 100 ft. from stranded pack-ice no more than 1 ft. above sea-level on the northern coast approximately three miles from Alert,
"...on the northwesterly shore of Lake Hazen, sporadic occurrence of organic terrain was again noted."

Peat also occurs at several places near Tanquary Fiord.

Soils

Soils in the Lake Hazen area have been described by Day (1964), who found, "...no significant development of genetic horizons," and that low soil moisture and sparse plant cover are reflected in the low organic content (less than 5% except where there is closed vegetation) of the surface soil. At both Hazen and Tanquary, sulphate salts (mainly thenardite) are leached upward to the soil surface in large quantity. Nitrification is a very important factor enriching the vegetation throughout northern Ellesmere, especially around carcasses and near bird perches.

Northern Ellesmere Island is underlain by continuous permafrost which, in summer, thaws to only one-half to one-meter depth. Common soil-frost phenomena include hummocks (on both flatlands and slopes), solifluction slopes (often with stone stripes), and both sorted and unsorted polygons (from a few centimeters to many meters in diameter).

Inhabitation

No Eskimos live on northern Ellesmere Island at present, but ruins, some dating back several thousand years (E. Knuth, pers. comm.), are common throughout the area. The Alert weather station and armed forces base are the only permanent settlements. Semi-permanent field stations located at Tanquary Fiord, Lake Hazen and Ward Hunt Island are often used by scientific or exploratory expeditions, especially in summer.

CHAPTER 3

THE MOSS COMMUNITIES OF NORTHERN ELLESMERE ISLAND

No previous attempt has been made to describe bryophyte habitats or communities in Arctic Canada. Only incidental observations and data have been included in works on vascular plant habitats (e.g. in Polunin 1948a, Savile 1964, Brassard 1968). In Greenland, where much work has been done on vascular plant communities, little ecological work has been done specifically on bryophytes. Holmen (1955) attempted a simple classification of bryophyte communities in northernmost Greenland. I am here presenting a similar assessment of bryophytic vegetation and individual moss communities on northern Ellesmere Island, which are generally similar to those in northern Greenland.

Based as it is only on field observations, and not intended to be a quantitative analysis, this work will nevertheless afford a basis for future quantitative ecological studies on northern Ellesmere mosses. It would be valuable to know, for instance, whether later quantitative studies reveal moss communities identical or similar to those which I am outlining here.

For my purposes a moss community is defined as a particular group of mosses, with or without associated vascular plants, which always or regularly grow together in similar habitats, and whose vegetation is dominated by one or several moss species or is characterized by one or more indicator mosses (i.e. species restricted to one community).

My separation of moss communities is non-hierarchical and follows a system closer to the flexible Scandinavian system rather than the rigid phytosociological system of the Zurich-Montpellier School (Gams 1932).

The criteria which I use to separate the moss communities are:

1) the physical characteristics of the habitat or microhabitat in which the community grows,

2) the phanerogamic vegetation where it directly influences the mosses associated with it, and,

3) the growth forms of some mosses.

The divisions that I have adopted are based entirely on my own observations in the field. The bryophyte communities which I recognize on northern Ellesmere Island are keyed below.

1. In standing or running water (the mosses always wet)

2. In running water or in the spray zone near waterfalls

3. The mosses directly attached to rocks
HYGROHYPNUM COMMUNITY

3. The mosses not directly attached to rocks, in large cushions consolidated by wet clay and silt
BRYUM CRYOPHILUM COMMUNITY

2. In standing water

4. The mosses always submerged (in lakes, deep ponds)
SCORPIDIUM SCORPIOIDES COMMUNITY

4. The mosses generally emergent (in very wet meadows and at edges of lakes and ponds)
DREPANOCLADUS BREVIFOLIUS COMMUNITY

1. Not in running or standing water

5. In areas of virtually complete plant cover

6. Plant cover dominated by Dryas integrifolia or Cassiope tetragona

7. Heath slopes, with hummocks
AULACOMNIUM-ABIETINELLA COMMUNITY

7. Flat heaths

8. Dry ORTHOTRICHUM SPECIOSUM COMMUNITY

8. Wet HYLOCOMIUM SPLENDENS COMMUNITY

6. Plant cover not dominated by Dryas integrifolia or Cassiope tetragona

9. Nitrophilic

10. On dung HAPLODON WORMSKJOLDII COMMUNITY

10. On bird perches or other enriched areas, but not on dung
BRYUM ARGENTEUM COMMUNITY

9. Non-nitrophilic

11. Around late-lying snowbeds
POGONATUM ALPINUM COMMUNITY

11. On seepage or solifluction slopes, and wet meadows with periodic drying
<u>TORTELLA ARCTICA COMMUNITY</u>

5. In areas of non-complete plant cover

12. Epipetric <u>GRIMMIA APOCARPA COMMUNITY</u>

12. Not epipetric

13. On fine substrata (sand, silt, clay)

14. On slopes

15. On solifluction slopes
<u>TORTELLA ARCTICA COMMUNITY</u>

15. On stable clay banks and slopes
<u>POLYTRICHUM HYPERBOREUM COMMUNITY</u>

14. In flatlands

16. In moist to wet places, usually near small streams
<u>POTTIA HEIMII COMMUNITY</u>

16. In dry plains
<u>BRYUM-ENCALYPTA COMMUNITY</u>

13. On coarse material, not on sand, silt, clay

17. On dry gravel terraces and slopes
<u>BRYUM-ENCALYPTA COMMUNITY</u>

17. Over disintegrating bedrock on mesic, stable slopes

18. In dense acrocarpous cushions
<u>PHILONOTIS-TIMMIA COMMUNITY</u>

18. In loose or spreading cushions, or pleurocarpous

19. In large cushions over and between rocks
<u>RHACOMITRIUM LANUGINOSUM COMMUNITY</u>

19. In small cracks and crevices between rocks
<u>CYRTOMNIUM HYMENOPHYLLOIDES COMMUNITY</u>

The species of mosses and vascular plants entering each of the above moss communities are listed in Appendix 1. Here I shall discuss, for each community, its extent, importance and variability on northern Ellesmere Island, and the relationships between the moss communities of northern Ellesmere Island and those of northermost Greenland (Holmen 1955).

HYGROHYPNUM COMMUNITY

This community is extremely rare in the area, and very restricted where it occurs. Cirriphyllum cirrosum, Hygrohypnum luridum, H. polare, and Seligeria polaris grow attached to rocks in small creeks. A different group of mosses grow on wet limestone in the spray zone near waterfalls; at least two mosses are restricted to such places: Mielichhoferia macrocarpa and an odd form of Tortella fragilis.

The HYGROHYPNUM COMMUNITY is sometimes intermediate to the BRYUM CRYOPHILUM COMMUNITY but is otherwise well delimited. In Peary Land the equivalent community was merely called "Communities on wet rocks and stones in rivers" (Holmen 1955).

BRYUM CRYOPHILUM COMMUNITY

Much more common and abundant than the preceding community, this occurs at all altitudes throughout northern Ellesmere, wherever there are small permanently flowing creeks (Fig. 10).

It is rather constant in composition, and only rarely intergrades with, among others, the DREPANOCLADUS BREVIFOLIUS and TORTELLA ARCTICA COMMUNITIES. The BRYUM CRYOPHILUM COMMUNITY is the northern Ellesmere counterpart of parts of the *Calliergon giganteum* community and the *Philonotis tomentella* community in northern Greenland (Holmen 1955).

SCORPIDIUM SCORPIOIDES COMMUNITY

This community is rare, since situations for it are not common. Most ponds are too shallow for it to develop, and lakeshores are often too unstable or too shallow.

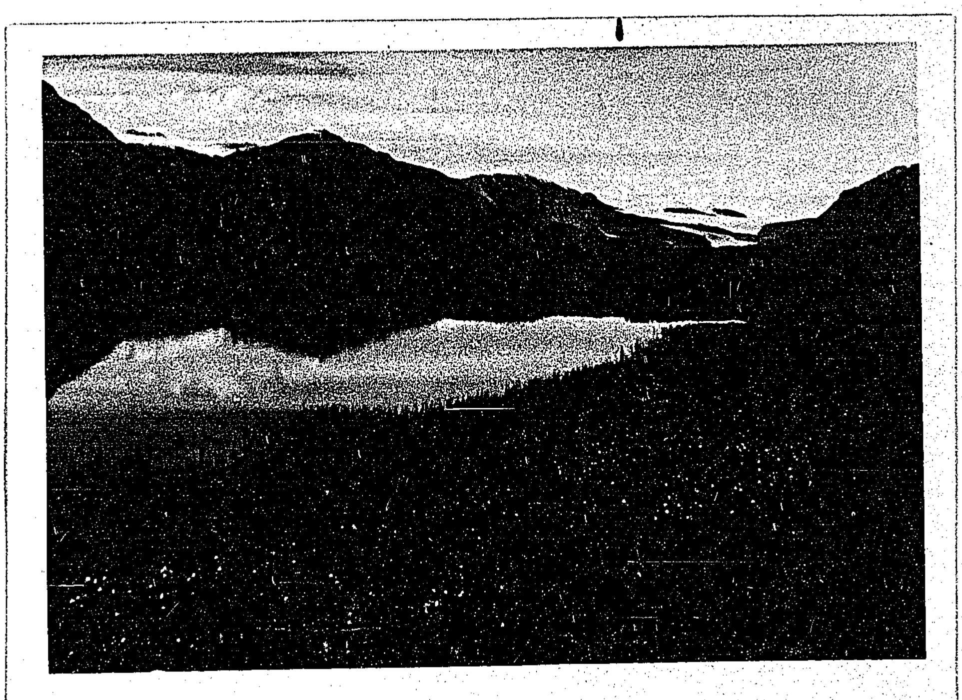
It often intergrades with the DREPANOCLADUS BREVIFOLIUS COMMUNITY. In Peary Land this community was not named, but included as "Lakes and ponds" (Holmen 1955).

DREPANOCLADUS BREVIFOLIUS COMMUNITY

This community accounts for a large part of the total plant biomass of northern Ellesmere Island, and occasionally covers many hectares. It is dominated by mosses alone or by mosses and flowering plants (Fig. 11). These so-called "muskox meadows" are preferentially grazed by muskoxen, whose dung and carcasses further enrich this already lush community (Shacklette 1963). The DREPANOCLADUS BREVIFOLIUS COMMUNITY also develops along the brackish shorelines of

Figure 10. BRYUM CRYOPHILUM COMMUNITY. The dominant species (*Bryum cryophilum*) grows as large turgid red cushions in a small stream. Tanquary Fiord. 17 July 1964. Knife blade is 2.8 cm wide.

Figure 11. DREPANOCLADUS BREVIFOLIUS COMMUNITY. Sedges (especially the Arctic Cotton, *Eriophorum scheuchzeri*) here co-dominate with the mosses around a small pond. Tanquary Fiord. 26 July 1967.



lagoons.

It often intergrades with the preceding and with the TORTELLA ARCTICA COMMUNITY. The DREPANOCLADUS BREVIFOLIUS COMMUNITY on northern Ellesmere corresponds exactly to that of the same name in Peary Land (Holmen 1955).

ORTHOTRICHUM SPECIOSUM COMMUNITY

This community is only well developed at Van Hauen Pass, where it is abundant in the lowlands and quite an important part of the total biomass at that locality. The dominant Dryas integrifolia forms irregular hummocks.

With increasing moisture the ORTHOTRICHUM SPECIOSUM COMMUNITY intergrades with the following moss community. In Peary Land a similar community is encountered, the Orthotrichum killiasii community (Holmen 1955).

HYLOCOMIUM SPLENDENS COMMUNITY

This is also most abundant in the Van Hauen Pass lowlands, and covers large areas there. The depressions between the hummocks are always very wet and support lush bryophytic vegetation.

Intermediates between this community and others are not frequent. The HYLOCOMIUM SPLENDENS COMMUNITY is the northern Ellesmere equivalent of what Holmen (1955) called "wet bryophyte tundra" in northernmost Greenland.

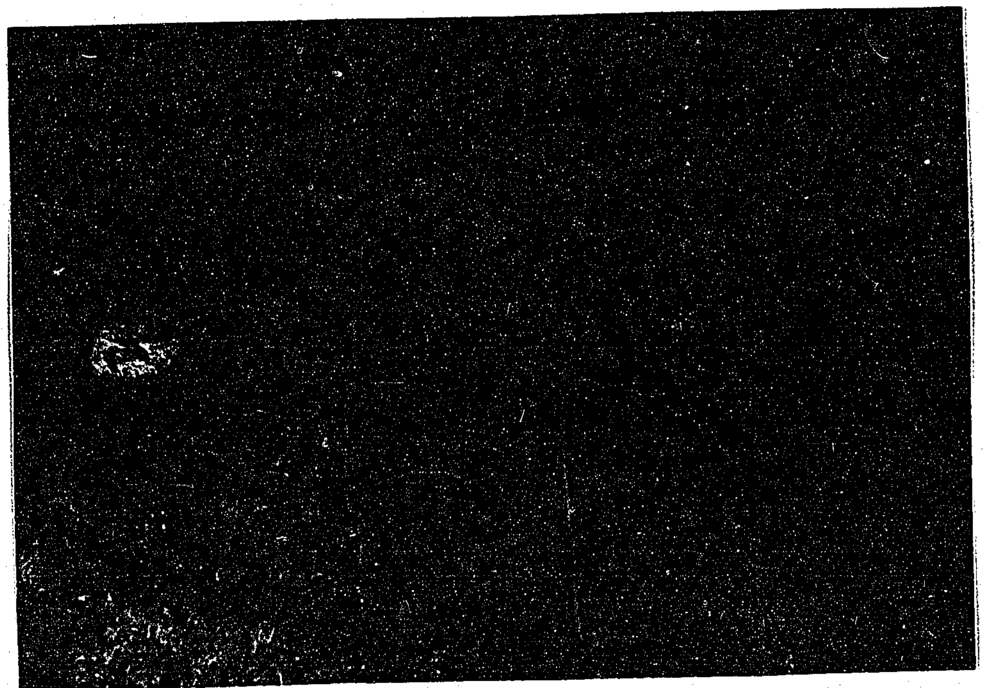
AULACOMNIUM-ABIETINELLA COMMUNITY

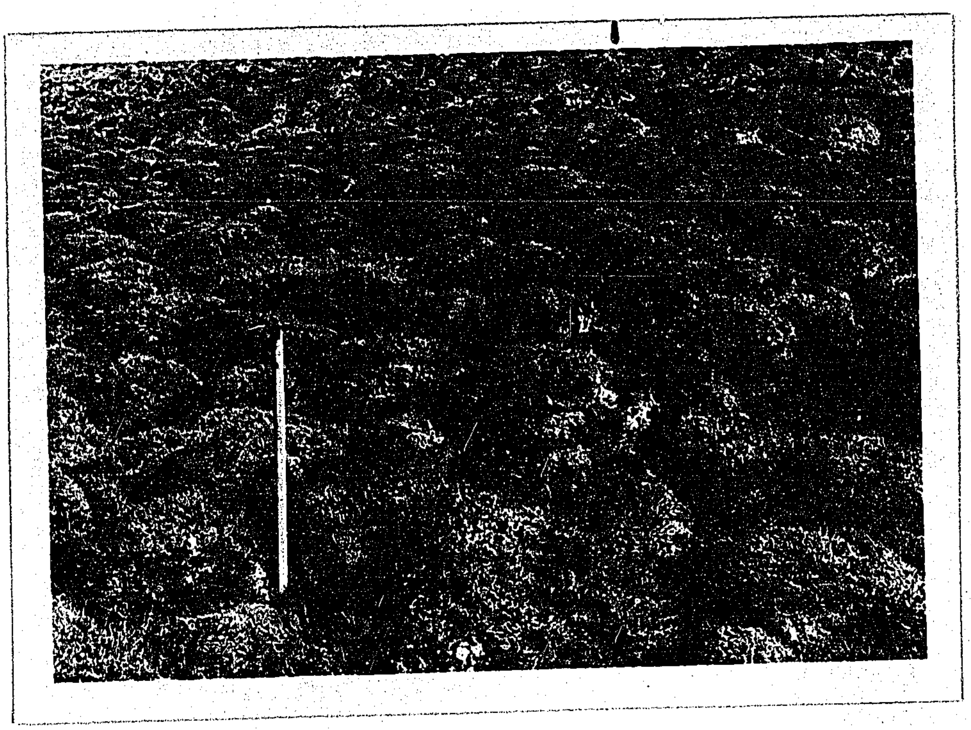
This community is abundant throughout most of northern Ellesmere. The mosses grow both on and between the hummocks. Dryas integrifolia hummocks (about 30 to 50 cm in diameter) are about half the size of Cassiope tetragona hummocks, and have a moss vegetation consisting primarily of Abietinella abietina, Arnellia fennica, Encalypta alpina and Orthothecium chryseum. They are especially abundant at Van Hauen Pass and Tanquary Fiord (Fig. 12). The vegetation of Cassiope hummock slopes (Fig. 13) differs considerably from that of Dryas hummocksslopes. On the former, species of Aulacomnium (especially A. acuminatum and A. turgidum) are very abundant, and may even co-dominate the vegetation along with the Cassiope. Cassiope tetragona hummock slopes are typical of areas with late-lying snow, and in winter are in places covered with up to one meter of hard, wind-packed snow.

Holmen's Hypnum revolutum community from Peary Land (Holmen 1955) there apparently replaces this community. But, on northern Ellesmere Hypnum revolutum is a moss with a very wide ecological range and is much more abundant in several other moss communities. This, plus the fact that two of the principal mosses composing the AULACOMNIUM-ABIETINELLA COMMUNITY (Aulacomnium acuminatum and Abietinella abietina) do not occur in Peary Land, shows that Holmen's Hypnum revolutum community cannot be considered identical to this.

Figure 12. AULACOMNIUM-ABIETINELLA COMMUNITY. Here *Dryas integrifolia* dominates the hummock slope. Tanquary Fiord, 500 m altitude. 14 August 1964.

Figure 13. AULACOMNIUM-ABIETINELLA COMMUNITY. The large hummocks are here dominated by *Cassiope tetragona*, and the mosses occur mainly between the hummocks. Tanquary Fiord, 500 m. 2 August 1967.





HAPLODON WORMSKJOLDII COMMUNITY

This very specialized moss community is composed mainly of species of the nitrophilic moss family Splachnaceae. The community is widespread on the dung of muskoxen (Fig. 14), hares, lemmings, and on regurgitated owl pellets. At Van Hauen Pass an even more specialized nitrophilic community occurs, dominated by *Funaria polaris*, a moss which grows only on lemming droppings (Steere 1963); associated with *F. polaris* at Van Hauen were *Desmatodon leucostomus*, *Encalypta rhaptocarpa*, *Pottia heimii* and *Tayloria acuminata*, all with abundant sporophytes.

Because of its specialized nature, the HAPLODON WORMSKJOLDII COMMUNITY does not intergrade with others, although it is often surrounded by the DREPANOCLADUS BREVIFOLIUS COMMUNITY or the TORTELLA ARCTICA COMMUNITY. It is equivalent to Holmen's *Splachnum* community, but on northern Ellesmere *Splachnum* is not restricted to animal dung while *Haplodon* is, and is also much more frequent.

BRYUM ARGENTEUM COMMUNITY

This community develops mainly around rocks or mounds used as bird perches; it is rarely more than two square meters in size and almost always surrounded by much more barren gravel habitats. It is thus an oasis with many more species than the surrounding terrain. The community differs

Figure 14. HAPLODON WORMSKJOLDII COMMUNITY. Muskox dung completely covered by *Splachnum vasculosum* var. *heterophyllum* in a very wet meadow. Tanquary Fiord, 500 m. 17 July 1964. Knife blade is 2.8 cm wide.

Figure 15. TORTELLA ARCTICA COMMUNITY. A solifluction slope in early spring. Numerous mosses and flowering plants occur here as single individuals or small cushions. Ward Hunt Island. 30 May 1969.

from the previous one in that the mosses and flowering plants composing it are not obligate nitrophiles, although they seem to grow preferentially on enriched soil. The BRYUM ARGENTEUM COMMUNITY can have from one-tenth to closed plant cover.

Holmen (1955) mentions bird perches under the Pottia heimii community but on northern Ellesmere the latter community is not at all related to the bird perch BRYUM ARGENTEUM COMMUNITY.

TORTELLA ARCTICA COMMUNITY

This community is very abundant throughout northern Ellesmere Island, and its total moss flora is very diverse. The TORTELLA ARCTICA COMMUNITY develops primarily on unstable seepage or solifluction slopes (Fig. 15), but also in flat places that are wet only in the spring. It is one of the most variable moss communities, since many species of mosses or flowering plants grow as single cushions on the unstable substrate. Seligeria polaris enters this community by growing on small rocks that are found on the wet fine-grained substrate.

The community intergrades freely with numerous others, notably the DREPANOCLADUS BREVIFOLIUS COMMUNITY (in areas not subject to periodic drying), the POGONATUM ALPINUM COMMUNITY (near late-lying snow), and the HYLOCOMIUM SPLENDENS COMMUNITY. Holmen separated two communities which correspond in part to my TORTELLA ARCTICA COMMUNITY; he recognized a *Tortella tortuosa* community on stable seepage slopes and a *Cinclidium arcticum* community on unstable substrates.

POGONATUM ALPINUM COMMUNITY

The POGONATUM ALPINUM COMMUNITY occurs mainly at high altitudes where the snow cover melts more slowly, and moisture is present throughout the summer.

There are frequent intermediates between it and the AULACOMNIUM-ABIETINELLA and TORTELLA ARCTICA COMMUNITIES. In northern Greenland Holmen (1955) distinguishes two snowbed communities, a *Polytrichum alpinum* community and an *Anthelia juratzkana* community.

GRIMMIA APOCARPA COMMUNITY

This simple community is restricted to dry rocks or cliffs. Since most northern Ellesmere rocks are soft (limestones, sandstones) and weather rapidly, epipetric communities are rare. The harder metamorphic rock outcrops on the north coast have more stable and varied moss communities.

The GRIMMIA APOCARPA COMMUNITY is very uniform and does not intergrade with others. It is identical to the *Schistidium apocarpum* community in Peary Land (Holmen 1955).

POLYTRICHUM HYPERBOREUM COMMUNITY

This is by far the most widespread pioneer moss community on northern Ellesmere Island. It is common at Van Hauen, Tanquary Fiord and Lake Hazen, but much rarer on the north coast. It is best developed on moist clay banks.

Although generally well delimited this community sometimes intergrades with the following one. Holmen (1955) does not list a moss community which in Peary Land corresponds to the POLYTRICHUM HYPERBOREUM COMMUNITY.

POTTIA HEIMII COMMUNITY

This is found mainly in wet lowlands, especially on wet deltas near the mouths of small creeks. Its moss vegetation is always sparse. Here the mosses grow as scattered individuals or in short turfs. Marine shorelines are in general poorly vegetated, but here and there a sparse vegetation of flowering plants (e.g. *Cochlearia officinalis*, *Dupontia fisheri*, *Puccinellia phryganodes*, *Stellaria humifusa*) and mosses (*Bryum argenteum*, *Distichium hagenii*, *Funaria arctica*) does develop.

The *Pottia heimii* community in Peary Land (Holmen 1955) corresponds precisely to this community.

BRYUM-ENCALYPTA COMMUNITY

This is the dry counterpart to the preceding community, and both are widespread throughout the region.

Neither contributes significantly to the biomass of northern Ellesmere Island.

One frequently encounters communities intermediate between this, the TORTELLA ARCTICA, the BRYUM ARGENTEUM, and the POTTIA HEIMII COMMUNITIES. Within the BRYUM-ENCALYPTA COMMUNITY the species of *Encalypta*, *Pogonatum capillare*, *Polytrichum piliferum* and *Stegonia latifolia* are much more frequent on gravel (Fig. 16). None of the moss communities mentioned by Holmen (1955) from Peary Land corresponds to the BRYUM-ENCALYPTA COMMUNITY.

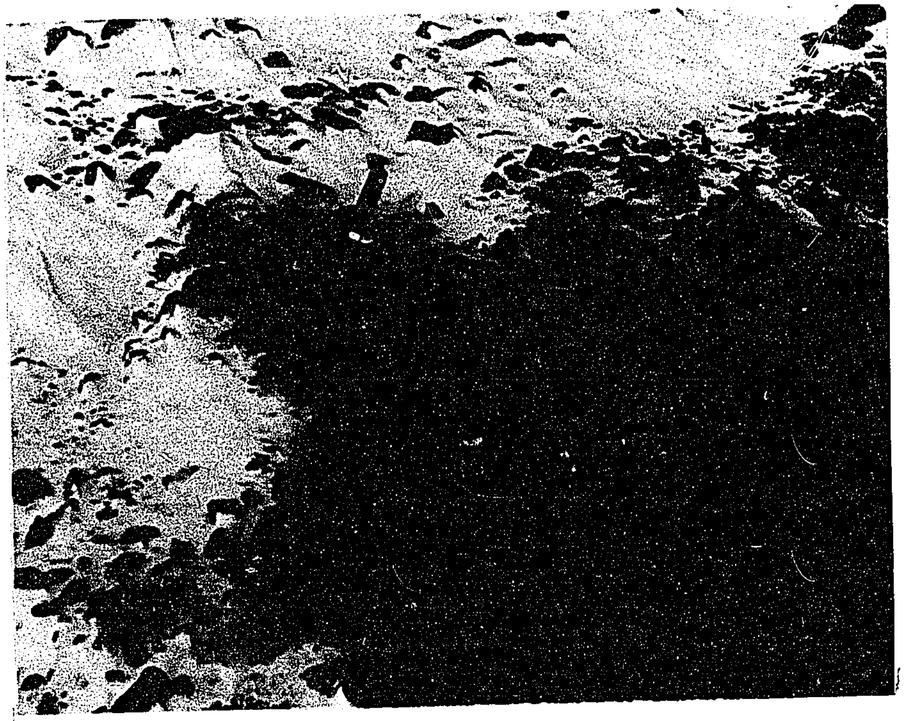
PHILONOTIS-TIMMIA COMMUNITY

This distinct and important community occurs on stable rock slopes and is very abundant at Tanquary Fiord, often occupying entire mountain-sides (Fig. 17). The dense moss cushions grow over bedrock or between boulders. The community is floristically rather constant, although *Timmia bavarica* is an abundant constituent only at Tanquary Fiord.

It rarely intergrades with other communities. The *Timmia bavarica* community which Holmen (1955) mentioned from Peary Land is quite different from the PHILONOTIS-TIMMIA COMMUNITY, which is not a nitrophilic community but one occurring on stable rock slopes. Holmen's *Timmia austriaca* community seems to be the most closely related to northern Ellesmere's PHILONOTIS-TIMMIA COMMUNITY.

Figure 16. BRYUM-ENCALYPTA COMMUNITY. A gravel flat in early spring, with scattered mosses: Aloina brevirostris, Encalypta rhaptocarpa, Hypnum revolutum and others. Ward Hunt Island. 30 May 1969.

Figure 17. PHILONOTIS-TIMMIA COMMUNITY. A high altitude stable rock slope with disintegrating bedrock. The mosses and flowering plants grow as dense dark cushions between the boulders. Mount Timmia, Tanquary Fiord, 600 m. 27 June 1964.



RHACOMITRIUM LANUGINOSUM COMMUNITY

This parallels the preceding community but occupies drier non-calcareous slopes, and its moss flora is quite different. At Tanquary the community is restricted to the highlands, but elsewhere it occurs near sea level. On Ward Hunt Island the community forms a substantial part of the total vegetation. The floristic composition of the RHACOMITRIUM COMMUNITY is constant. Dicranoweisia crispula is restricted to it, but rare.

The same community occurs in northern Greenland (Holmen 1955).

CYRTOMNIUM HYMENOPHYLLOIDES COMMUNITY

This occurs everywhere on northern Ellesmere, but its total biomass is negligible. The CYRTOMNIUM HYMENOPHYLLOIDES COMMUNITY almost always has the same species, several of which apparently need a high pH.

Holmen (1955) did not differentiate a similar moss community in Peary Land.

CHAPTER 4

ANNOTATED LIST OF THE MOSSES OF NORTHERN ELLESMERE ISLAND

The following annotated list of northern Ellesmere Island mosses is arranged in the taxonomic order of Crum, Steere and Anderson (1965), which is also used as the nomenclatural base. I have generally followed their taxonomic concepts, but where mine differ I state the reasons. Species in square brackets are provisionally excluded from the northern Ellesmere moss flora. Only important synonyms are mentioned.

After the name of each species and variety I have listed the localities from which the taxon is known (localities are abbreviated as in Fig. 2 and on page 6 and listed in that order). Each locality abbreviation is followed by brackets containing collection numbers in italics (which are mine unless otherwise preceded by a name); an asterisk "*" indicates a specimen with sporophytes, and "!" denotes specimens which I have examined but which were not collected by me. A name followed by a date (no italics, e.g. "Steere 1959") is a published report based on material which I have been unable to verify. A fire at Van Hauen Pass in 1967 destroyed many of my moss specimens, and a few species which I had definitely identified in the field but of which no specimen remains are cited as "sight record".

After the list of localities and specimens I have added annotations about the biology and ecology of the taxon. When necessary, I have also included comments on taxonomy, morphological variation, illustrations or keys.

Andreaea rupestris Hedw.

GG (Powell M16*!).

This genus is among the rarest on northern Ellesmere, and apparently restricted to high altitude scree slopes (700-800 m) (Powell 1967). I have examined the specimen, which contains a few sporophytes.

Fissidens arcticus Bryhn

VH (2820a, 2829), TF (1328d, 1448b, 1603a, 1664b, 1867), LH (Longton 2221!, Richards 67-4!), GG (Powell M5!), AL (Steere 1959), DB (4199a*), WH (Serson s.n.!), JL (4041d), TI (4109b), AF (4141), YB (4244).

Fissidens arcticus was described by Bryhn (1906) from specimens collected during the Second Norwegian Expedition in the "Fram". The original specimens came from three localities in southern Ellesmere Island, Lastrea Valley on the east coast of Ellesmere Island, and from Foulke Fiord in northwest Greenland.

For many years no further collections of this diminutive species were made. Steere (1948) listed only the original localities and cast doubt on the validity of

Fissidens arcticus as a distinct species. The same year Hesselbo (1948) reported it from east Greenland. Bryhn's original sketch was reproduced by Grout (1936), and later (Grout 1943) *F. arcticus* was "fully" illustrated for the first time.

In 1948 Steere collected the first fruiting specimens of *Fissidens arcticus* in the Great Bear Lake area, N.W.T., and he subsequently collected the species in Arctic Alaska, as did Sherrard (1955). In 1959 *F. arcticus* was reported from Alert (Steere 1959) and shortly thereafter from northernmost Greenland (Holmen 1960). I recently documented additional specimens from the Canadian High Arctic (Brassard 1967a), and I have subsequently found the species in numerous localities on northern Ellesmere Island.

Bryhn, in the original description says, "Lamina et apicalis et dorsalis elimbata," and is followed by Grout (1936, 1943) who says, "vaginant laminae...bordered by a narrow margin of linear cells;...dorsal lamina...not bordered." The only illustrations of the species show no border on the dorsal or apical laminae (Bryhn 1907, Grout 1943), and *Fissidens arcticus* was placed in Section *Semilimbidium* by both authors.

Nevertheless, the species has the appearance of a member of Section *Bryoidium*, related to *F. bryoides* Hedw. Study of original material of *F. arcticus* showed a distinct border on both dorsal and apical laminae. Under unfavourable conditions and in underdeveloped leaves the border may be suppressed in almost any species of Section Bryoidium. It is not at all surprising to find that Fissidens arcticus is really a member of this section (instead of belonging to Semilimbidium) after having examined well-developed specimens.

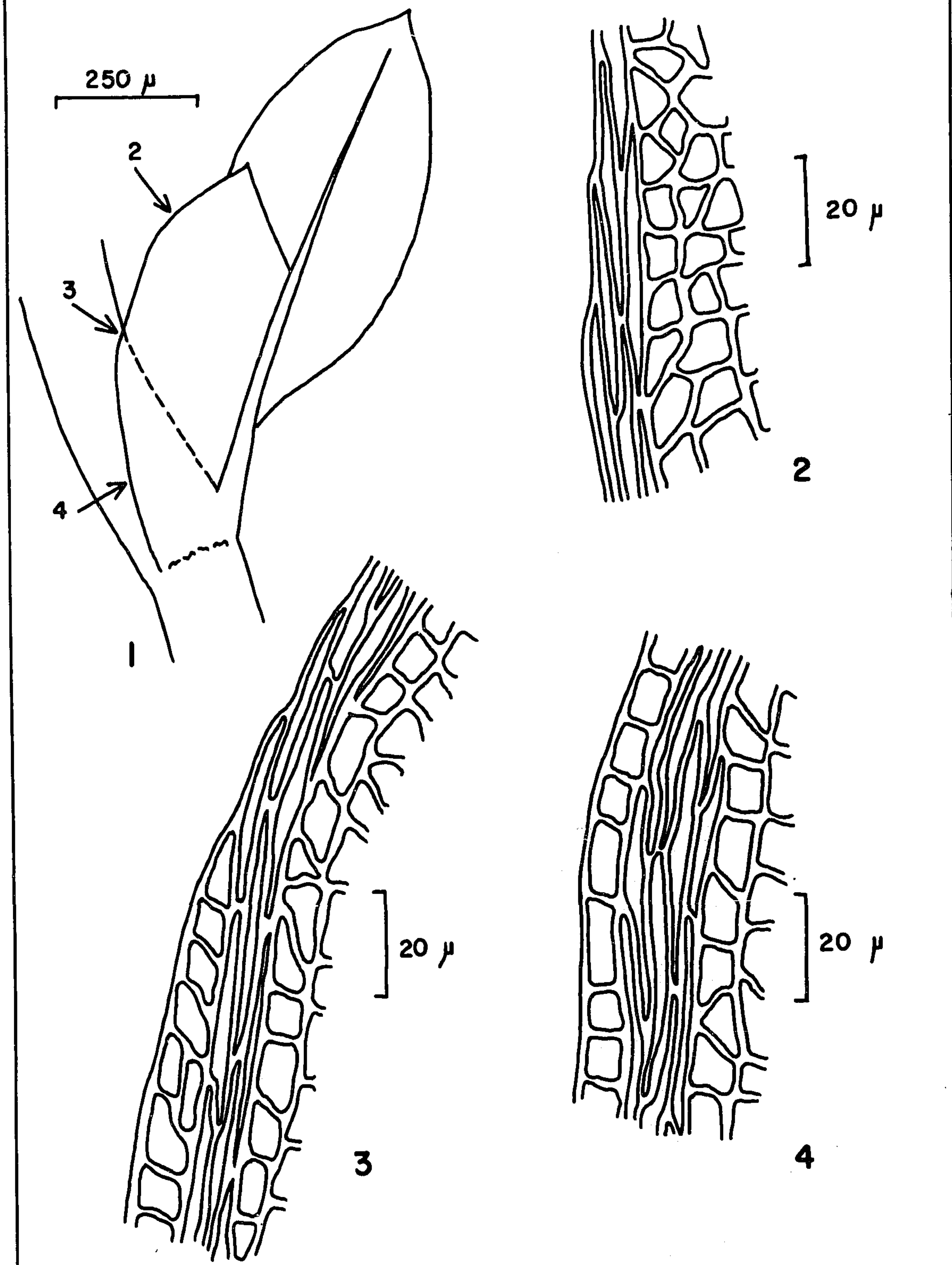
Specimens also show another feature only suggested in the original material, namely, the presence of an intramarginal border on the vaginant lamina (Fig. 18). Although the marginal rows of cells are somewhat incrassate and elongated, a conspicuous series of very long and narrow cells lie within them, towards the costa.

The tendency for suppression of the hyaline border in the dorsal and apical laminae, with best development towards the costa, forming a distinct intramarginal border, and the short dorsal lamina ending abruptly before the costa joins the stem, are characters which set F. arcticus apart from any other in Section Bryoidium (Steere and Brassard, manuscript). Based on specimens at my disposal Fissidens arcticus is redescribed and the sporophyte is described for the first time.

Fissidens arcticus Bryhn, Rept. Second Norweg. Exped. in the "Fram", 2(5): 57. 1906.

Plants growing generally on fine soil closely intermingled with other mosses, bright to dark green; stems erect, 2-10 mm tall, mostly unbranched; leaves lanceolate,

Figure 18 . *Fissidens arcticus*, specimen from Gilman Glacier (*Powell M5*). 1. Portion of the stem, showing a leaf and the abrupt ending of the dorsal lamina. 2. Marginal cells of vaginant lamina. 3. Margin of vaginant lamina, showing intramarginal border. 4. Intramarginal border near base of leaf.



FISSIDENS ARCTICUS Powell M5

to 1 mm long, acute, often faintly serrate near the apex; costa ending below the apex; leaves bordered on dorsal, apical and vaginant laminae with a generally distinct border of elongated hyaline cells; vaginant laminae with a distinct intramarginal border of very long cells (Fig. 18); dorsal laminae ending, often abruptly, well above the stem (Fig. 18); leaf cells irregularly quadrate to rounded, 7-10 (15) µ in diameter. Synoicous; sporophyte terminal; perichaetial leaves similar to the stem leaves; setae 2-4(5) mm long, 0.1 mm wide, orange-yellow; capsules erect, symmetrical, orange or brown; deoperculate capsules 0.4-0.6(1.0) mm long, 0.3 mm wide; operculum ± conic, 0.3-0.4 mm tall; peristome single, of 16 teeth divided to more than one-half their length into two filiform prongs; teeth 0.15-0.20 mm long, 36 µ wide at base, orange-yellow; spores pale green, round, smooth, (12)14-17 µ in diameter; calyptra not seen.

Judging from the numerous specimens from northern Ellesmere Island cited above, F. arcticus is widespread there, although never abundant and sporulating only at Alert and Doidge Bay. It probably grows at all altitudes.

Fissidens viridulus (Sw.) Wahlenb.

AL (Steere 1959).

It is with reluctance that I include this species; I have been unable to see the specimen, and the species is very rare in the High Arctic.

Ditrichum flexicaule (Schwaegr.) Hampe

OF (Harington 503!), VH (2851a), TF (1357, 1362, 1532a, 1817, 1828, 1886, 3117, 3235, 3279), LH (Harington 515!, Richards 67-8!, 67-23!, 67-35!, 67-46!, 68-30!, 68-34!, 68-38!, Savile 4402!, 4475!), GG (Powell M1!, M17!), HL (4260), FC (Peary 4!, 10!), WB (Bryhn 1908), LB (Wolf s.n.!), AL (4455, Steere 1959), CM (4208), DB (4179), GI (4100a), WH (4023, 4365, 4376, 4414, Kingston s.n.!), JL (4064), TI (4119), AF (4173, 4175), YB (4212, 4236, 4238).

This is the most widely distributed moss on northern Ellesmere, and is generally abundant everywhere and at all altitudes, to at least 1,150 m. It grows in wet to dry habitats, on fine or coarse substrates, and is especially abundant on stable rock slopes and in moist depressions on solifluction slopes. Both the large form (D. giganteum Williams) and the small compact form, var. densum (B.S.G.) Braithw., occur on northern Ellesmere but a continuous spectrum of forms connects those two extremes, and I believe that all should be kept under Ditrichum flexicaule in the wide sense.

Ceratodon purpureus (Hedw.) Brid.

VH (2853*), TF (3214), FC (Bryhn 1908), WB (Bryhn 1908), LB (Wolf 8!), AL (Steere 1959), WH (4279a), AF (4141a, 4145, 4160).

Found throughout the area but never abundant; with sporophytes only at Van Hauen Pass. The species grows with other mosses on moist silt and in hummocky places, from sea level to 550 m.

Distichium capillaceum (Hedw.) B.S.G.

OF (Harington 503!), VH (2832*), TF (1314*, 1373*, 1449*, 1600*, 1629a*, 1668a*, 1867*, 1882*, 1895*, 3115*, 3149*, 3284*), LH (Oliver s.n.!, Richards 67-1!, 67-12!, 67-24!, 67-43!, 68-24!, 68-28!, Savile 4402*!, 4475!, 4634!, 4757!, 4758!), GG (Powell 1967), FC (Peary 4a!, 10!), WB (Bryhn 1908), LB (Wolf s.n.!), AL (4469, Steere 1959), GI (4103*), WH (4286*, 4296*, 4299*), JL (4083, Christie 1!, 2!, Hattersley-Smith 8!, 9!), TI (4133*), AF (4150*).

Distichium capillaceum is the most widely distributed species of that genus on northern Ellesmere, and is generally everywhere fruiting. It grows in poorly vegetated habitats: on silt or gravel, on rock slopes, in rock cracks, on seepage or solifluction slopes. It occurs from sea level to about 1,000 m altitude.

Distichium hagenii Ryan ex Philib.

TF (1310*, 1371*, 1425*, 1441*, 1475*, 1769*, 1915*, 1975*), WH (4299a*, 4404*, 4423*).

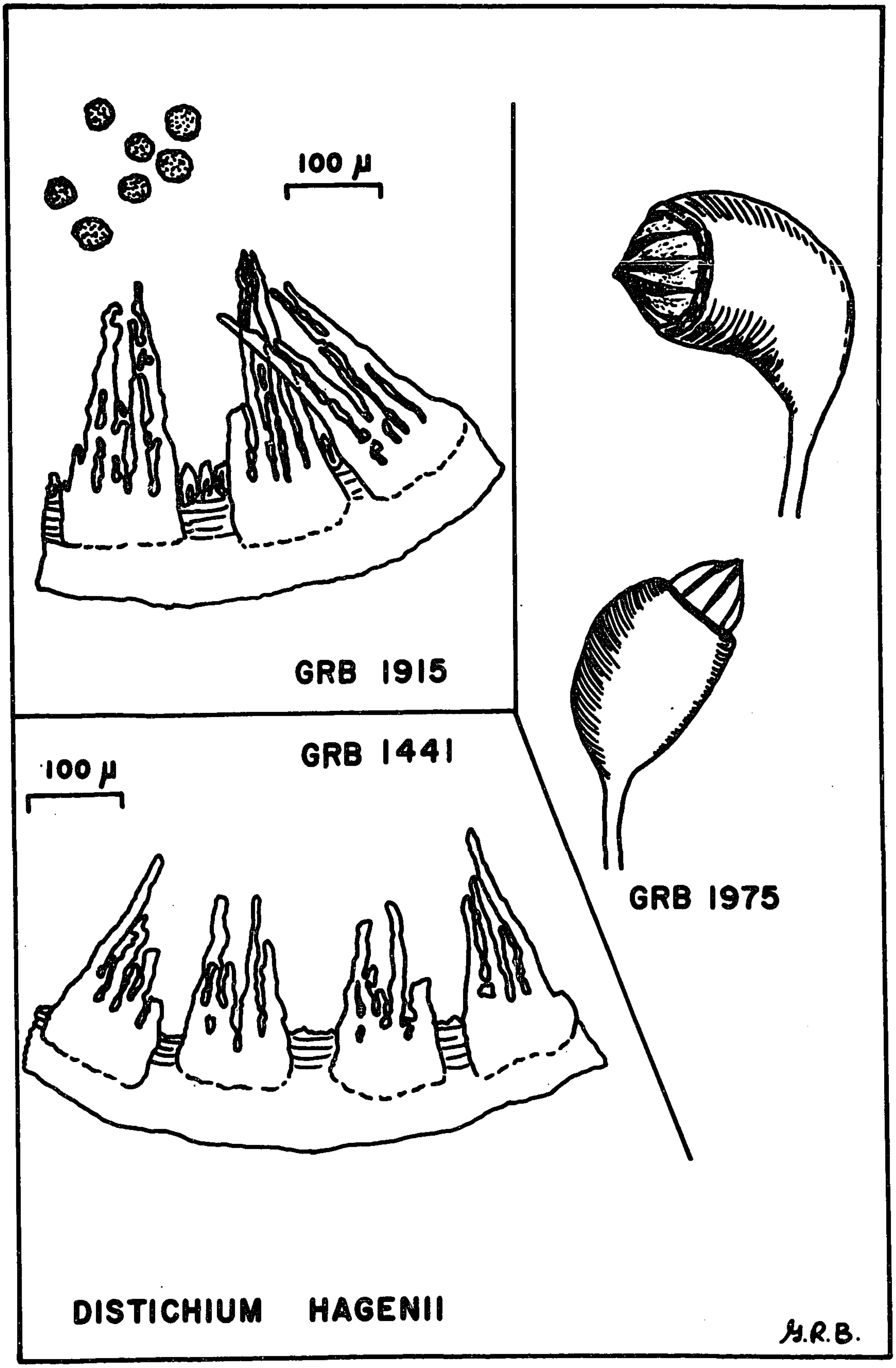
Distichium hagenii is very common and often abundant at Tanquary Fiord (Brassard 1967a), but rare or absent at all other northern Ellesmere localities. It grows on moist clay or silt, in cracks of limestone cliffs, in intertidal flats, and the species is restricted to the lowlands. Plants are usually abundantly fruiting and are very distinct from D. inclinatum by their eight- or fewer-lobed peristome (Fig. 19). D. hagenii may have a wider distribution in the High Arctic since several reports of D. inclinatum (e.g. Mitten 1878, Steere 1948) may really represent D. hagenii, long a neglected arctic species. Until doubtful reports of Distichium inclinatum are checked the relative commonness of the two species will remain uncertain.

Distichium inclinatum (Hedw.) B.S.G.

VH (2835 *), FC (Mitten 1878), AL (Mitten 1878, Steere 1959).

This has only been collected at the above three localities on northern Ellesmere, but as mentioned above, some confusion has existed between it and D. hagenii. D. inclinatum also appears to grow on moist fine substrates in the lowlands.

Figure 19 . Distichium hagenii, specimens from Tanquary Fiord (Brassard 1441, 1915, 1975). Two capsules of collection 1975 are shown, with the 8-lobed peristomes. Details of part of the peristomes of collections 1441 and 1915 show the irregularly broken peristome segments characteristic of D. hagenii, and the large spores.


100 μ
GRB 1915
GRB 1441
100 μ
GRB 1975
DISTICHIUM HAGENII
G.R.B.

Seligeria polaris Berggr.

VH (2817*, 2831*), TF (1518*, 3189*).

Seligeria polaris is not widely distributed on northern Ellesmere Island, but it is not uncommon at Van Hauen Pass. It grows on wet rocks on solifluction slopes or near small streams, and has been collected from sea level to 600 m. All the material is abundantly sporulating.

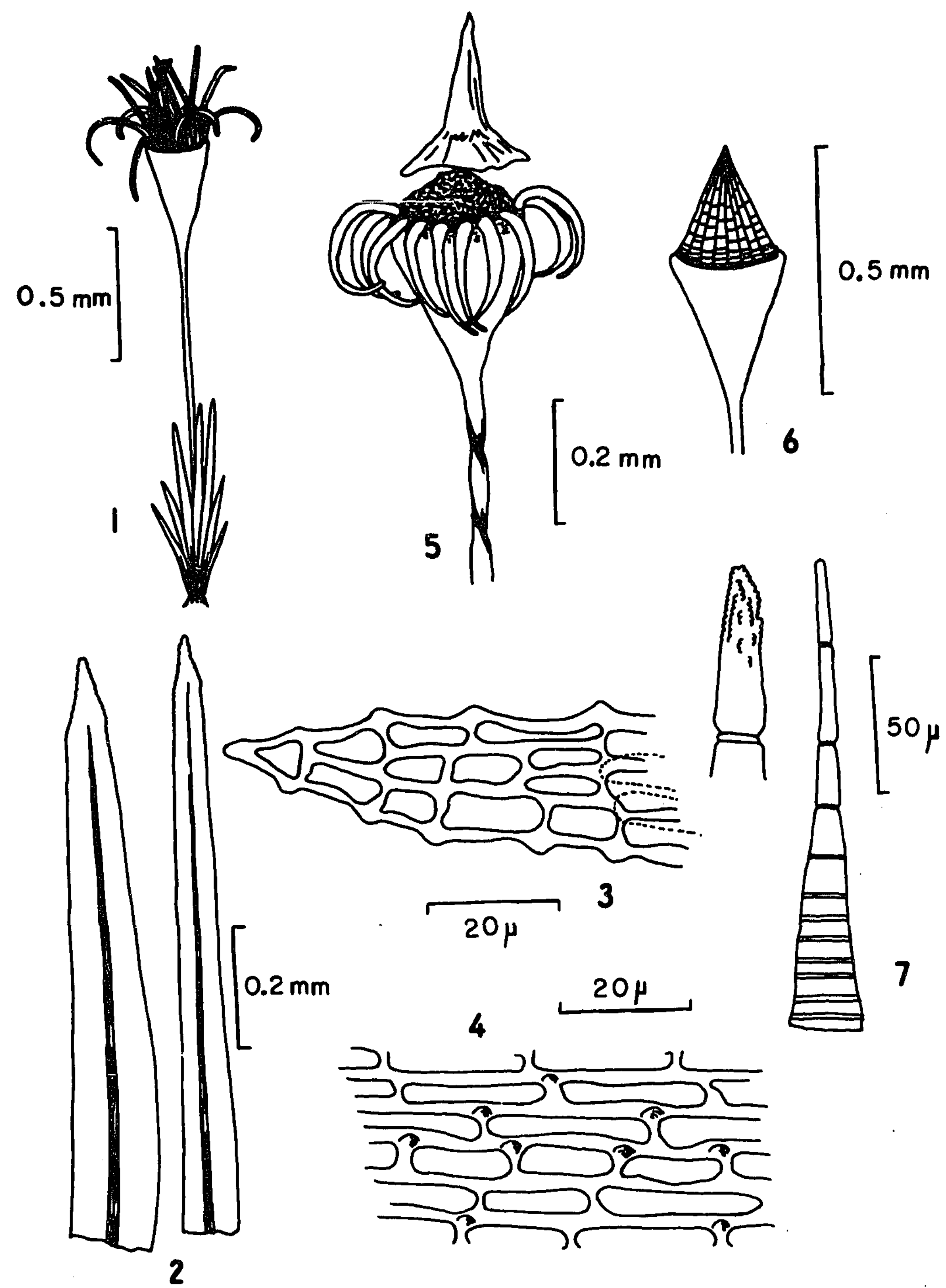
Seligeria pusilla (Hedw.) B.S.G.

VH (2988*).

Since this is the first report from northern Canada I include here a full description and illustrations (Fig. 20), both based on the above specimen (see also Brassard 1970).

Plants growing singly or in small clusters directly on limestone rocks. Plants minute, mature sporophytes less than 2 mm tall. Leaves of gametophyte erect, linear, very shortly apiculate, with the inconspicuous costa ending a few cells below the apex; leaves crenulate, with low rounded swellings above the end walls of the cells of the lamina and margin; leaf cells large, incrassate, quadrate to rectangular, 4 to 5 times as long as wide, ca. 5-7 μ X 20-35 μ ; perichaetial leaves similar but broader. Seta yellow, 0.5-1 mm long, slightly twisted when dry. Capsule erect, smooth, $\pm$ pyriform and generally tapering gradually to the seta. Operculum rostrate. Peristome

Figure 20. Seligeria pusilla, Ellesmere Island specimen (Brassard 2988). 1. Whole plant, dry. 2. Leaves of gametophyte. 3. Leaf apex. 4. Cells of midleaf region. 5. Dry capsule, with strongly revolute peristome. 6. Wet capsule. 7. Peristome tooth, with enlargement of the tip, showing tiny papillae.



SELIGERIA PUSILLA GRB 2988

single, spirally reflexed when dry, conic or incurved when wet; teeth 16, long-lanceolate, bright orange-red, about 30 μ wide at base, to 180 μ or more in length, composed of 10 to 13 segments, with tiny papillae at the tips. Spores light green, round to ovate, 10-12 μ in diameter.

The Ellesmere plants agree very well with specimens from Arctic Alaska in the New York Botanical Garden. There are, however, the following differences between arctic and temperate specimens of Seligeria pusilla.

Arctic specimens:	Temperate specimens:
Peristome teeth normally from 150 to 180 μ long,	Peristome teeth to 100 μ long,
long-lanceolate,	broadly lanceolate,
with papillose tips,	non-papillose,
composed of 10-13 segments;	composed of 6-8 segments;
leaf cells ± incrassate;	leaf cells thin-walled;
capsule obconic,	capsule obovate,
neck not developed.	with a distinct neck.

Despite these substantial differences, and the extreme disjunctions of the arctic populations, the arctic plants obviously belong to the S. pusilla group. These differences in my opinion do not at present warrant creating a new taxon. They do, however, emphasize the relict nature of the arctic plants.

Dicranella crispa (Hedw.) Schimp.

TF (1327b), GG (Powell M5!), AL (Steere 1959), JL (4041a), AF (4146a, 4163*).

This species is not uncommon on northern Ellesmere, but is very rare at individual localities, as it is throughout the Canadian Arctic (Steere 1948). It grows in wet places, usually on silt at low altitudes, and rarely produces spores.

Amphidium lapponicum (Hedw.) Schimp.

TF (3061, 3187b, 3189*), AL (Steere 1959), WH (4310*, 4349*, 4395*).

Restricted on northern Ellesmere to the above three localities, Amphidium lapponicum is abundant and richly fruiting only on Ward Hunt Island where it grows on seepage or solifluction slopes. At Tanquary Fiord, I have only seen it at altitudes of 500 to 600 m, on a limestone rock slope, on a very wet seepage slope (with Seligeria polaris), and in a moist meadow.

Dichodontium pellucidum (Hedw.) Schimp.

FC (Bryhn 1908), AL (Steere 1959).

I have not seen plants from either locality, and the species can hardly be common on northern Ellesmere Island.

Dicranoweisia crispula (Hedw.) Milde

GG (Powell L26B*!, M15!), AL (Steere 1959), WH (4322).

This is evidently quite rare, and grows in non-calcareous places, especially at high altitudes (250-1,000 m). At Ward Hunt Dicranoweisia is restricted to a metamorphic rock outcrop where it grows with Rhacomitrium lanuginosum and other acidophilic species.

Oncophorus wahlenbergii Brid.

VH (2657), TF (3320), LH (Richards s.n.!, 67-25!, 68-24!)

Oncophorus wahlenbergii is known only from the more favourable northern Ellesmere localities and not from the outer coastal stations. It also prefers non-calcareous sites; although it grows in the lowlands at Van Hauen Pass, it is mainly encountered from 700 to 800 m at Tanquary. The species grows on hummock slopes as well as on scree slopes. The reports by Powell (1967) are incorrect: both specimens are Dicranoweisia crispula.

Arctoa andersonii Wich. [≠ A. fulvella (Dicks.) B.S.G. var. andersonii (Wich.) Grout]

GG (Powell s.n.*!), AL (Steere 1959).

I have examined the previously unidentified specimen from the Gilman Glacier area but have not seen the Alert material. Arctoa is restricted to high altitudes (500 to 1,450 m) on northern Ellesmere. The Gilman Glacier plants grew on fine soil with Pohlia wahlenbergii. Arctoa andersonii is among the rarest mosses on northern Ellesmere as well as in Arctic Canada as a whole (Steere 1959). It always sporulates, and grows near sea level in the western Queen Elizabeth Islands (Borden Island, Horn s.n.*!).

Dicranum

Arctic specimens of this genus are extremely difficult to identify. The genus is rare, all specimens are sterile and mostly reduced arctic forms, and very little reliably determined arctic material is available for comparison. Teeth, and lamellae on the back of the nerve, are especially reduced. I include here only recent reports or older ones which I have verified or revised.

Dicranum acutifolium (Lindb. & H.Arnell) Weinm.

WH (4328).

This appears to be the only northern Ellesmere representative of the D. muehlenbeckii complex [D. acutifolium, D. brevifolium (Lindb.) Lindb., D. muehlenbeckii B.S.G.] and is extremely rare in Arctic Canada. The plants grew on metamorphic rocks on a low mountain summit (250 m).

[Dicranum bonjeanii De Not. ex Lisa]

LB (Wolf s.n., published by Williams 1918).

I have seen the specimen and it is a reduced form of Dicranum scoparium.

Dicranum elongatum Schwaegr.

VH (2854a, 2869), TF (3062), WH (4405, 4431), TI (4133a).

This is the most common species of Dicranum in the area, and grows principally at high altitudes (e.g. at Tanquary I have only found it above 600 m altitude). At Van Hauen and Tanquary it occurs on non-calcareous rock slopes and at Ward Hunt on seepage slopes.

Dicranum fuscescens Turn.

VH (2782), TF (3310a), FC (Peary 16a!), LB (Wolf s.n.!), AL (Steere 1959).

This species is very restricted and not abundant at any locality. Peary's plants were originally determined as D. spadiceum var. obtusum (Bryhn 1908).

Dicranum majus Turn.

AL (Steere 1959).

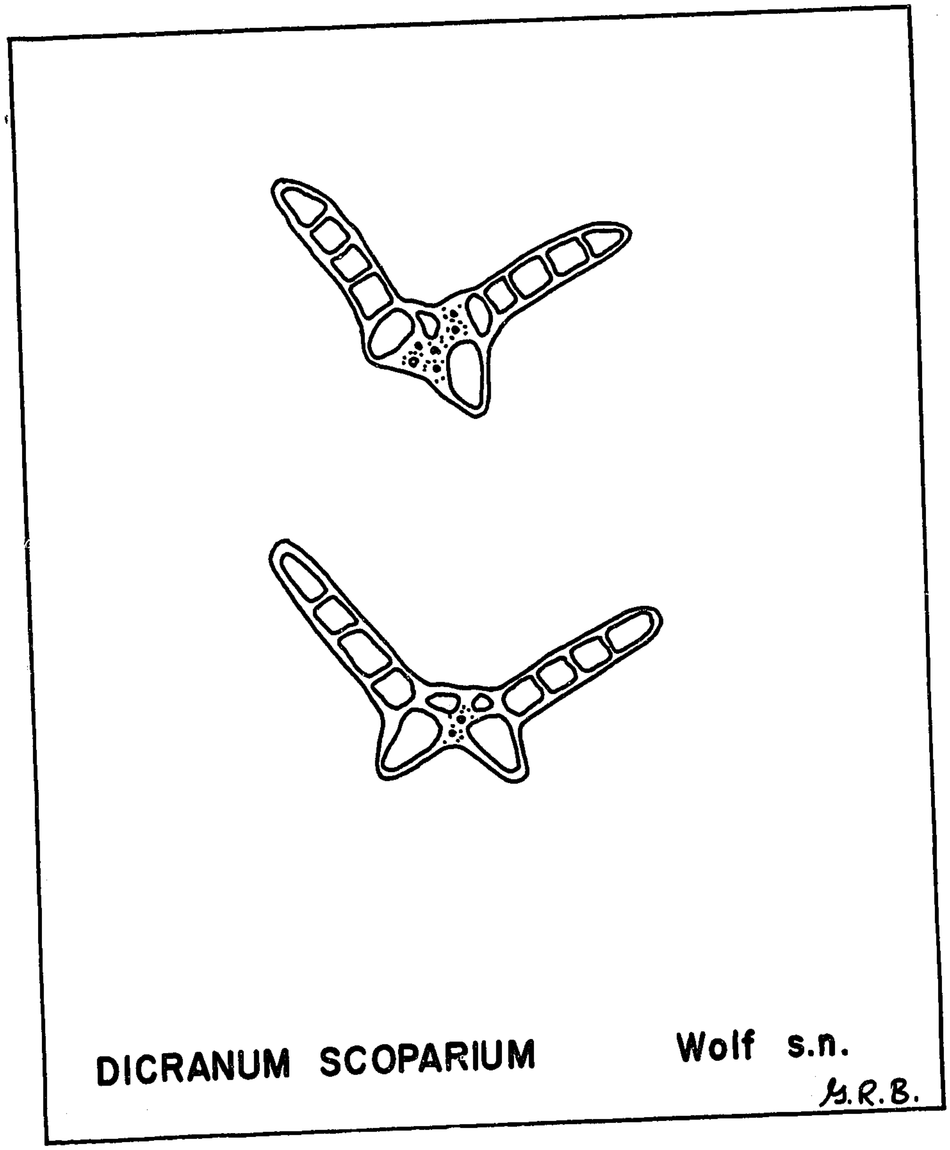
I have not seen the plants and include the species in the northern Ellesmere moss flora with reluctance.

Dicranum scoparium Hedw.

LB (Wolf s.n.!), AL (Steere 1959).

I have not seen the Alert specimen (from a scree slope) and the Wolf specimen is a reduced form with only two prominent lamellae on the back of the nerve (Fig. 21). At these

Figure 21. <u>Dicranum scoparium</u>, specimen from Lincoln Bay. Cross sections of the upper leaf, showing the two ridges on the back of the nerve.



latitudes Dicranum scoparium is not common, and is largely replaced by other species, especially D. elongatum.

[Dicranum spadiceum Zett. var. obtusum Bryhn]

FC (Peary 16a).

The specimen is an odd form of D. fuscescens.

Encalypta alpina Sm.

TF (1631a*, 1797a*, 3282), LH (Richards67-8!, 67-32!, 67-41!, 68-10!, 68-38!, Savile 4475!), FC (Peary 4a!), WB (Bryhn 1908), AL (Steere 1959), GI (4107b), WH (4383a, 4402b, Christie 8!), JL (4051, 4086), AF (4157), YB (4228a, 4246b).

Widespread but not often sporulating, this species occurs admixed with many other mosses on seepage slopes, in gravelly places, on mossy tundra, and on wet clay or silt from sea level to 900 m altitude.

Encalypta procera Bruch

TF (1629b*, 1631b*), LH (Richards 67-32!, 67-40!, 68-32!, 68-34!, 68-39!),AL (Steere 1959).

Although Encalypta procera is supposedly a wide-ranging arctic and boreal species it is surprisingly rare in Arctic Canada, including northern Ellesmere Island. The Tanquary plants grew with E. alpina in a clay meadow at 30 m, but E. procera was collected in more varied habitats to a height of approximately 100 m at Alert (Steere 1959).

Encalypta rhaptocarpa Schwaegr.

VH (2776a*, 2833*), TF (1476b*, 1767*, 1797b*, 1798c*, 1866*, 1928*, 3113*, 3173a*, 3224*), GG (Powell M5*!), WB (Bryhn 1908), AL (4468*, Mitten 1878, Steere 1959), CM (4211*), DB (4182*), GI (4101*), WH (4019*, 4024*, 4279*, 4308*, 4325*, 4337*, 4412*, 4433*), JL (4049*, 4079*, 4087*), TI (4117*, 4130*), AF (4165*, 4171*, 4174*), YB (4226*).

Encalypta rhaptocarpa is certainly one of the most widespread and abundant mosses on northern Ellesmere. It is primarily found on gravelly substrates but also in a wide variety of other habitats: in cracks on rocky slopes, around bird perches and other enriched sites, on wet clay or silt, and on seepage and solifluction slopes. It grows from sea level to about 1,000 m altitude.

Encalypta vulgaris Hedw.

VH (2873*), TF (1321*, 1471a*, 1517*, 1802*, 1815a*), WH (4422*), TI (4112*).

Not common on northern Ellesmere, this species grows in similar habitats as *E. rhaptocarpa* but has only been collected below 200 m. It is easily separated from *E. rhaptocarpa* by the complete lack of peristome.

Bryobrittonia pellucida Williams

LH (Richards 67-6!, 68-27!), AL (Steere 1959).

Apparently very rare on northern Ellesmere, as it is throughout the Canadian Arctic. It grows near late-lying snowbanks on mossy tundra at both Alert and Lake Hazen.

Anoectangium tenuinerve (Limpr.) Par.

TF (1669, 2528, 3187, 3245b), AL (4458, Steere 1959), CM (4205), GI (4095), WH (4292, 4304, 4378), YB (4224a, 4246d).

Common in the region, and often abundant, it is found as dense pure cushions in wet meadows (Brassard 1967a), on wet seepage slopes, and in cracks on a metamorphic rock cliff. It grows from sea level to about 1,000 m altitude. On northern Ellesmere the species' usual appearance is exactly that of Gymnostomum laeve Bryhn (Bryhn 1906), which was later shown to be Anoectangium tenuinerve (Györffy 1912). In the High Arctic, small depauperate specimens of Anoectangium tenuinerve can be difficult to separate from Gymnostomum recurvirostrum although the two species are normally quite easily separated.

Gymnostomum recurvirostrum Hedw.

TF (1534b, 3245a), LH (4272a, Oliver s.n.!, Richards 67-13!, 67-42!, 68-32!), CM (4203a), WH (4386, 4419a, 4440), JL (4041b), TI (4122).

This species is undoubtedly more common on northern Ellesmere than the above records indicate. It usually grows very sparsely among other mosses and is easily overlooked. I have collected it on wet seepage or solifluction slopes, on wet limestone rocks, and in clayey areas, from sea level to at least 300 m altitude.

Tortella arctica (H.Arnell) Crundw. & Nyh.

VH (2816), TF (3066, 3086, 3163, 3185, 3273), LH (Richards 68-44!), WH (4360, 4398).

Apparently localized in the area, this is not infrequent at the above localities. It grows best on wet seepage or solifluction slopes but also invades other wet habitats such as pond margins. I have found it growing near sea level and at altitudes as high as 800 m.

Tortella fragilis (Drumm.) Limpr.

VH (2724, 2783), TF (1830b, 3208, 3223, 3245), LH (Richards 67-27!), CM (4202), GI (4108a), WH (4303, 4341, 4353), TI (4136).

Tortella fragilis is infrequently collected because it is rarely abundant and most often mixed with other mosses. It generally occurs on seepage slopes and in hummocky areas from sea level to at least 600 m altitude. The plants from Clements Markham Inlet were collected near a high waterfall on a limestone cliff, and resemble Tortella tortuosa (Hedw.) Limpr. in being bright green with strongly undulate leaves; however, the leaf cross section clearly shows that the plants are an aberrant form of T. fragilis.

Didymodon asperifolius (Mitt.) Crum, Steere& Anderson

TF (3239), AL (4464a, Steere 1959).

Evidently quite rare on northern Ellesmere, this species has been collected on wet seepage or solifluction slopes as well as on moist clay and screes. It grows from the lowlands to about 800 m altitude.

Bryoerythrophyllum recurvirostrum (Hedw.) Chen

VH (2836*), TF (1475a*, 1534a, 1664, 3076, 3168*, 3184, 3211, 3234, 3255, 3278, 3314), LH (Richards 67-4!, 67-14!, 67-41!, 68-12!, 68-31!, 68-42!), GG (Powell M5*!), FC (Bryhn 1908, as Didymodon alpigenus Vent. in part), WB (Bryhn 1908), LB (Wolf s.n.!), AL (4459, Mitten 1878, Steere 1959), CM (4206), DB (4201a), WH (4362, 4424, 4428, 4441, 4442, Christie 8!), JL (4070), TI (4133c), YB (4243).

This species is among the most widely distributed mosses on northern Ellesmere and will most certainly be found at the remaining localities. It grows in a wide variety of habitats: among other mosses on seepage or solifluction slopes, on soil on rock outcrops, in cracks of limestone cliffs, on gravel ridges, on dung with Splachnaceae, between Cassiope hummocks. It occurs from sea level to 900 m. At Ward Hunt Island two distinct forms grew side by side: my specimen 4441 is an unusually robust form resembling Didymodon asperifolius, while collection 4442 is the much smaller typical arctic form of Bryoerythrophyllum recurvirostrum. Variety dentata has been reported from a few localities on northern Ellesmere but I do not believe that this form has any taxonomic value.

Barbula icmadophila Schimp. ex C.Müll.

VH (2828a), TF (1307, 1487, 1656, 1657, 1668, 1785, 1799, 2532, 3288a, 4001), LH (4274, Richards 67-8!, 67-26!, 67-42!, 68-15!, 68-21!, 68-32!, Savile 4402!), HL (4257a, 4260a), FC (4267, Peary 10!), AL (4464, 4469a, Mitten 1878, Steere 1959), DB (4199), GI (4098), WH (4020, 4285), JL (4057, 4058), TI (4122a), YB (4218, 4239a).

Barbula icmadophila is also among the widespread mosses on northern Ellesmere; it is found in habitats similar to the preceding species but is more common in calcareous areas. B. icmadophila grows at all altitudes.

Pottia heimii (Hedw.) Hampe var. arctica Lindb.

VH (2706*, 2808*), TF (1312*, 1462*, 1469*, 1472*, 1567*, 1646*, 1683*, 1760*, 1914*, 1964*, 3146*, 3230*), LH (1381*, Longton 2174*!, Richards 67-17!), AL (4470*, Feilden s.n.*!, Steere 1959), TI (4125*).

Pottia is variable in abundance on northern Ellesmere, although common. In the Tanquary Fiord lowlands it is one of the most common mosses, but is much more restricted at Van Hauen and Alert, and very rare along the north coast. It grows most abundantly on moist or wet silt or clay near small streams or marine shorelines with Desmatodon leucostomus, Funaria arctica, Tortula mucronifolia, and other mosses. Pottia heimii occurs from sea level (intertidal flats) to about 200 m altitude (except at Alert where it grows at 500 m), and is amost always richly fruiting.

Stegonia latifolia (Schultes) Broth. var. latifolia

VH (sight record), TF (3058*, 3194*, 3319*), GG (Powell M3B*!), AL (4476a*), GI (4102*), WH (4312*, 4343*, 4366*), JL (4041*), TI (4137*).

Stegonia latifolia also appears to be common in the area but rarely abundant. The typical variety is the more common, but frequently both varieties are found together. The species grows on silt or fine sand and on rock or gravel slopes from sea level to 1,450 m. At Tanquary it is only found above 500 m altitude.

var. pilifera (Brid.) Broth.

VH (sight record), TF (3058a*, 3194a*), AL (4476a*), TI (4113*, 4137a*).

Much less widespread than the type, this often grows with it. I have checked Powell's specimen from Gilman Glacier (Powell 1967) and find that it is not var. pilifera but a very poor specimen of var. latifolia.

<u>Desmatodon cernuus</u> (Hüb.) B.S.G.

TF (<u>3136*</u>).

This species was not reported by Steere (1948) from the Canadian Arctic, although it has since been reported from northernmost Greenland (Holmen 1960). The Tanquary plants were growing on fine sand along the shore of the fiord.

<u>Desmatodon latifolius</u> (Hedw.) Brid. var. <u>latifolius</u>

AL (Steere 1959).

The species, and this variety are apparently quite rare on northern Ellesmere. The Alert specimen grew on a scree slope at 700-1,000 m (Steere 1959).

var. <u>muticus</u> (Brid.) Brid.

TF (<u>3075*</u>).

This variety of <u>Desmatodon latifolius</u> is likewise very rare, and restricted to a high altitude (500 m) where it grew with <u>D. leucostomus</u> in a rock crack on a sandstone rock slope. Powell (1967) reported <u>D. latifolius</u> var. <u>muticus</u> from the Gilman Glacier area, but I have seen the specimen and it is <u>D. leucostomus.</u>

<u>Desmatodon leucostomus</u> (R.Br.) Berggr.

VH (<u>2830a*</u>), TF (<u>1316c*</u>, <u>1460*</u>, <u>1461*</u>, <u>1479b*</u>, <u>1527*</u>, 1534*, 3057*, 3075a*, 3233*), GG (Powell M5*!, M10a*!), FC (Mitten 1878), AL (4477*, Mitten 1878, Steere 1959), DB (4181*), WH (4309*, 4312*, 4416*, Christie 5*!), JL (4041*, 4044*), AF (4146*).

This is by far the most widespread Desmatodon on northern Ellesmere, and is generally abundant where it occurs. It can safely be expected at all localities. It is found from intertidal flats to 600 m and grows in several habitats: on silt in frost cracks, in cracks on rocky slopes, around lemming burrows, on wet limestone (with Mielichhoferia macrocarpa), along marine or freshwater shores, on gravel flats. Desmatodon leucostomus is always richly sporulating.

Aloina brevirostris (Hook. & Grev.) Kindb.

VH (2705a, 2830*), TF (1941a), GG (Powell M5B!), AL (Steere 1959), CM (4208a), WH (4281*).

This calciphilic species is common but probably often overlooked when not fruiting. It is mainly found on moist clay or silt in strongly calcareous places, but the Clements Markham Inlet plants grew on wet limestone near a large waterfall. Aloina brevirostris only rarely produces fruit, and grows from sea level to at least 700 m altitude.

Tortula mucronifolia Schwaegr.

VH (2893*), TF (1470*, 1478*, 1516*, 1664*, 3229*, 3283*), GG (Powell 1967), AL (Feilden s.n.*!, Steere 1959), WH (4295*, 4315*, 4338*, 4341a*), JL (4072), TI (4126*), AF (4166a), YB (4228*).

Tortula mucronifolia is very widely distributed in the area, often abundant at individual localities, and almost always richly fruiting. It grows on gravel, in wet meadows, on hummock slopes, on disintegrating bedrock, and on seepage and solifluction slopes, and ranges from sea level to 1450 m.

Tortula norvegica (Web.) Limpr.

VH (2824*), LH (Richards 68-7!), AL (Steere 1959), WH (4021).

This species appears to be among the rarest on northern Ellesmere, and none of the specimens is typical or well developed. Bryhn's reports (1908) are based on specimens of T. ruralis. Tortula norvegica has only been collected below 100 m.

Tortula ruralis (Hedw.) Gaertn., Meyer & Scherb.

VH (2837a), TF (1318, 1502, 1532*, 1798b, 3119, 3172, 3287, 4002), LH (4273, Richards 67-27!, Savile 4402!, 4475!), GG (Powell s.n.!), HL (4257), FC (4261a, 4265, Peary 8!, 11!), LB (Wolf s.n.!), AL (4450, Davis 48!, Harington 210!, Mitten 1878, Steere 1959), DB (4115), GI (4094), WH (4008, 4012, 4324, 4363), JL (4029, 4036, 4039, 4056, 4078), TI (4115), AF (4168), YB (4233, 4247).

Tortula ruralis and Ditrichum flexicaule are the two most widespread and abundant mosses on northern Ellesmere Island. Tortula ruralis occurs in many different habitats: between boulders on stable rock slopes, among broken rocks on mountain summits, between hummocks, on dung and near bird perches, on gravel flats and slopes, on clay or silt, on disintegrating bedrock, on nunataks and in glacier fore-lands, and on solifluction and seepage slopes. It is one of the most conspicuous species around the ruins of Fort Conger, even growing on the roofs of the long-abandoned huts. Tortula ruralis grows from sea level to at least 1000 m, and appears equally common at all altitudes. It apparently rarely produces fruit; I have only seen a few specimens with old setae and aborted capsules.

Grimmia alpestris (Web. & Mohr) Nees, Hornsch. & Sturm

AL (Steere 1959).

I have not seen the specimens but include the species provisionally. It is not known from any other part of the Canadian Arctic.

Grimmia alpicola Hedw. sensu latu

TF (3072*, 3094*, 3099*, 3127*), AL (Steere 1959), WH (Walker s.n.*!).

Thus far known only from three northern Ellesmere localities. At Tanquary it grows on rocks in running water and at the base of talus slopes from 150 to 700 m, and at Alert in clayey areas and on calcareous rock slopes and moss tundra. The Tanquary plants are all var. rivularis (Brid.) Wahlenb. and Steere (1959) listed var. latifolia (Zett.) Möll. from Alert. My specimen 3127 is an unusual form with secund leaves. Walker's specimen grew submerged on the Ellesmere Ice Shelf, off Ward Hunt Island.

Grimmia anodon B.S.G.

TF (2524*, 2530*, 2537*, 3108a*, 3138*, 3232*, 4000*), HL (4254*), AL (Steere 1959), DB? (4192), GI (4096*), WH (4011*).

This small species is uncommon on northern Ellesmere and rarely abundant. It grows on rock outcrops and on both stable and very unstable rock slopes from sea level to 500 m. On Garlic Island it and Anoectangium tenuinerve were very abundant on a near-vertical metamorphic rock cliff.

Grimmia apocarpa Hedw. var. apocarpa

VH (2641*, 2650*), TF (3097*, 3108*, 3155*, 3247*, 3260*, 3281*, 3290*), AL (Steere 1959), GI (4091*), WH (4022*, 4370*, 4415*), TI (4131*, 4135*).

Grimmia apocarpa is common on northern Ellesmere Island, and the typical variety is the most abundant.

G. apocarpa var. apocarpa grows at all altitudes on both sedimentary and igneous rock outcrops and among boulders on rock or gravel slopes.

var. nigrescens Mol.

VH (2743*).

This handsome and distinct variety of the usually polymorphic Grimmia apocarpa has been rather neglected since its description by Molendo (1865). During the course of my studies I have seen several specimens from Arctic North America (some misidentified as other species). Of all the specimens which I have examined none had any characters intermediate to other forms of G. apocarpa. Variety nigrescens is immediately recognizable by its black colour — an unbelievably intense black, and by its large size and habitat. Preceding his description Molendo (1865) wrote, "An propria species?" an indication that var. nigrescens was perhaps a good species. The robust specimens from the Nearctic tend to support this view, and future examination of the type may well show that a good species is at hand.

At Van Hauen Pass G. apocarpa var. nigrescens grew in a wet sedge meadow (an unusual habitat for any Grimmia) in the lowlands. I have seen other specimens from similar habitats in several other Queen Elizabeth Islands (Cornwallis Island, Mackenzie King Island, Melville Island) as well as from Banks Island, other parts of the Low Arctic, and Arctic Alaska.

var. stricta (Turn.) Hook. & Tayl.

TF (1368b*), LH (Harington 518*!), AL (4475*, Steere 1959, as G. gracilis Schwaegr.), CM (4203), WH (4447*, Walker s.n.!).

This variety is not as common as the type but grows in similar habitats from sea level to 1,000 m. The plants are usually quite easily separated from var. apocarpa by well-developed papillae on the upper leaf.

Grimmia flaccida (DeNot.) Lindb.

BP (Hattersley-Smith s.n.*!).

This species has not previously been reported from Arctic Canada. I am certain that my identification is correct since sporophytes were present. It was collected at about 2,400 m, on a southwest-facing nunatak. At the time of collection the temperature near the rock face was 0° C (on 7 June 1967, Hattersley-Smith, pers. comm.).

Grimmia plagiopodia Hedw.

TF (2538*).

This specimen is also the first from the Canadian Arctic Archipelago, although the species is known from the Hudson Bay region (Steere 1948) and Alaska (Steere 1965).

Grimmia tenera Zett.

AL (Steere 1959, as *G. tenuicaulis* Williams).

Evidently very localized in this region, this is only found on high altitude scree slopes. I have not seen the specimens and they were not cited by Ireland (1964) but I include it since the species also occurs in nearby Peary Land (Holmen 1960).

Grimmia torquata Hornsch. *ex*. Grev.

AL (Steere 1959).

Also known only from the Alert area, *Grimmia torquata* is so unmistakable that I have no qualms about accepting the report although I have not seen the specimen, which grew on loose scree at 500 m. *G. torquata* cannot be common on northern Ellesmere.

Rhacomitrium canescens (Hedw.) Brid. var. *canescens*

VH (*2767*, *2867*), TF (*3059*, *3095*, *3152*, *3326*), LH (*Savile 4491*!), GG (*Powell L24A*!), AL (Steere 1959).

This species, although not as widespread as *R. lanuginosum*, is common except on the north coast. I have collected this variety from near sea level to at least 800 m, but it is much more abundant above 500 m altitude. It grows on talus slopes and on more stable rock slopes (in large cushions between the boulders).

var. ericoides (Brid.) B.S.G.

TF (1700a, 3289).

Surprisingly, these are the first reports of this variety from Arctic Canada. It grew on rock slopes from 100 to 900 m altitude. It undoubtedly occurs elsewhere on northern Ellesmere and in the High Arctic.

[Rhacomitrium heterostichum (Hedw.) Brid. var. sudeticum (Funck) G.Jones]

AL? (Steere 1959, as R. sudeticum (Funck) B.S.G.).

I exclude this species from the list until the specimen is located, since the species is quite rare in the Canadian Arctic.

Rhacomitrium lanuginosum (Hedw.) Brid.

VH (2640, 2648, 2854), TF (3077, 3160, 3259, 3275, 3285), GG (Powell L26A!), LB (Wolf s.n.!), AL (Steere 1959), DB (4188), WH (4318, 4321, 4372, 4407), TI (4129).

Rhacomitrium lanuginosum is one of the common and abundant mosses on northern Ellesmere and can safely be expected at all localities. It was mentioned from Lake Hazen by Savile (1964) but his specimen is R. canescens. At Van Hauen R. lanuginosum is very abundant in the lowlands and often co-dominates the vegetation with other mosses or with Cassiope tetragona, but at Tanquary it is mostly restricted to the highlands and only abundant above 500 m (reaching 900 m) while almost entirely absent from the strongly calcareous lowlands around Tanquary Camp. At Ward Hunt Island it is perhaps the most abundant moss, and and is almost the only plant species on rock talus slopes. The acidophilic nature of R. lanuginosum partly explains its local occurrence at individual stations; it is often associated with other acidophilic mosses, e.g. Dicranoweisia crispula, Dicranum elongatum, Hylocomium splendens, and species of Polytrichaceae.

Funaria arctica (Berggr.) Kindb. [= F. hygrometrica Hedw. var. arctica Berggr.]

VH (2705*, 2809*), TF (1430*, 1647*), LH (Longton 2167*!), FC (4262*), WH (4313*), JL (4040*), TI (4124*).

This species is common on northern Ellesmere but rarely abundant. It grows on fine substrata and on disintegrating bedrock, and sometimes grows very close to the high-tide line with other mosses such as Bryum argenteum, Desmatodon leucostomus and Pottia heimii. It ascends to 200 m.

All the above specimens differ somewhat from typical Funaria arctica, which should have setae 7-10 mm long and spores about 20 µ in diameter (Holmen 1960). The Ellesmere plants all have short setae but several specimens contained plants with very large spores, (22)24-29(31) µ in diameter, much larger even than the spores of F. microstoma (Holmen 1960).

The Funaria hygrometrica-arctica-microstoma group may have differentiated into several species relatively recently, perhaps during the Pleistocene epoch. In arctic areas F. hygrometrica certainly became reduced in stature, and at the same time the spores of some high arctic populations of the northern taxon (F. arctica) became much larger. The plants with large spores are probably a relict form which developed in the High Arctic during more severe conditions and not, as is usual with Funaria hygrometrica, recent immigrants. F. arctica is most often found on pioneer substrata in association with other high arctic endemics such as Desmatodon leucostomus, Polytrichum hyperboreum and Psilopilum cavifolium. At Ward Hunt Island, one anomalous population of Funaria arctica which was quite abundant around the disturbed soil near the campsite had well-developed capsules, none of which produced any spores.

Funaria polaris Bryhn

VH (2774*).

This distinct species had not previously been collected north of the type collection on southern Ellesmere Island until I discovered it at Van Hauen Pass. It grew abundantly around a lemming burrow, and the plants were in large part covered by lemming droppings. This marked association of Funaria polaris with lemmings has already been noted by Steere (1963).

Voitia hyperborea Grev. & Arnott [= V. nivalis Hornsch. sensu Crum et al. (1965) in part]

VH (2632*), TF (1447*, 1526a*, 1530a*, 1812*, 1836a*, 3101*, 3157*), LH (Longton 2075*!), GG (Powell M13*!, published as V. nivalis by Powell (1967)), FC (Peary 4c*!, Mitten 1878), AL (Feilden s.n.*!, Steere 1959).

Voitia hyperborea is common on northern Ellesmere but has yet to be collected on the extreme north coast, where it undoubtedly also occurs. It is usually found on muskox dung in wet meadows but grows on other enriched substrates as well, from sea level to at least 600 m. I am convinced, after studying almost all the North American material, that V. hyperborea is a good species and that both it and V. nivalis occur in North America. The latter species is apparently restricted to the Rocky Mountains and I have seen specimens from Alberta and Colorado. Voitia hyperborea is a truly arctic species with a wide distribution in the Nearctic.

The differences between the two species, apart from separate geographical distributions, were well stated and illustrated in the original description of V. hyperborea

(Greville and Walker-Arnott 1822). The principal difference is the shape of the capsule — oblong-ovate in Voitia nivalis, ovate-globose in V. hyperborea. In addition, the base of the capsule in V. hyperborea is very abruptly narrowed to the seta, forming a definite ridge along the base (well illustrated in the original drawing and more recently in Holmen (1960)). In V. nivalis the more elongated capsule narrows gradually to the seta without any formation of a ridge.

Tayloria acuminata Hornsch.

VH (2776*), TF (3139a*).

This species was previously unknown from northern Ellesmere and is among the rarest mosses in that area. At Van Hauen it was associated with Funaria polaris near lemming burrows, but at Tanquary only two plants were found, on a Cassiope hummock slope at 60 m altitude.

[Tayloria serrata (Hedw.) B.S.G.]

TF? (1315b*).

This single specimen (from a dense sod of Leptobryum pyriforme) was sent to Dr. H. Crum after preliminary determination as T. acuminata. He returned it with the following comment (Brassard 1967a), "Tayloria serrata ? - Poor material. (The peristome is very different from the T. acuminata type)." Until further material is found, and in view of the later collection of good T. acuminata from Tanquary, I prefer to exclude T. serrata from the list of northern Ellesmere mosses.

Tetraplodon mnioides (Hedw.) B.S.G.

VH (2576*, 2777*, 2786*), TF (1526c*, 1837b*, 3170*, 3243*), LH (Longton 2052*!, 2090*!), FC (4263*, Hart s.n.*!, Bryhn 1908), WB (Wolf s.n.*!), AL (4474*, Feilden s.n.*!, published as T. urceolatus, Steere 1959, as T. urceolatus in part), WH (4300*, 4326*, 4347*, 4379*, 4387*), JL (4037*, 4089*), AF (4152*, 4172*).

This is the most widely distributed species of the family Splachnaceae on northern Ellesmere, and it certainly occurs at all localities. It grows abundantly on dung or owl pellets in wet places and is usually associated with other members of the same family, especially Haplodon wormskjoldii. It is found at all altitudes, to about 1,000 m at Alert. Tetraplodon urceolatus (Brid.) B.S.G. is only a reduced form unworthy of taxonomic recognition (Crum 1969, Steere 1959). Most Ellesmere specimens of T. mnioides key to var. cavifolius (Schimp.) Möll. but this variety, in my opinion, does not warrant taxonomic rank either. Powell's report from the Gilman Glacier area (Powell 1967) is based on a specimen of T. paradoxus.

Tetraplodon paradoxus (R.Br.) I.Hag. [= T. mnioides var. paradoxus (R.Br.) C.Jens.]

VH (2632a*), TF (1526b*, 1530b*, 1836b*), LH (Longton 2076*!), GG (Powell M13A*!), AL (Steere 1959).

Relatively localized on northern Ellesmere, this grows sparsely on dung. It is more common in the lowlands but occurs to 500 m altitude at Tanquary. There seem to be no specimens intermediate to T. mnioides and I believe T. paradoxus to be a good species. The comment by Steere (1959) that the Alert specimens occurred with Voitia hyperborea is of interest because all subsequent specimens of Tetraplodon paradoxus from northern Ellesmere were also growing with the Voitia, and often with both Voitia hyperborea and Tetraplodon mnioides. Indeed, on Ellesmere I have not found T. paradoxus growing without Voitia hyperborea and the theory (Savicz 1924) that the former is a hybrid between Voitia hyperborea and Tetraplodon mnioides is strengthened by the evidence from Ellesmere Island specimens.

Haplodon wormskjoldii (Hornem.) R.Br.

VH (2702*, 2993*), TF (1833b*, 1837a*, 3168*, 3190*, 3209*), LH (Longton 1862*!, 1907*!, Powell s.n.*!), FC (4264*, Mitten 1878), AL (Mitten 1878, Steere 1959), WH (4379a), AF (4152a).

Haplodon is common on northern Ellesmere (but only collected without sporophytes on the north coast). In the north-central parts it is often abundant on dung in wet meadows and near pond margins, and is occasionally associated with Cinclidium latifolium. Haplodon wormskjoldii grows at all altitudes, to about 1,000 m.

[Splachnum ovatum Hedw.]

LH (reported by Powell 1967).

The specimen in question, which I have examined, is not Splachnum ovatum but sterile Haplodon wormskjoldii.

Splachnum vasculosum Hedw. var. heterophyllum (Drumm. ex Hook.) Brassard, var. nov. [= S. heterophyllum Drumm. ex Hook., Musci Americani Thomas Drummond 37. 1840]

VH (2653*, 2992*), TF (1407*, 1433*, 1520*, 1592, 1694*, 1784*, 1833a*, 3128*, 3244*), LH (Longton 1943*!), FC? (Mitten 1878, as S. vasculosum).

Splachnum vasculosum was one of the first plant species reported from the Canadian Arctic (Brown 1823), and it has since been reported from numerous additional localities. During the past few years, after examining specimens from Arctic Canada, I have come to the conclusion that two distinct varieties of S. vasculosum are present there. Splachnum vasculosum var. vasculosum is a boreal moss which does not grow far beyond the tree line. Most specimens from the tundra, and all the specimens which I have seen from the arctic islands belong to a smaller variety collected long ago by Thomas Drummond and distributed by him under the name Splachnum heterophyllum, spec. nov. as No. 37 of his Musci Americani. The type specimen came from the Rocky Mountains, Alberta (Bird 1967). I have seen isotype material at the New York Botanical Garden, and most of the specimens of S. vasculosum from the Canadian Arctic are identical with S. heterophyllum (Brassard 1967a). Splachnum heterophyllum is, I believe, merely a variety of S. vasculosum and I am here making the proper combination. The main differences between the two varieties are:

var. vasculosum	var. heterophyllum
seta long, usually greater than 1 cm;	seta very short, rarely exceeding 1 cm;
hypophysis inflated and much wider than the urn of the capsule;	hypophysis weakly inflated and usually less than twice the width of the urn;
leaves rounded or emarginate.	leaves almost always bluntly pointed.

On northern Ellesmere Splachnum vasculosum var. heterophyllum has only been collected at the more favourable localities, where it is not uncommon. It is generally found on muskox dung (Fig. 14), but several specimens are from enriched soil where the plants grew singly. The species grows from sea level to at least 500 m altitude.

Mielichhoferia elongata Hornsch.

TF (3217).

This species was previously known only from Great Britain and continental Europe (Nyholm 1958). Although my specimen lacks sporophytes it compares perfectly with European specimens in the National Herbarium of Canada, and my identification has been verified by Mrs. E. Nyholm. The Tanquary plants grew on a moist clayey north-facing slope at about 400 m (Brassard 1969).

Species of Mielichhoferia have long been considered "copper mosses", and a complete review of this assumption was recently published by Shacklette (1967) who states,

> "The tendencies of species in the genus Mielichhoferia to be regularly associated with greater than average amounts of heavy metals in their substrates should lead one to consider all occurrences of these plants as possible locations of useful deposits of minerals."

The substrate on which M. elongata was growing at Tanquary Fiord was analysed for heavy metals at the Geochemical Census Branch, U. S. Geological Survey, Denver. Semiquantitative spectrographic analyses were carried out on the upper 14 mm of the moss polster (consisting of living and dead moss plants and organic soil), and on the inorganic soil beneath the moss polster (from 14 to 30 mm deep). The inorganic soil beneath the polster (lab. no. D133744) contained much greater than average amounts of copper (70 ppm), boron (700 ppm), and lead (50 ppm); average amounts of these three elements in soils are, respectively, 20, 10, and 10 ppm (Hawkes and Webb 1962). The high amounts of copper and lead in my sample may be significant in the occurrence of the Mielichhoferia. Another copper moss, M. macrocarpa (Brassard 1967a), occurs only a few kilometers from the site where I later found M. elongata, and I strongly suspect that both copper mosses are associated with the same deposit, although the rock on which M. macrocarpa grew was not analysed for heavy metals. Analysis of the upper 14 mm of the M. elongata polster indicate that the moss is concentrating several elements including barium, lanthanum, lead, nickel, strontium and zinc (lab. no. D412933).

Mielichhoferia macrocarpa (Drumm.) Jaeg. & Sauerb.

TF (1535).

Apparently this is also restricted to Tanquary Fiord, where the plants were abundant (although sterile) in pure mats on the underside of a very wet limestone ledge at 300 m.

Mielichhoferia mielichhoferi (Hook.) Loeske

AL (Steere 1959), DB (4187).

Only reported from the above two relatively close localities on the north and northeast coasts of Ellesmere Island. The Doidge Bay specimen was collected only a few centimeters from veins of the copper ore chalcopyrite

($CuFeS_2$) at the base of a disintegrating rock slope, a habitat strikingly similar to that of the specimen cited by Steere (1959). This species is separated from M. elongata by its leaf shape and areolation (Coker 1968) and also by its bluish-green colour and more lax growth habit.

Pohlia annotina (Hedw.) Lindb.

TF (3302b, with gemmae), DB (4190, with gemmae).

These two specimens, along with another from southern Ellesmere (collected by W. Blake) are the first from Ellesmere Island, where the species is very restricted. The Tanquary specimen came from the highlands (600 m), from silty areas on a rock slope, while the Doidge Bay plants grew very close to sea level (2 m) in deep cracks on a disintegrating rock slope. The specimens are possibly P. grandiflora Lindb. but I am not convinced that the latter is a valid species.

Pohlia cruda (Hedw.) Lindb.

VH (2870*), TF (1689, 1922, 1926), LH (Savile 4475!, 4634!, 4758!), AL (Steere 1959), WH (4287, 4302, 4340, 4345*, 4388), TI (4133b), AF (4166).

Pohlia cruda grows at most northern Ellesmere Island localities. It rarely produces sporophytes and usually grows sparsely among other mosses on soil or gravel in sheltered places, on solifluction slopes, and in well-vegetated sites from the lowlands to about 1,000 m.

[Pohlia drummondii (C.Müll.) Andr.]

FC (Peary 16, published as P. commutata var. filum in Bryhn (1908)).

The specimen, which I have seen, is sterile and cannot be reliably identified to species.

[Pohlia gracilis (B.S.G.) Lindb.]

LH? (Savile 4758).

I have not been able to find P. gracilis in Savile's specimen 4758. I am excluding the species from the northern Ellesmere moss flora, but it may occur on northern Ellesmere since it is known from the High Arctic (I have seen a specimen from Ellef Ringnes Island, Savile 4177!).

Pohlia nutans (Hedw.) Lindb. (incl. P. rutilans (Schimp.) Lindb. = P. schimperi Kindb.)

VH (2752b*), TF (1743*, 3228a*, 3303b*, all three dioicous), LH (Savile 4553), AL (Steere 1959).

This predominantly southern species does reach northern Ellesmere but is not really common there. It generally sporulates and grows among dense moss cushions and in more poorly vegetated sites from sea level to about 600 m.

Pohlia proligera (Limpr.) H.Arnell

TF (3318a, with gemmae).

This is the first report of Pohlia proligera from Ellesmere Island. The plants grew on near-vertical clay banks at 600 m. The typically vermicular bulbils were very abundant in my specimen.

Pohlia wahlenbergii (Web. & Mohr) Andr.

GG (Powell s.n.!), AL (Steere 1959).

I have only seen some plants which had previously escaped detection in a specimen collected by Powell. The species is apparently quite rare on northern Ellesmere, and restricted to high altitudes (1,000 to 1,400 m).

Leptobryum pyriforme (Hedw.) Wils.

VII (2842*), TF (1315a*, 1342*, 1479*, 1645*, 1685*, 1779*, 1843a*, 1854a*, 1953a*, 1976*, 1977*, 3171*, 3327*), LH (1382*, Harington 511*!, Powell 1967), FC (4268a*), AL (4477a), AF (4143a).

Leptobryum pyriforme is extremely variable in abundance at individual localities on northern Ellesmere. At Tanquary Fiord it is among the most abundant and fertile mosses in the lowlands (below 200 m), but at most other localities it seems to be rather rare. Only scanty sterile material was found along the north coast. Leptobryum grows in a wide variety of habitats but is best developed on dung, on silty or sandy plains, and on humus. It occurs from sea level (storm beaches) to 200 m.

Bryum angustirete Kindb. ex Mac.

TF (1529*, 1735a*, 1836c*, 1891*, 1978*, 3168b*, 3264*), LH (Richards 67-12*!, 67-38*!), GG (Powell 1967), FC? (Peary 4a, 4b), AL (Feilden s.n.), WH (4298*, 4408*), JL (4063*),

This is among the common Brya on northern Ellesmere where it grows commonly on dung in or near wet meadows and on seepage slopes. It occurs from sea level to about 700 m. The specimens from Fort Conger are too poor for critical determination.

Bryum arcticum (R.Br.) B.S.G.

VH (2853b*), TF (1768*, 1865*), FC (Mitten 1878), AL (Steere 1959), WH (4288*, 4417*).

Rather localized on northern Ellesmere, this species grows in depressions on gravel slopes, in well-vegetated tundra, and calcareous barrens from sea level to 1,000 m.

Bryum argenteum Hedw.

VH (sight record), TF (1390, 1494, 1586, 4004), FC (4261), AL (4456, 4471, Steere 1959), WH (4339), TI (4114), AF (4167), YB (4234).

This cosmopolitan weedy moss is very widely distributed on northern Ellesmere, but not often abundant at individual stations. Its most common habitats are bird perches, clay or silt near rock outcrops, marine shorelines, and it was especially abundant around the ruins at the Fort Conger site. Bryum argenteum is the moss species that grows nearest to salt water (just at the high-tide line) and it grows to 550 m. All the specimens are sterile but at Fort Conger and Alert plants have abundant bulbils in the axils of the upper leaves. Such a method of vegetative reproduction for B. argenteum also occurs in Antarctica. These propagula, and the rather specialized habitats of Bryum argenteum probably account for its wide distribution on northern Ellesmere; birds could easily transport the species to new localities. Man has undoubtedly also contributed to its spread, even in sparsely inhabited northern Ellesmere Island; at Tanquary Fiord B. argenteum is found primarily around paleo-Eskimo ruins.

Bryum bimum Schreb. ex Brid. [= B. pseudotriquetrum (Hedw.) Gaertn., Meyer & Scherb. sensu Crum et al. (1965)]

TF (1624*, 1786*), FC (4269*, Bryhn 1908, as B. pseudotriquetrum), WB (Bryhn 1908, as B. pseudotriquetrum), WH (4315a*, 4425*).

Apparently rather localized on northern Ellesmere, this species grows on clay or gravel from sea level to about

50 m. All my specimens are synoicous, and I have followed Nyholm's interpretation for this group (Nyholm 1958).

[Bryum caespiticium Hedw.]

LH? (mentioned in Savile 1964).

I have examined all of Savile's Lake Hazen collections and have not found Bryum caespiticium among them.

Bryum calophyllum R.Br.

VH (2865*), TF (1406a*, 1591*, 1690*, 1774*, 1780*, 1871*), FC (Bryhn 1908, Mitten 1878), LB (Bryhn 1908), AL (Mitten 1878, Steere 1959).

Bryum calophyllum is a very distinct species in a very difficult genus. The species is relatively widespread on northern Ellesmere, but rare or absent from the north coast. It most often grows in wet clayey areas rich in mosses or in wet meadows, and has thus far only been collected below 100 m. One of my Tanquary specimens is very anomalous; it is very close to B. calophyllum yet differs considerably from it. This anomalous collection (no. 1871) has yellow-green, rounded-pyriform capsules without a neck, flat opercula, and very large spores (36-47 μ, mean 40 μ). Bryum calophyllum typically has reddish, ovate capsules with a distinct neck, conical opercula, and smaller spores (25-35 μ). Although these differences appear significant I prefer to merely document them here, and not to propose any taxonomic rank. If further material similar to the above anomalous specimen is found a new taxon might then be considered to accommodate them.

Bryum capillare Hedw.

AL (Steere 1959).

The above is the sole report from northern Ellesmere and I reluctantly accept it, not having seen the single specimen, which was collected on moss-tundra below hanging snowbanks.

Bryum cryophilum Mårt. [= B. obtusifolium Lindb.]

VH (2687), TF (1533, 1774, 1903, 3073, 3207), LH (Savile 4634!), FC? (Peary 15, published as B. cyclophyllum in Bryhn (1908)), LB (Bryhn 1908), AL (Steere 1959).

This species is undoubtedly more common on northern Ellesmere than the above records indicate. It grows from sea level to at least 600 m and is almost always found in small creeks, where it forms large turgid blood-red cushions (Fig. 10). It apparently does not produce sporophytes at these latitudes. Peary's specimen from Fort Conger (no. 15) is too poor for critical determination.

Bryum knowltonii Barnes

TF (1917*), FC (Powell 1967), WH (4290*, 4331*), AF (4148*).

Evidently very restricted on northern Ellesmere, as it appears to be in the entire Canadian Arctic (Brassard 1967a), the species grows in sandy or gravelly places or on moist clay, and occurs to 250 m altitude.

Bryum neodamense Itzigs.

TF (1854), LH (Richards 67-18!, 67-45!, 68-1!, 68-47!).

Again I have followed Nyholm's interpretation of this species rather than that of Crum et al. (1965). Bryum neodamense is quite characteristic of wet habitats (e.g. very wet pond margins), and occurs to 600 m at Tanquary. It has so far only been found sterile.

Bryum nitidulum Lindb.

TF (1406b*, 1431*, 1781*), LH (Powell 1967), WB (Bryhn 1908), AF (4176*).

Restricted to the above four localities, this species grows in the lowlands in moist places with other mosses. The Ayles Fiord specimen fits perfectly the description of Bryum nodosum Bryhn & Ryan (Bryhn 1906), and critical examination of the type might reveal that a good species is at hand. Unfortunately, the plethora of new Bryum species described by Bryhn and Ryan have caused much confusion to arctic bryologists, and only a thorough revision of the Simmons collections can solve the many problems.

<u>Bryum purpurascens</u> (R.Br.) B.S.G.

FC (Bryhn 1908, as <u>B. pearyanum</u> Bryhn), WB (Bryhn 1908, as <u>B. pearyanum</u>).

I have not seen the specimens in question but follow the view of Andrews (1940) that <u>B. pearyanum</u> is synonymous with <u>B. purpurascens</u>, which is not uncommon in the Arctic.

<u>Bryum stenotrichum</u> C.Müll.

VH (<u>4632b</u>*), TF (<u>1474</u>*, <u>1680</u>*, <u>1684</u>*, <u>1855</u>*), LH (Powell 1967), GG (Powell 1967), FC (<u>4268</u>*), AL (Steere 1959), DB (<u>4198</u>*), WH (<u>4418</u>*), YB (<u>4223</u>*).

This appears to be one of the more common <u>Brya</u> on northern Ellesmere, where it has been collected from sea level to about 1,000 m, mainly on fine substrata or on gravel, but also on animal dung.

<u>Bryum</u> - <u>Excluded species</u>

The following <u>Bryum</u> species were long ago reported from northern Ellesmere, often as sterile specimens, but have not been collected in the area since, and I am therefore provisionally excluding them from this list.

<u>B. brownii</u> B.S.G. (Mitten 1878)

<u>B. crispulum</u> Hampe (Bryhn 1908)

<u>B. cyclophyllum</u> (Schwaegr.) B.S.G. (Bryhn 1908) is probably <u>B. cryophilum</u>

<u>B. pallens</u> Sw. (Bryhn 1908)

<u>B. rutilans</u> Brid. (Mitten 1878)

<u>B. teres</u> Lindb. (Bryhn 1908, Savile 1964) from sterile and unidentifiable specimens

<u>B. ventricosum</u> Dicks. (Bryhn 1908)

Mnium affine Bland. ex Funck (incl. M. rugicum Laur.)

TF (1687, 3135), GG (Powell 1967), AL (Steere 1959).

The Mnium affine-rugicum-medium group is one of the taxonomically most troublesome groups in arctic mosses. The group as a whole is rather uncommon on northern Ellesmere and throughout the High Arctic, and specimens are unfortunately usually sterile. I have included all synoicous specimens under M. medium and the remainder under M. affine. All the specimens of both species have perfectly entire leaves. Mnium affine seems to grow mainly in wet marshes.

Mnium blyttii B.S.G.

TF (1604b, 1688, 1697), LH (Richards 67-23!, 68-34!), AL (Steere 1959).

Evidently localized on northern Ellesmere and rarely abundant, at Tanquary it is found in rock cracks and between Cassiope hummocks on slopes up to 200 m.

Mnium marginatum (With.) P.Beauv.

VH (2795a, 2840), TF (2535, 3111), AL (Steere 1959).

Quite rare, even at the localities where it occurs, I have found it in rocky cracks on stable slopes from sea level to about 500 m; M. marginatum is quite distinct from M. orthorrhynchum on northern Ellesmere Island.

Mnium medium B.S.G.

VH (2882), TF (3088), WH (4297a).

Apparently not common, although the first two of the above specimens contained abundant material. It grows near pond margins and on rocky slopes and also on solifluction slopes. At Ward Hunt Island it grew near sea level but at Van Hauen and Tanquary Fiord it was only found at altitudes above 500 m. The above specimens (all synoicous) indicate that my earlier assumption regarding the commonness of Mnium medium in the High Arctic (Brassard 1967a, 1967b) was not unwarranted.

Mnium orthorrhynchum Brid.

TF (1367, 1701, 1880, 3185a, 3257, 3313b), LH (Richards 68-38!), AL (4457, Steere 1959), CM (4210), WH (4292, 4383, 4444, Serson s.n.!), JL (4080), TI (4109), AF (4169), YB (4229).

Mnium orthorrhynchum is the most common species in the genus on northern Ellesmere, and can be expected at all localities. It grows from sea level to at least 600 m in a wide variety of habitats: stable rock slopes, wet depressions on vegetated slopes, on gravel ridges with Saxifraga oppositifolia, and on clay or silt seepage slopes with Dryas integrifolia or Salix arctica.

Cyrtomnium hymenophylloides (Hüb.) Nyholm [= Mnium hymenophylloides Hüb.]

VH (2829a), TF (1703, 3231), LH (Longton 1920!), AL (Steere 1959), DB (4201), WH (4291, 4390, Lenton s.n.!), JL (4046, Christie 1!), TI (4118a), AF (4159), YB (4230).

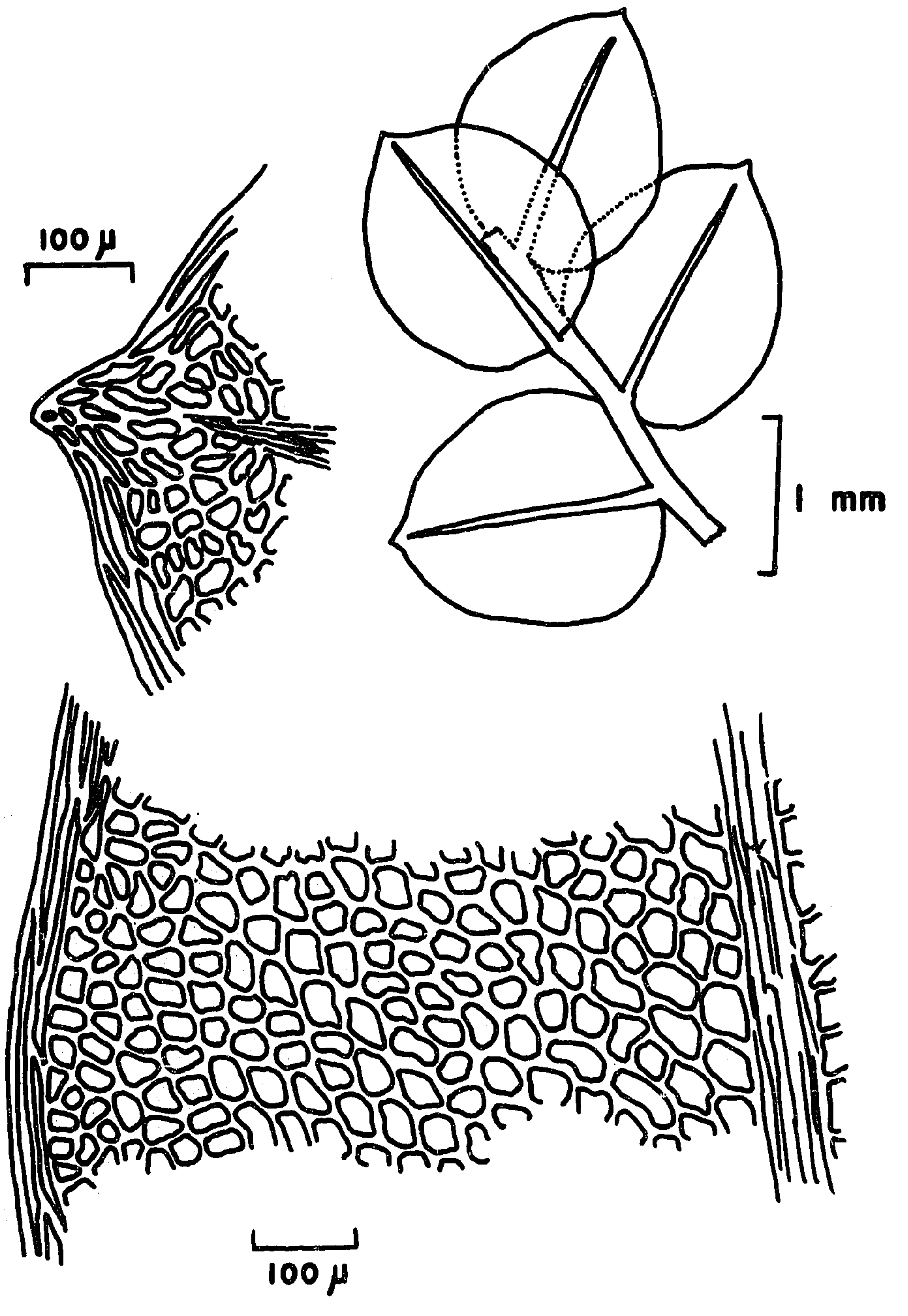
This species is quite widespread in the northern Ellesmere area and can safely be expected at most localities. It is generally found in cracks among rocks, in cushions dominated by other mosses, and on mossy seepage slopes, but it is rarely abundant. It grows from sea level to about 500 m. Most specimens are distinctly bifarious (Fig. 22) but some do not have the leaves in two ranks and thus approach in general appearance the following species, a situation previously noted in northern Greenland (Holmen 1960).

Cyrtomnium hymenophyllum (B.S.G.) Holmen [= Mnium hymenophyllum B.S.G.]

VH (2885), TF (1528c, 3313), LH (Longton 1924!, Richards 67-35!, 67-41!, 68-32!, 68-34!), FC (Bryhn 1908), AL (Steere 1959).

Much less common than the preceding this is more often abundant where it occurs. At Tanquary, Van Hauen, and Lake Hazen it is primarily found above 500 m but descends to sea level at Alert. In contrast to C. hymenophylloides this species has not yet been collected on the extreme north coast. Cyrtomnium hymenophyllum grows mainly on

Figure 22 . _Cyrtomnium hymenophylloides_, specimen from Tanquary Fiord (_Brassard_ _1703_). Shown are the arrangement of the leaves and the cellular detail of the leaf tip, margin, and lamina.



CYRTOMNIUM HYMENOPHYLLOIDES GRB 1703

G.R.B.

stable rock slopes rich in mosses, but also grows on moist or wet soil.

Cinclidium arcticum Schimp.

OF (Harington 503!), VH (2839, 2844, 2883), TF (1528b, 3093, 3129, 3269), LH (Harington 513!, Richards 68-18!, 68-21!, 68-23!, 68-40!), FC (Peary 3b!), LB (Wolf s.n.!), AL (Harington 180!, Steere 1959), GI (4106), WH (4393, 4439, Christie 6!, Lenton s.n.!), JL (4027).

Cinclidium arcticum is common on northern Ellesmere Island, and locally abundant. It grows most vigorously on mossy slopes, where it grows with numerous other mosses (e.g. Cyrtomnium hymenophyllum, Ditrichum flexicaule, Mnium affine, Philonotis fontana). It also grows in wet meadows, on rocks slopes, and in seepage areas below late-lying snowbanks; it is less abundant on hummock slopes. The species is extremely polymorphic on northern Ellesmere, but dioicous and therefore usually easily separated from Cinclidium subrotundum or C. stygium. Cinclidium latifolium is so distinct that it can hardly be confused with C. arcticum. Some Ellesmere specimens (e.g. my 3269) resemble C. polare (Kindb.) Bryhn, which I consider only a reduced arctic form. The Ward Hunt specimen collected by Lenton was published as C. stygium (Powell 1967) and Peary's specimen from Fort Conger as C. subrotundum (Bryhn 1908).

Cinclidium latifolium Lindb.

VH (2704), TF (3196), LH (Savile 4552!), AL (Steere 1959).

Cinclidium latifolium is certainly not widespread on northern Ellesmere, but plants are abundant at the individual sites where the species occurs. It grows in very wet meadows and near pond margins, not infrequently on dung with Haplodon wormskjoldii. Cinclidium latifolium occurs near sea level at Van Hauen Pass but only above 500 m altitude at Tanquary Fiord.

[Cinclidium stygium Sw.]

GG? (Powell 1967).

The Ward Hunt Island specimen which Powell (1967) cited as C. stygium is C. arcticum; I have not seen the Gilman Glacier plants but strongly doubt that they are Cinclidium stygium.

[Cinclidium subrotundum Lindb.]

FC (Peary 3b).

I have examined Peary's specimens (Bryhn 1908) at the New York Botanical Garden and they are C. arcticum. Although provisionally excluded, Cinclidium subrotundum is quite likely to occur on northern Ellesmere since I have seen typical plants from nearby Fosheim Peninsula (Holmen 1953).

Aulacomnium acuminatum (Lindb. & H.Arnell) Paris

VH (2651, 2752a, 2990), TF (1528, 1823a, 3071, 3100, 3123, 3159, 3271), AL (Steere 1959), WH (Hattersley-Smith s.n.!).

Already found or to be expected in all major regions of northern Ellesmere Island but surprisingly variable in abundance at individual localities. At Van Hauen and Tanquary it is common and very abundant, but it has not been collected at Lake Hazen despite careful searches for it. At Alert, only one specimen was cited (Steere 1959) and only one other specimen is known from the remainder of the north coast. *Aulacomnium acuminatum* is almost always associated with *Cassiope tetragona* on hummocky slopes or in wet heaths. It is also regularly associated with *A. turgidum* or *Hylocomium splendens* and occasionally with *Aulacomnium palustre*. Its altitudinal range is quite wide, from near sea level to almost 1,000 m. Fig. 23 shows the typical habit and colour.

Aulacomnium palustre (Hedw.) Schwaegr.

VH (2752, with propagula), LH (Richards 67-7!, Powell s.n.!), FC (Peary 16!), AL (Steere 1959).

Much less common than the preceding, this is easily distinguished from it, even when lacking propagula, by its bright green colour (*A. acuminatum* is almost always golden green), slender stem tips (*A. acuminatum* has larger swollen or julaceous stem tips), and leaves crisped when dry (*A. acuminatum* does not change on drying). The habitats of the two

Figure 23. Aulacomnium acuminatum. Habit and colour of specimen from Van Hauen Pass (Brassard 2651).

species are similar, and Aulacomnium palustre has also been collected from near sea level to about 800 m.

Aulacomnium turgidum (Wahlenb.) Schwaegr.

VH (2656), TF (1698, 1823b, 3060*, 3165), LH (Powell s.n.!, Richards 68-7!), GG (Powell M18A!), FC (Bryhn 1908), LB (Wolf s.n.!), AL (Steere 1959), WH (4344, 4395).

A. turgidum is the most widespread species of the genus on northern Ellesmere Island, and generally abundant where it occurs. It is found with Dryas integrifolia or Cassiope tetragona on hummocky or rocky slopes, and also on wet seepage slopes, and has been collected from sea level to about 1,000 m. It is rarely found with sporophytes in arctic latitudes, and the fruiting plants from Tanquary Fiord were quite unexpected.

Meesia trifaria Crum, Steere & Anderson

VH (2703), TF (1735b, 1833c, 3089), LH (Richards 67-19!, 67-42!, 68-40!, 68-46!), GG (Powell M4!), FC (Peary s.n.!), AL (Harington 180a!).

Not yet collected on the extreme north coast of Ellesmere but not uncommon in the north-central parts of the island, this is usually rare at individual stations. It grows in very wet meadows from near sea level to 700 m.

Meesia uliginosa Hedw.

VH (2769*, 2845*), TF (1713*), LH (Longton 1880*!, Richards 68-1!, 68-28!, 68-29!, 68-39!), GG (Powell M4*!).

Meesia uliginosa is apparently restricted to the four most favourable localities on northern Ellesmere, and is nowhere abundant although almost always sporulating. It grows in a wide variety of habitats: on Dryas or Cassiope hummocks, in mossy cracks, and near pond margins. It is not infrequently associated with Meesia trifaria. M. uliginosa grows from the lowlands to about 700 m altitude.

Catoscopium nigritum (Hedw.) Brid.

OF (Harington 504!), TF (3242), LH (Richards 67-3!, 68-34!, 68-39!), AL (Steere 1959).

This is very restricted on northern Ellesmere and not abundant at any locality. No fruiting specimens have been reported and sterile specimens might possibly be confused with sterile Ceratodon purpureus. Its habitat is mossy tundra or pond margins and Catoscopium has only been found in the lowlands.

Plagiopus oederiana (Sw.) Limpr.

VH (2581*), TF (3321*).

Plagiopus is quite rare even at the two localities where it occurs. Both specimens are from hummocky areas, in the lowlands at Van Hauen but at about 600 m at Tanquary Fiord.

Bartramia ithyphylla Brid.

VH (2779, 2856*), TF (3308, 3324*), LH (Savile 4758!), GG (Powell M17!, M20!), AL (Steere 1959), WH (4357).

Common on northern Ellesmere this is rare at individual localities. It grows primarily on moist slopes from near sea level to about 1,000 m; at Tanquary Bartramia ithyphylla is restricted to altitudes greater than 500 m.

Conostomum tetragonum (Hedw.) Lindb.

TF (Longton s.n.!).

This is only known from the highlands southeast of Tanquary Camp and among the rarest mosses there.

Philonotis fontana (Hedw.) Brid. var. pumila Brid.

VH (2884), TF (1505, 1717, 1807a, 1884, 1885*, 2531, 3120*, 3143), LH (Richards 67-23!, 68-45!, Savile 4402!, 4475!, 4758!), GG (Powell M1!), FC (Peary 2!, 10!), AL (Mitten 1878, Steere 1959), GI (4107a), WH (4010, 4356, Christie 6!), JL (Christie 1!, Hattersley-Smith 9!), AF (4142a, 4161).

One of the most widespread mosses on northern Ellesmere, Philonotis fontana can be expected at all localities. I have assigned all the material to var. pumila (= P. tomentella Mol.) although some sterile specimens can only be identified ...

as P. fontana sensu latu. All the material which I have seen with fruit or with antheridial heads is clearly var. pumila, and var. fontana is certainly rare, if present at all on northern Ellesmere. Philonotis fontana grows in a wide range of habitats, on well-vegetated seepage slopes, on stable rock slopes (where it often co-dominates the vegetation), on clay or silt near small creeks, and on hummocky slopes. I have collected it from sea level to 600 m, but the species grows to altitudes up to 1,000 m at Alert.

Timmia austriaca Hedw.

VH (2884a), TF (1369, 1704, 3051, 3112, 3252, 3288), LH (Richards 67-23!, 67-26!, 68-21!, 68-38!, Savile 4402!, 4758!), GG (Powell M1!, M8!), FC (Bryhn 1908, Mitten 1878), AL (4451, Davis 48!, Harington 136!, 175!, Mitten 1878, Steere 1959), DB (4196), GI (4104), WH (4009, 4283, Hattersley-Smith 8!, 17!, Kingston s.n.!), JL (4038, 4062, 4088, Christie 1!, Hattersley-Smith 9!), TI (4134), AF (4154), YB (4216, 4245).

Undoubtedly present everywhere on northern Ellesmere and locally abundant. It grows in several habitats: moist clay or silt, hummock slopes, stable rock slopes, gravel slopes with willow or saxifrages, bird perches and rock outcrops. It grows equally well at all altitudes, from sea level to about 1,000 m. There are two common growth habits:

plants from moist places are more elongated and have leaves which do not or hardly overlap while plants from dry situations are stunted and compressed, with strongly overlapping leaves.

Timmia bavarica Hessl. [= T. megapolitana Hedw. var. bavarica (Hessl.) Brid.]

VH (2771*), TF (1313*, 1334*, 1447*, 1462, 1531, 1602*, 1634*, 1674*, 1879*, 1881*, 1883*, 1934*, 3053*, 3109*, 3173*, 3182*, 3266*), LH (Longton 1914*!).

This species is extremely abundant at Tanquary Fiord but very rare at Van Hauen Pass and in the Lake Hazen area. At Tanquary it has been collected from most mesic habitats but it is especially common on stable rock slopes (Fig. 17) where it forms large cushions and dominates the vegetation along with other species such as Ditrichum flexicaule and Philonotis fontana. Timmia bavarica grows from near sea level to at least 600 m. Since most specimens have sporophytes they are quite unmistakable, with long appendiculate cilia on the inner peristome (Fig. 24), autoicous inflorescences, and small (6-10 μ) upper leaf cells.

Timmia norvegica Zett.

VH (2828), TF (1785, 1982b, 3050, 3241, 3254, 3292), LH (Longton 1910!, Richards 68-32!, 68-39!), GG (Powell M8!),

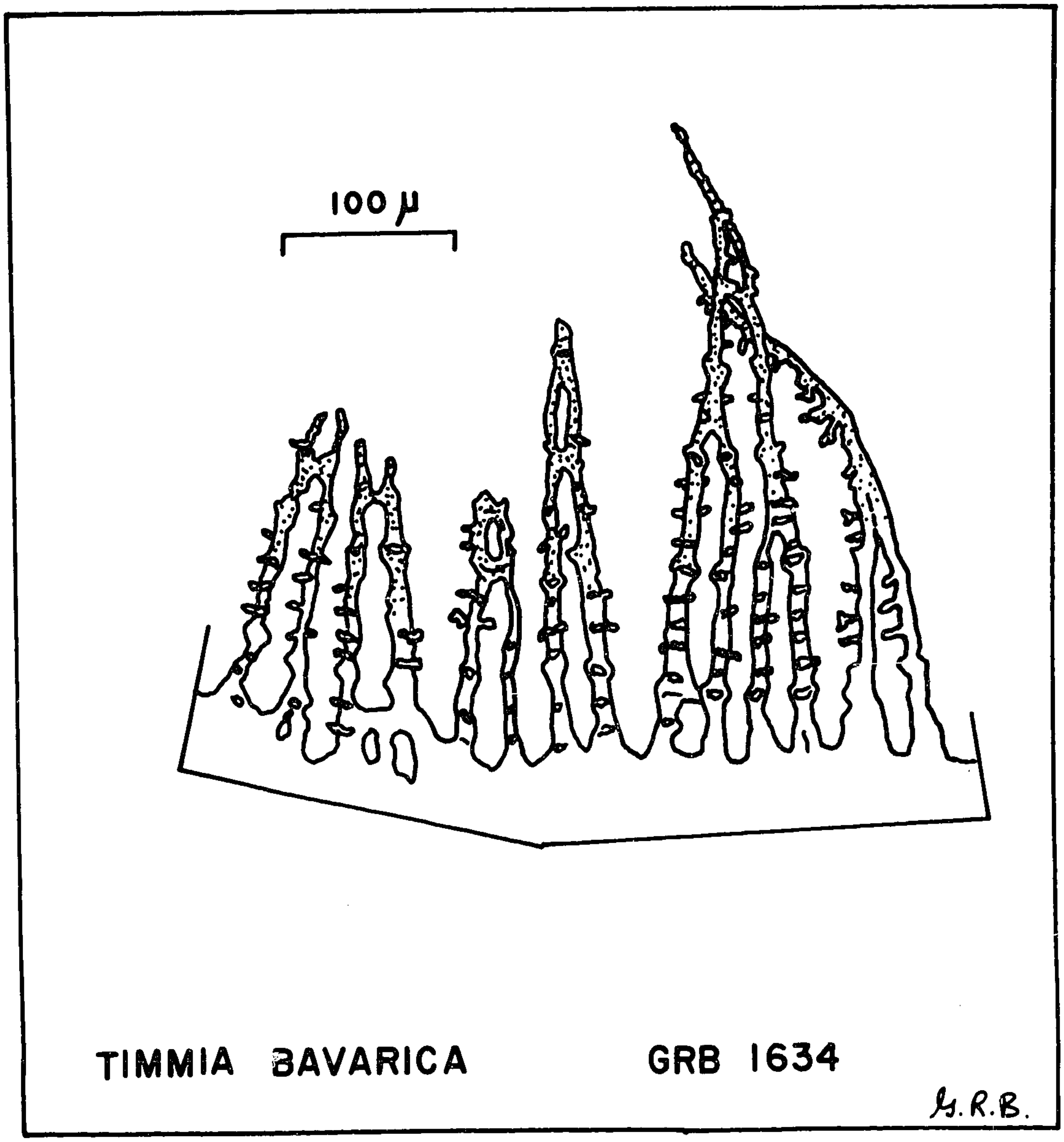


Figure 24. Timmia bavarica, specimen from Tanquary Fiord (Brassard 1634). Part of the inner peristome, showing the long, appendiculate cilia.

FC (Peary 10!), WB (Bryhn 1908), LB (Wolf 8!), AL (4460, Steere 1959), GI (4106b, 4108), WH (4005, 4336, 4410, Lenton s.n.!, Walker s.n.!), AF (4142), YB (4237).

This species is quite widespread in the northern Ellesmere area, and occasionally abundant where it occurs. It seems to prefer clay or silt substrata with some but not excessive moisture, but also grows well on gravel or on hummock slopes. I have collected it from sea level to at least 900 m. I have examined the specimens cited by Bryhn (1908) and they are *Timmia norvegica*, not some other species as suspected by Steere (1948).

Orthotrichum speciosum Nees *ex* Sturm (incl. *O. killiasii* C.Müll.)

VH (2768*), TF (1347*, 1360*, 1524*, 1818*, 3054*, 3154*, 3261*, 3280*), LH (Powell s.n.*!), AL (4473*, Steere 1959), GI (4090), WH (4323*, 4371*, 4432*), JL (4055), TI (4132*), YB (4232*, 4252*).

The genus *Orthotrichum*, of which this species is the only northern Ellesmere representative, is quite widespread in the area and can be expected at all localities. It grows primarily on dry rocky slopes, in *Dryas* heaths, and around bird perches, and is almost always richly sporulating. It is equally common at all altitudes to about 1,000 m in the Alert area. I agree fully with Crum et al. (1965) who do not consider O. killiasii worthy of taxonomic recognition. In several of the above specimens one could find plants ranging from O. speciosum s.str. to O. killiasii.

Myurella julacea (Schwaegr.) B.S.G.

OF (Hattersley-Smith s.n.!), VH (2712, 2834), TF (1778b, 1885b, 1921, 3074, 3220, 3290), LH (Richards 67-35!, 67-41!, Savile 4475!, 4758!), GG (Powell M1A!, M17!), WB (Wolf s.n.!), AL (4466, Steere 1959), DB (4200), GI (4107), WH (4298, 4320, 4357a, 4380, Walker s.n.!), JL (4031, 4069, Hattersley-Smith 9!), TI (4120), AF (4158), YB (4213, 4244a).

M. julacea is one of the most widespread mosses on northern Ellesmere Island. It is normally found on slopes in small moist depressions or cracks, but also grows intermingled with numerous other mosses in moss cushions. The species is rarely abundant. Myurella julacea has been collected from sea level to at least 900 m altitude.

var. scabrifolia Lindb. ex Limpr.

TF (CDH-1a).

The above specimen is so typical of var. scabrifolia (with large papillae and extremely spinose-dentate leaf margins) that it cannot be anything else despite the tremendous range extension involved. The variety has not been reported from any area of the Canadian Arctic. The plants were growing at the base of Cassiope hummocks at 50 m.

Myurella tenerrima (Brid.) Lindb.

VH (2727a), TF (1372, 1514, 1530c, 1746a), LH (Richards 67-23!, 67-41!), GG (Powell M1!), WB (Bryhn 1908), AL (Harington 180!, Mitten 1878, Steere 1959), DB (4196a), WH (4293, 4357b, 4389, 4420), JL (4030a, Christie 2!, Hattersley-Smith 8!, 9!), AF (4156), YB (4215, 4250).

This species grows in similar habitats as M. julacea and is about as common on northern Ellesmere. Kuc (1969a) described a new variety, var. glabra Kuc, from Axel Heiberg Island, but I believe that it is probably only an environmental modification. Similarly modified plants also occur on northern Ellesmere.

Abietinella abietina (Hedw.) Fleisch.

VH (2871), TF (3140, 3195, 3312).

Apparently localized in two localities on northern Ellesmere, it has not been found at Lake Hazen despite careful searches for it (R. E. Longton, pers. comm.). At Van Hauen it is common and locally abundant in the lowlands, but at Tanquary it is more frequent in the higlands, to 500 m altitude. Its most common habitat is between cushions of Dryas integrifolia or Cassiope tetragona hummocks.

[Cratoneuron arcticum Steere]

AL (Steere 1959).

I have examined the type, and several other specimens from northern Ellesmere Island, and I am not convinced that this is a valid species, nor that it is Amblystegium varium. Most of the material can be assigned to Cratoneuron filicinum without much difficulty. The habitat difference may well account for the very different appearance and stunted nature of the arctic plants. In material which I have seen, at least the lower stem leaves are usually quite typical of C. filicinum.

Cratoneuron filicinum (Hedw.) Spruce

VH (2827a), TF (1448, 1780a, 2529a), LH (Richards 67-13!, 67-14!, 67-17!, 67-42!, 67-44!, 68-4!, 68-9!, 68-18!), LB (Wolf 15!), AL (Steere 1959), WH (4359a).

Probably often overlooked, the plants usually occur sparsely among other mosses such as Campylium arcticum or Cirriphyllum cirrosum. Most of the above collections came from moist or wet habitats. The species grows from near sea level to about 350 m altitude.

Campylium arcticum (Williams) Broth.

VH (2742, 2827), TF (1770, 1856, 1899, 1968, 1982*, 2526, 3083, 3145), LH (Longton 1957a!, Richards 67-1!, 67-4!, 67-5!, 67-6!, 67-16!, 67-24!, 67-30!, 67-38!, 68-3!, 68-4!, 68-5!, 68-42!, 68-47!), GG? (Powell 1967), FC (4266, Bryhn 1908(?)), AL? (Steere 1959).

The above specimens, and others which I have seen, establish Campylium arcticum as one of the locally abundant mosses on northern Ellesmere, although not yet known from the extreme north coast. It is probably the only Campylium on northern Ellesmere. All previous reports of C. stellatum (Hedw.) C.Jens. from the Canadian Arctic should be checked since many are probably C. arcticum, a heretofore neglected arctic species. Campylium arcticum prefers wet places, where it is often abundant or even dominating the vegetation. I have found it growing in storm lagoons periodically inundated by salt water and in wet meadows to heights of 500 m. The sporulating specimen from Tanquary Fiord was most unexpected, since extremely few species in the large boreal-arctic moss family Amblystegiaceae produce fruit at these high latitudes.

Platydictya jungermannioides (Brid.) Crum

VH (2727), TF (1882b, 1933, 1937), FC (Peary 10!), AL (Steere 1959), DB (4178), WH (4246, 4421), JL (4064a).

This is undoubtedly more common in the area than the above records would indicate. It grows mostly in sheltered cracks, but also occurs sparsely among other mosses in moist places. I have collected it from sea level to 600 m.

Drepanocladus aduncus (Hedw.) Warnst.

VH (2742a, 2848a), TF (1341, 1851, 3316), LH (Richards 67-15!, 67-19!, 67-21!, 67-39!, 67-45!, 68-1!, 68-18!), GG (Powell M23!, published as D. vernicosus in Powell 1967), FC (Peary 3c!, published as D. polycarpus in Bryhn 1908).

Drepanocladus aduncus is apparently not widely distributed at the high latitudes of northern Ellesmere, and found only in the lowlands. It is usually abundant where it occurs, in wet meadows or moist depressions.

Drepanocladus badius (C.J. Hartm.) Roth

LH (Richards 67-19!), AL (Steere 1959).

This is obviously very localized. The Hazen specimen is atypical, and I have not seen the Alert material.

Drepanocladus brevifolius (Lindb.) Warnst.

VH (2697, 2773, 2843), LH (Oliver s.n.!, Richards 67-20!, 67-27!, 67-34!, 67-35!, 67-39!, 68-19!, 68-20!, 68-23!), FC (Peary 3!), LB (Wolf s.n.!), AL (Steere 1959), WH (4305, 4334, 4375).

Rather common and abundant where it occurs D. brevifolius is notably absent from several localities (e.g. from Tanquary Fiord where I have not found the species despite extensive searches for it). At Lake Hazen and Ward Hunt Island it is more common and abundant than any other species of *Drepanocladus*.

Drepanocladus exannulatus (B.S.G.) Warnst.

TF (2522, 3081, 3147).

Quite rare, this only occurs near the shore of Tanquary Fiord (in storm lagoons and near the mouths of small creeks).

Drepanocladus fluitans (Hedw.) Warnst.

FC (Bryhn 1908), AL (Steere 1959).

I have been unable to examine either of the above collections but see no reason to exclude them. The species is undoubtedly exceedingly rare on northern Ellesmere.

Drepanocladus lycopodioides (Brid.) Warnst.

FC (Mitten 1878), AL (Steere 1959).

Likewise I have seen no Ellesmere Island material of this species but include it provisionally even though some confusion exists between *D. brevifolius* and *D. lycopodioides* (Steere 1959).

Drepanocladus revolvens (Sw.) Warnst.

VH (2630, 2696, 2701, 2826), TF (1735c, 1832, 3068a, 3179, 3191), LH (Oliver s.n.!, Richards 67-2!, 67-18!, 67-22!, 67-26!,67-31!, 67-36!, 68-11!, 68-24!, 67-47!), GG (Powell 1967), FC (Peary 3!), AL (Steere 1959), WH (Lenton s.n.!), JL (4030), AF (4160).

One of the most common and abundant species of *Drepanocladus*, this occurs at most, and probably all, northern Ellesmere localities. It often dominates wet "muskox meadows" and also invades other habitats where it grows intermingled among other species. I have collected it from near sea level to 400 m. Many of the above plants can be referred to var. *intermedius* (C.J.Hartm.) Rich. & Wallace, but I do not believe that the differences warrant assigning more than varietal status, if that, to the latter form.

Drepanocladus uncinatus (Hedw.) Warnst.

VH (2824b), TF (1357a, 1606*, 2533, 3116, 3139, 3161, 3272), LH (Richards 68-7!), GG (Powell M1!), FC (Bryhn 1908, Mitten 1878), LB (Wolf s.n.!), AL (4472, Steere 1959), WH (4413, 4448), JL (4985), TI (4111), AF (4151).

Widely distributed in the area this is only locally abundant. Its habitat is quite different from that of other *Drepanocladus* species, i.e. stable rocky slopes, hummocky tundra, and bird perches, all much drier habitats. It occurs from sea level to 800 m and is predominantly sterile, although one capsule was found on a plant from Tanquary.

Drepanocladus vernicosus (C.Hartm.) Warnst.

TF (1451, 1522, 1655, 1663, 1771, 3084), LH (1376, Richards 68-17!, Powell 1967), FC (Peary 6!, published as D. exannulatus var. polaris in Bryhn 1908).

At Tanquary D. vernicosus is one of the most common species of Drepanocladus. It grows mainly in very wet meadows and ponds, but occasionally also in mesic habitats. The species is apparently more or less restricted to the north-central parts of Ellesmere, and occurs from sea level to about 500 m. A specimen reported from Gilman Glacier (Powell 1967) is D. aduncus.

[Hygrohypnum alpestre (Hedw.) Loeske]

AL? (Steere 1959).

This is not a typical arctic species and as I have not been able to check the specimen in question I exclude it from this list of northern Ellesmere mosses. It may belong to the very polymorphic H. luridum.

[Hygrohypnum eumontanum Crum, Steere & Anderson]

AL? (Steere 1959, as H. montanum (Wils.) Broth.).

For similar reasons I provisionally exclude this species from the northern Ellesmere moss flora.

Hygrohypnum luridum (Hedw.) Jenn.

TF (1513, 1614, 3126, 3176), WH (4437).

The genus Hygrohypnum is among the rarest on northern Ellesmere, but this species seems to be the most common. It grows in very wet seepage channels or on wet rocky slopes from sea level to 250 m. H. luridum is very polymorphic in the High Arctic.

Hygrohypnum polare (Lindb.) Loeske

TF (1536), AL (Steere 1959), WH (4352).

This species probably occurs in all major regions of northern Ellesmere Island, but is undoubtedly very rare at all localities. It grows on rocks in streams and on very wet clayey tundra from 50 to 300 m. Hygrohypnum polare has also been collected on Ice Island T-3 (which is presumed to have broken away from the ice shelf north of Ellesmere Island) and was still living when collected, at 85°41' N (Polunin 1958).

Calliergon giganteum (Schimp.) Kindb.

VH (2714, 2818), TF (1340, 1525, 1897, 1900, 1950, 3090, 3124, 3178), LH (Longton 1951!, Richards 67-5!, 67-7!, 67-44!, 68-5!, 68-11!, 68-40!, 68-46!, Savile 4554!, 4592!), FC (Peary 3a!), LB (Wolf s.n.!), AL (Steere 1959).

Common and usually very abundant in the north-central part of Ellesmere Island but apparently rare or absent from the extreme north coast. The species is by far the most common Calliergon in the area. It grows in standing water at the edges of small ponds and along small streams (Fig. 25), and I have collected it from sea level to over 500 m. C. giganteum is very distinct from C. richardsonii (Mitt.) Warnst., which has not yet been collected on northern Ellesmere Island.

Calliergon sarmentosum (Wahlenb.) Kindb.

FC (Bryhn 1908).

Although this old report has yet to be confirmed I accept it since C. sarmentosum has recently been reported from Fosheim Peninsula (Holmen 1953) and Peary Land (Holmen 1960), two areas adjacent to northern Ellesmere. I have seen the Fosheim Peninsula specimen and another from Ellef Ringnes Island (Savile 4250). As Calliergon sarmentosum occurs in several areas surrounding northern Ellesmere it almost certainly must occur there also, although it cannot be very common.

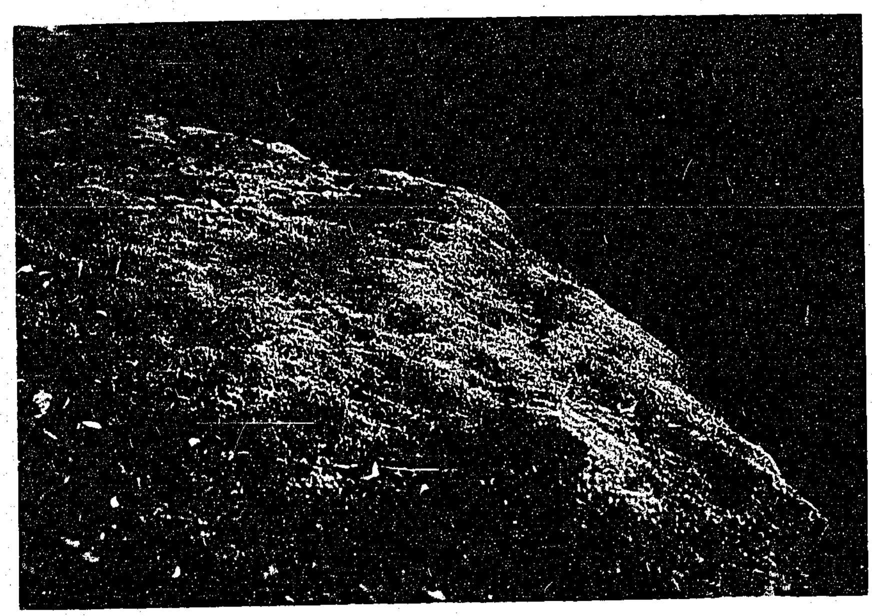
Calliergon stramineum (Brid.) Kindb.

TF (3069), FC (Bryhn 1908), AL (Steere 1959).

Apparently very rare and localized even at the places where it occurs. I have seen only the Tanquary specimen, which I collected in a wet sedge meadow at 700 m altitude. At Alert it grew near lowland ponds (Steere 1959).

Figure 25 . *Calliergon giganteum* (Brassard 1950). Note the large turgid cushions near this small rivulet in a wet meadow. Tanquary Fiord. 17 August 1964. The cushion on the left is about 20 cm wide.

Figure 26 . *Brachythecium groenlandicum* (Brassard 1952). The plants are forming a strand along the shore of a small lake near Tanquary Fiord. 18 August 1964. The width of the strand is about 1 m.



Scorpidium scorpioides (Hedw.) Limpr.

TF (3181), LH (Powell M24!).

Apparently restricted to the highlands of north-central Ellesmere Island, this grows in deep standing water. Both the above specimens are from altitudes of 400 to 500 m.

Scorpidium turgescens (T. Jens.) Loeske

VH (2850), TF (1772, 1872b, 3082, 3134, 3180, 3222, 3238, 3246), LH (Richards 67-13!, 67-15!, 67-34!, 67-44!, 68-33!), AL (Steere 1959), WH (4335), AF (4147).

Relatively common on northern Ellesmere, this is rarely very abundant and grows mostly in very wet places (wet sedge meadows, in streams, at edges of ponds) from sea level (storm beach lagoons) to at least 500 m.

Tomenthypnum nitens (Hedw.) Loeske

VH (2839a), TF (1491, 1605, 1711, 1816, 2536, 3118, 3140a, 3162), LH (Richards 67-3!, 67-23!, 67-28!, 67-40!, 67-47!, 68-9!, 68-28!, 68-30!, 68-36!, Savile 4553!, 4634!, Powell s.n.!), GG (Powell M23A!), AL (Mitten 1878, Steere 1959), WH (4402, 4406, 4436), JL (4074), TI (4110), AF (4153), YB (4214, 4249).

Very widely distributed on northern Ellesmere, and often abundant, this grows mainly in moist depressions on rock or gravel slopes from sea level to at least 700 m. Almost all the northern Ellesmere plants are non-tomentose but the typical tomentose form is encountered occasionally.

<u>Brachythecium-Cirriphyllum</u>

Arctic specimens belonging to these two genera have caused much confusion, and have been assigned to a number of different species by various bryologists. The major problems are that all arctic material is sterile, the two genera can closely resemble each other, and reliably determined arctic specimens are very rare. Bryhn (1907) assigned most of the material from the "Fram" expedition to east and south Ellesmere to <u>Brachythecium salebrosum</u> and stated (translated),

> "Very common everywhere in all kinds of places, especially in marshes. It was collected in pure tufts, partly in admixtures with other mosses. The typical form is rare; the species here appears most often as one of the varieties mentioned below or also as intermediate forms to one or the other varieties."

Bryhn then listed the varieties: var. <u>arcticum</u> Berggr. "The most common form, which was found almost everywhere," var. <u>binervulum</u> Bryhn, var. nov., and var. <u>turgidum</u> Hartm. But what is most puzzling is Bryhn's comment under <u>Cirriphyllum cirrosum</u> (as <u>Eurhynchium cirrosum</u>), "...brought back from only a single station...where the plants grew sparsely among other mosses." This can hardly be correct since <u>Cirriphyllum cirrosum</u> is among the most common and abundant mosses on Ellesmere Island and in other parts of the Canadian High Arctic. I strongly suspect that the specimens Bryhn determined as *Brachythecium salebrosum* are in large part *Cirriphyllum cirrosum*, as was shown in part by Kuc (1969). The latter is much more common on northern Ellesmere than any *Brachythecium* species. However, the two are not always easily separated (especially in the Arctic) and *Cirriphyllum cirrosum* is among the most polymorphic mosses on northern Ellesmere Island.

Well-developed *Cirriphyllum cirrosum* is easily identified by the julaceous stems, very concave leaves which are abruptly narrowed to a long acumen; the two *Brachythecia* which occur on northern Ellesmere usually have very plicate leaves and a much more gradually narrowed acumen. The two *Brachythecium* species can be separated as follows:

B. groenlandicum:

Costa weak and narrow even at the base, hardly reaching the leaf middle; costa 40-50 μ wide at base. Alar cells more or less hyaline-inflated and usually reaching the costa. Leaves less distinctly toothed.

B. turgidum:

Costa strong and wide, usually reaching 3/4 the length of the leaf; costa 65-80 μ wide at leaf base. Alar cells more or less hyaline, but in a small group not reaching the costa. Leaves usually distinctly toothed, especially at the tips.

Brachythecium groenlandicum (C.Jens.) Schljak.

VH (2711), TF (1952), FC?(Bryhn 1908).

Apparently quite rare, at Tanquary the species was growing along a wide strand at the shore of a small lake at 60 m (Fig. 26). The Van Hauen specimen came from a wet place near a small stream.

Brachythecium turgidum (C.J.Hartm.) Kindb.

LH (Richards 67-3!, 67-13!, 67-25!, 68-35!, 68-36!, 68-42!, 68-45!), AL (Harington 131!).

Like the preceding, this species is also very localized in the northern Ellesmere region.

Cirriphyllum cirrosum (Schultes) Grout

VH (2814), TF (1319, 1426, 1662, 2525, 2534, 3125, 3143a, 3150, 3256), LH (Longton 1957!, Richards 67-37!, 67-46!, 68-28!), FC (Peary 3a!, Mitten 1878), AL (4465, Steere 1959), WH (4359, 4399, 4443), AF (4151a).

Quite common at all altitudes to at least 1,000 m, this is abundant in wet clay or silt in wet meadows or near running water but it also invades drier habitats such as hummock slopes.

Eurhynchium pulchellum (Hedw.) Jenn.

VH (2795), WH (4025), JL (4050, 4065), AF (4170).

More common on the north coast than elsewhere on northern Ellesmere, Eurhynchium pulchellum grows sparsely on soil and in sheltered cracks to about 100 m. The plants from Van Hauen belong to the complanate form (f. depressum).

Orthothecium chryseum (Schultes) B.S.G.

OF (Harington 503!), VH (2839a, Longton 1577a!), TF (1501, 1659, 1776, 1833, 1894, 3114, 3144, 3221, 3240, 3277), LH (Harington 517!, Richards 67-8!, 67-24!, 67-29!, 67-41!, 67-43!, 68-10!, 68-21!, 68-26!,68-29!, 68-44!, Savile 4553!, 4634!, 4758!, Powell 1967), GG (Powell M1!, M8!, M17!), FC (Peary 2!, 3a!, 4!, 9c!, 10!), WB (Wolf 8!), AL (4461, Feilden s.n.!, Steere 1959), GI (4105), WH (4333, Hattersley-Smith 5!, Lenton s.n.!), JL (Christie 1!, 2!, 6!), TI (4118), AF (4144), YB (4225, 4248).

Among the most ubiquitous mosses on northern Ellesmere Island, Orthothecium chryseum occurs in almost all localities and at almost all altitudes. Large luxuriant forms grow in clay or silt beside small creeks and on seepage or solifluction slopes but the species also grows in drier or less favourable habitats and it is a frequent component of bryophytic vegetation on hummock slopes. It is quite polymorphic, and some shade-forms lack the golden-red pigmentation. Some plants resemble slightly O. rufescens (Brid.) B.S.G. but I do not believe that the latter occurs on northern Ellesmere.

Orthothecium strictum Lor.

OF (Harington 503!), TF (3200, 3219, 3236), LH (Richards 68-15!), FC (Bryhn 1908, Mitten 1878), WB (Wolf s.n.!), LB (Bryhn 1908), AL (Steere 1959), WH (4351, 4391, Christie 12!, Lenton s.n.!, Serson s.n.!).

Much less widespread and never as abundant as O. chryseum, this is not uncommon and probably under-collected; it seems best developed on seepage slopes where it grows in tight cushions, often with Philonotis fontana. On northern Ellesmere Orthothecium strictum has not been collected above 200 m altitude.

Hypnum bambergeri Schimp.

VH (2772), TF (3184a, 3235a, 3286), LH (Richards 67-5!, 67-44!, 68-6!), FC? (Bryhn 1908, see comment in Steere 1948), LB (Wolf s.n.!), AL (4454, Steere 1959), CM (4207), DB (4193), WH (4358, 4374, 4400, 4419, 4434, 4438), JL (4034, 4043), TI (4110a, 4121, 4126a), AF (4149), YB (4227, 4246).

Noticeably more widespread in the coastal areas of northern Ellesmere than in the Tanquary-Hazen area, on the north coast this is the second most common and abundant Hypnum (after H. revolutum). H. bambergeri is generally associated with vascular plants, especially Dryas integrifolia, and grows in a wide variety of habitats, e.g. seepage or solifluction slopes, gravel or rock slopes, hummock slopes, or mossy tundra. Near Tanquary Camp I have only found it from 500 to 900 m altitude, but the species grows in the lowlands on the northwest shore of Tanquary Fiord and at all the north coast localities.

Hypnum callichroum Brid.

AL (Steere 1959).

Hypnum callichroum is quite localized on northern Ellesmere and in the entire Canadian High Arctic.

Hypnum cupressiforme Hedw.

TF (1333, 1495, 1498, 1691b, 1804), LH (Powell 1967), AL (Steere 1959).

Seemingly abundant where it occurs, this species is very localized. At Tanquary it grows mainly on rocky slopes from 50 to 250 m, but H. cupressiforme grows at an altitude of at least 700 m at Alert. K. Holmen has verified my identifications of this species.

Hypnum hamulosum B.S.G.

FC (Bryhn 1908).

I have been unable to verify this old report, but include it provisionally although I suspect that it may be H. subimponens, which can be very similar to this species. Steere (1948) accepted Bryhn's report, and H. hamulosum was also reported from Fosheim Peninsula, just south of northern Ellesmere (Holmen 1953).

Hypnum procerrimum Mol.

VH (2642, 2837, 2991), TF (1829b, 3141), AL (4453).

This is one of the rarer Hypna on northern Ellesmere, although quite common and abundant at Van Hauen Pass. At Tanquary the species reaches 350 m. H. procerrimum grows on unstable soil (usually calcareous) and in hummocky places where it is associated with other Hypna.

Hypnum revolutum (Mitt.) Lindb.

VH (2837b), TF (1356, 1363, 1705, 1829a, 2539, 3055, 3110, 3291), LH (Savile 4402!, 4475!), HL (4255), FC 4270, Hart s.n.!), WB (Bryhn 1908), AL (4452, Harington 85!, Mitten 1878, Steere 1959), CM (4209), DB (4180), GI (4097), WH (4017, 4282, 4373, 4382, 4411, 4426), JL (4059, 4073, 4077), TI (4111a, 4127, 4137c), AF (4167a), YB (4217, 4231, 4239, 4241, 4252a).

Hypnum revolutum is among the most widespread plant species on northern Ellesmere Island, and will most cer - ainly be found at all localities there. It grows at all altitudes (to 900 m at Tanquary) in many habitats but especially on dry rock or gravel slopes and around bird perches, where, with Tortula ruralis, it dominates the vegetation.

Hypnum subimponens Lesq.

TF (3060a).

Very rare, and previously unknown from Ellesmere Island, H. subimponens was growing among Aulacomnium turgidum on a stable rock slope at 600 m altitude. Determined by K. Holmen.

Hypnum vaucheri Lesq.

VH (2833a), TF (1691a , 1803, 1827, 3151, 4003), LH (4272, Richards 67-42!), GG (Powell s.n.!), LB (Wolf 12!), AL (Steere 1959), WH (4361), YB (4220).

This is widespread on northern Ellesmere, but everywhere sparse. Hypnum vaucheri occurs from sea level to 1,050 m, on moist to dry slopes of gravel or silt.

Isopterygium pulchellum (Hedw.) Jaeg. & Sauerb.

VH (sight record), TF (1925*, 1927), LH (Richards 67-1!, 67-12!, 68-47!), WB (Bryhn 1908), AL (Steere 1959), DB (4183), WH (4346a), TI (4137b), YB (4219).

Quite widespread on northern Ellesmere, where it probably grows at all localities and at almost all altitudes. Its habitat is fine soil in cracks or crevices on rocky or gravelly slopes. Where Isopterygium occurs it is generally sparse, and associated with other species of similar habitats, e.g. Fissidens arcticus, Myurella julacea, M. tenerrima, Platydictya jungermannioides. The specimen of

Isopterygium pulchellum from Tanquary Fiord with sporophytes was most unexpected since the species does not ordinarily produce fruit in arctic latitudes.

Hylocomium splendens (Hedw.) B.S.G. var. alaskanum (Lesq. & James) Limpr. [= H. alaskanum Lesq. & James]

VH (2750, 2778a, 2825), TF (3052, 3164, 3300, 3311), LH (Longton 1918!, 1929!, Richards 68-7!), AL (Steere 1959), WH (4327, 4409).

This is common at the localities where it has been collected (except at Ward Hunt where it is rare) and occurs from near sea level to at least 750 m. At Tanquary Fiord and Lake Hazen it is one of the mosses more or less restricted to the highlands whereas at Van Hauen Pass Hylocomium is more common in the lowlands, where it is often associated with Aulacomnium acuminatum in wet heaths. Hylocomium splendens var. alaskanum usually grows on hummocky flats or slopes with Dryas integrifolia or Cassiope tetragona. All the Ellesmere specimens belong to the arctic variety, which does not merit recognition as a separate species.

Psilopilum cavifolium (Wils.) I.Hag.

TF (1740*, 3212*, 3227, 3302*, 3318*), LH (Longton 1860*!).

Although Psilopilum cavifolium has only thus far been collected at two northern Ellesmere stations it probably occurs in several others. The species is characteristic of wet or moist silt or clay banks, clayey soil in wet heaths or meadows, and I have also collected it in a glacier foreland. It occurs from sea level to at least 600 m. *P. cavifolium* is almost always richly fruiting, and very distinct from the related *P. laevigatum* (Wahlenb.) Limpr. (Brassard 1967a, 1967b). The latter does not occur on northern Ellesmere.

Philocrya aspera C.Jens.

VH (Longton 1577!).

This first specimen from Ellesmere Island, and only the second from Canada, was found with *Cassiope tetragona* on a steep, north-facing rocky slope at 75 m altitude. It is probably truly rare but undoubtedly occurs in other parts of the Canadian Arctic.

Pogonatum alpinum (Hedw.) Röhl.

VH (2882a), TF (1358, 1364, 1699, 1736, 1746*, 1822, 1825, 3056*, 3068*, 3166, 3186, 3253, 3276, 3301*), LH (Richards 67-41!, 67-47!, 68-8!, 68-34!, Savile 4758!), GG (Powell M1!, M20*!), FC (Peary 13*!, 16!), LB (Wolf s.n.!), AL (4478, Harington 5!, 180!, Mitten 1878, Steere 1959), GI (4100), WH (4280, 4297, 4329, 4355, 4377, 4396, 4427, Christie 3!), JL (4081, Christie 1!), AF (4155), YB (4224).

Among the most widespread mosses on northern Ellesmere Island, Pogonatum alpinum can be expected to occur at all localities. It grows in many habitats but is best developed in wet meadows and on seepage or solifluction slopes where it is generally closely associated with numerous other mosses. It is found from sea level to 1,300 m. Longton (1969) observed that in many places on northern Ellesmere aborted capsules were present but that ripe mature capsules were infrequent. I find no valid reason to separate the arctic representatives of Pogonatum alpinum into varieties or forms, since intermediates between all forms are frequent, yet the species itself is remarkably distinct.

Pogonatum capillare (Michx.) Brid.

VH (2858), LH (Powell s.n.!), GG (Powell s.n.!), AL (Steere 1959), DB (4186), AF (4162a).

This is much rarer than P. alpinum, and does not produce sporophytes. My specimens were collected on rock talus or gravel slopes, associated with Polytrichum piliferum or, on finer substrates, with P. hyperboreum. Pogonatum capillare grows from the lowlands to 1,450 m altitude.

Polytrichum hyperboreum R.Br.

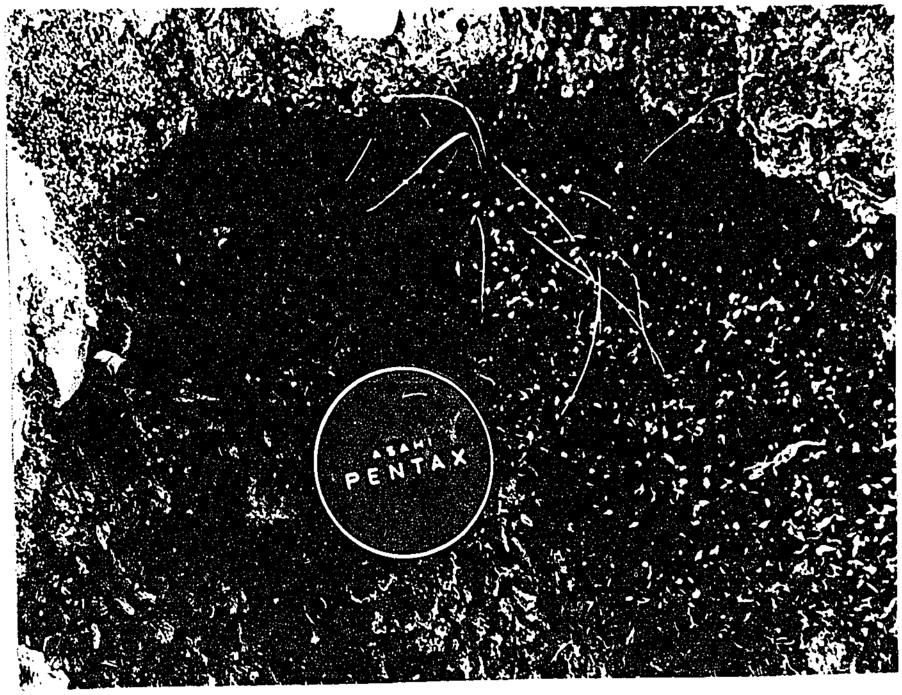
VH (2708*), TF (1515, 3199*, 3215*, 3226, 3303*), LH (4271, Longton 1913*!, Savile 4440*!, 4441!, 4826*!), GG (Powell M9!, M14*!), DB (4814), AF (4162).

In areas such as Tanquary Fiord and Lake Hazen (Savile 1964) Polytrichum hyperboreum is common and usually very conspicuous on clayey slopes. It is quite distinct from P. piliferum and fully merits recognition as a separate species. On northern Ellesmere Island, where both species occur, they differ in gross appearance, fertility, and habitat. Polytrichum hyperboreum is very robust and highly branched (Fig. 28), almost always richly sporulating (Figs. 27 , 28) and grows in wet clay or other fine substrata. Polytrichum piliferum, which is much rarer, is stunted, unbranched, sterile, and grows in gravelly places. The development of the awns also serves to differentiate the two species and this and the other differences mentioned above are very constant, with no intermediate specimens.

I have collected Polytrichum hyperboreum from sea level to 600 m. Figs. 27 and 28 show the typical habit of the species on northern Ellesmere, and Fig. 29 the unusual festoon-like habit of the Doidge Bay plants.

Figure 27. <u>Polytrichum hyperboreum</u> (<u>Brassard</u> <u>3215</u>) on a clay slope, Tanquary Fiord. Male plants are above the lens cap (which is 5 cm in diameter), and female plants (with sporophytes) are seen throughout the right half of the photograph. 5 August 1967.

Figure 28. <u>Polytrichum hyperboreum</u> (<u>Brassard</u> <u>3215</u>). Sporulating plants which show the typical branching pattern. The scale is in centimeters.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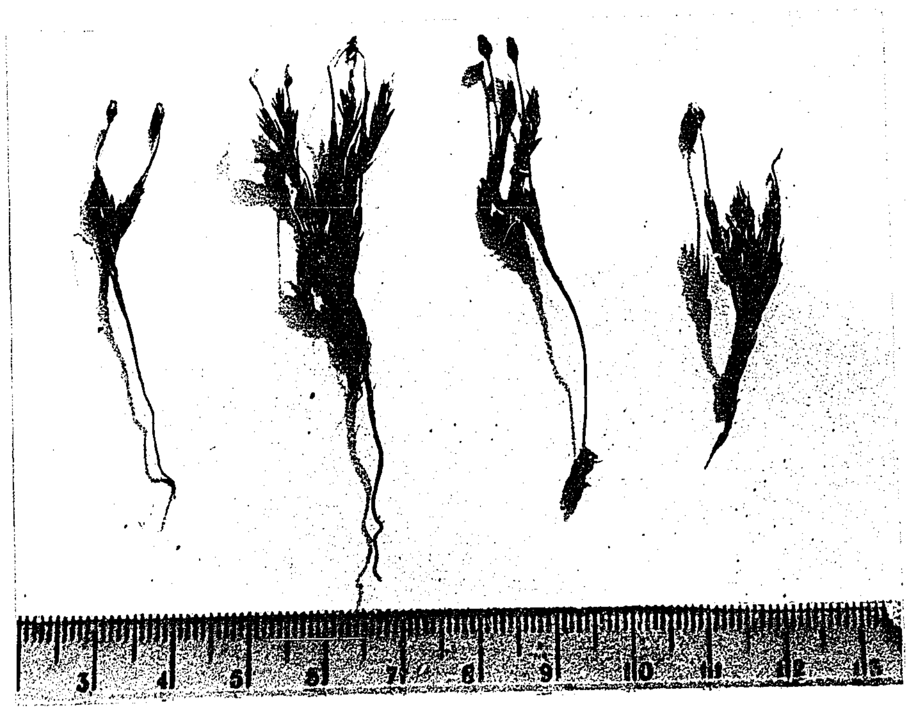


Figure 29. <u>Polytrichum hyperboreum</u> (<u>Brassard</u> <u>4184</u>).

A. Festoon-like habit of plants at base of rock cliff (the plants appear to be growing downward). Doidge Bay. 23 May 1969. The knife blade is 2.5 cm wide.

B. Close-up of the plants.

A

B

Polytrichum juniperinum Hedw.

VH (2657a), TF (3062a, 3304, 3323), LH (Longton 2090a!, Savile 4634!), GG (Powell M18A*!), AL (Wolf s.n.!, Steere 1959).

Polytrichum juniperinum is common but not abundant at any locality, and only one specimen was found with sporophytes. At Tanquary it occurs only above 400 m altitude, and it grows at 1,000 m at Alert. It occurs on stable, vegetated slopes.

Polytrichum piliferum Hedw.

VH (2857), TF (3305), LH (Powell 1967), AL (Steere 1959).

Among the rarest of the Polytrichaceae on northern Ellesmere Island, this is much rarer and always very distinct from P. hyperboreum (see my comments under that species). Powell's report from the Gilman Glacier area (Powell 1967) is based on a specimen of P. hyperboreum.

Summary

The foregoing list comprises 71 genera, 150 species and four varieties of Musci. This total, already high for such high latitudes, will likely increase, since several widely distributed arctic mosses have yet to be collected on northern Ellesmere Island. I included some of these in square brackets but one can also expect in this area mosses such as Blindia acuta, Calliergon trifarium, Encalypta affinis, Fissidens osmundioides, Polytrichum swartzii, Pterigoneurum arcticum, and Saelania glaucescens.

I confidently expect that future investigations on northern Ellesmere will raise its known moss flora to at least 160 species, and will, in addition, provide more material of rare species. Although we are highly indebted to non-bryologists who collect mosses, only a bryologist trained to recognize arctic mosses in the field can hope to obtain a representative moss collection from any area of the Canadian High Arctic.

CHAPTER 5

BRYOGEOGRAPHY

Bryogeography, the study of the geographical distribution patterns of mosses and the possible causes behind these patterns, has not been studied in Arctic Canada. Steere (1948) listed several aspects of bryogeography which especially needed study in Arctic Canada; these were:

1) establishing the precise distributions of mosses,

2) special study of the arctic element of mosses,

3) studies on the relative abundance of moss species at different altitudes and latitudes, and,

4) special studies on rare disjunct or relict mosses.

From studies of my own collections and those made by others in various regions of the Queen Elizabeth Islands I can now attempt a first analysis of bryogeography in the Canadian High Arctic in general, and in northern Ellesmere Island in particular.

My stüdies on northern Ellesmere Island mosses have dealt with all the aspects of bryogeography listed by Steere, and the bryogeography of that area, although still needing much study is certainly better investigated than in any other part of the Canadian Arctic.

For the Queen Elizabeth Islands as a whole our knowledge is less complete than for northern Ellesmere Island, and there are still substantial areas from which mosses are poorly known. Some of these have very recently been investigated but the results are not yet available. However, one can at least discern the distribution patterns of the mosses and see some of the relationships between the floras of different regions within the Queen Elizabeth Islands. More field studies are continually being carried out, and the next decade should certainly see a large addition to our knowledge of bryogeography in the Canadian High Arctic.

At these latitudes there are more species of mosses and lichens than species of vascular plants. Northern Ellesmere Island has 150 moss species and 143 vascular plant species (Brassard and Beschel 1968); Peary Land has 134 moss species (Holmen 1960, following his species concept) and only 106 vascular plants (Fredskild 1966). Judging in part from the work at Alert (Bruggemann and Calder 1953, Schuster et al. 1959) an individual locality in the High Arctic has roughly similar numbers of species of vascular plants, mosses, and lichens.

Thus a complete phytogeographical study of arctic regions should include data from the terrestrial cryptogams, since they outnumber vascular plant species at least two to one. I am presenting here distribution studies on mosses, which, when combined with similar studies on vascular plants, yield data that are vital to a complete understanding of the past history of the Canadian High Arctic.

Part 1. Bryogeography of northern Ellesmere Island.

Floristic comparisons of the moss floras of the regions and localities within northern Ellesmere Island

The total number of moss species known from each of the 19 localities and five regions of northern Ellesmere Island are listed in Table 1. The locality with the lowest number of moss species is Barbeau Peak, which, because of its extreme climate, can hardly support many more plant species. From Table 2 one sees that 12 of the 19 northern Ellesmere localities have fewer than 40 moss species; these 12 localities are largely poorly sampled. From my field studies I believe that very few localities (within walking distance of one camp) have fewer than 50 mosses, and that most have between 50 and 100 moss species. Few localities have more than 100 species: Tanquary Fiord and Alert. However, the moss floras of Van Hauen Pass and Lake Hazen will undoubtedly also surpass 100 species as more specimens are collected there.

Except for Region 5, the regions of northern Ellesmere Island have similar numbers of moss species. All five regions probably have more than 100 moss species, and Region 2 will undoubtedly be found to contain over 130 species.

Table 1 . The moss flora of northern Ellesmere Island localities and regions.

Locality	Number of species
Otto Fiord	7
Van Hauen Pass	89
Tanquary Fiord	117
Barbeau Peak	1
Lake Hazen	76
Gilman Glacier	43
Heintzelman Lake	5
Fort Conger	46
Wrangle Bay	16
Lincoln Bay	8
Alert	102
Clements Markham	11
Doidge Bay	21
Garlic Island	21
Ward Hunt Island	70
Jasper Lake	33
Taconite Inlet	30
Ayles Fiord	36
Yelverton Bay	25
Mean	40

Region	Number of species
West coast (1)	90
Central (2)	128
East coast (3)	112
North coast (4)	78
Northwest coast (5)	25
Mean	85

Table 2 . The number of localities and regions on northern Ellesmere Island from which multiples of 20 moss species are known.

Number of moss species	Number of localities	Number of regions
1-20	6	-
21-40	6	1
41-60	2	-
61-80	2	1
81-100	1	1
101-120	2	1
121-140	-	1

Similarity values (Jaccard's coefficient, Jaccard 1912) between the moss floras of the five regions of northern Ellesmere Island, and the formula used, are given in Table 3.

Because the northwest coast (Region 5) is very poorly studied its moss flora has low similarity values to all other regions. A constellation (Fig. 30) illustrates the similarities between the moss floras of the five regions, and readily shows that Regions 1 (west coast), 2 (central), and 3 (east coast) constitute a distinct group, with very similar moss floras. Region 4 (north coast) stands apart from Regions 1, 2 and 3, and its moss flora is more similar to that of Region 5.

More collecting in Regions 4 and 5 will undoubtedly raise the similarity values between those two regions on the one hand, and between those two regions and Regions 1 to 3 on the other. However, I would expect that the moss floras of the north and northwest coast will remain more similar to each other than to the moss floras of the west, central and east coasts.

Table 3. Similarity values between the moss floras of the regions of northern Ellesmere Island.

	Region 5	Region 4	Region 3	Region 2	Region 1
Region 1	38	70	72	79	--
Region 2	33	73	80	--	
Region 3	36	69	--		
Region 4	49	--			
Region 5	--				

$$\text{Similarity } (\underline{S}) = \frac{2\underline{w}}{\underline{a} + \underline{b}} \times 100, \text{ where}$$

$\underline{w}$ = the number of species in common between area A and area B

$\underline{a}$ = the number of species in area A

$\underline{b}$ = the number of species in area B

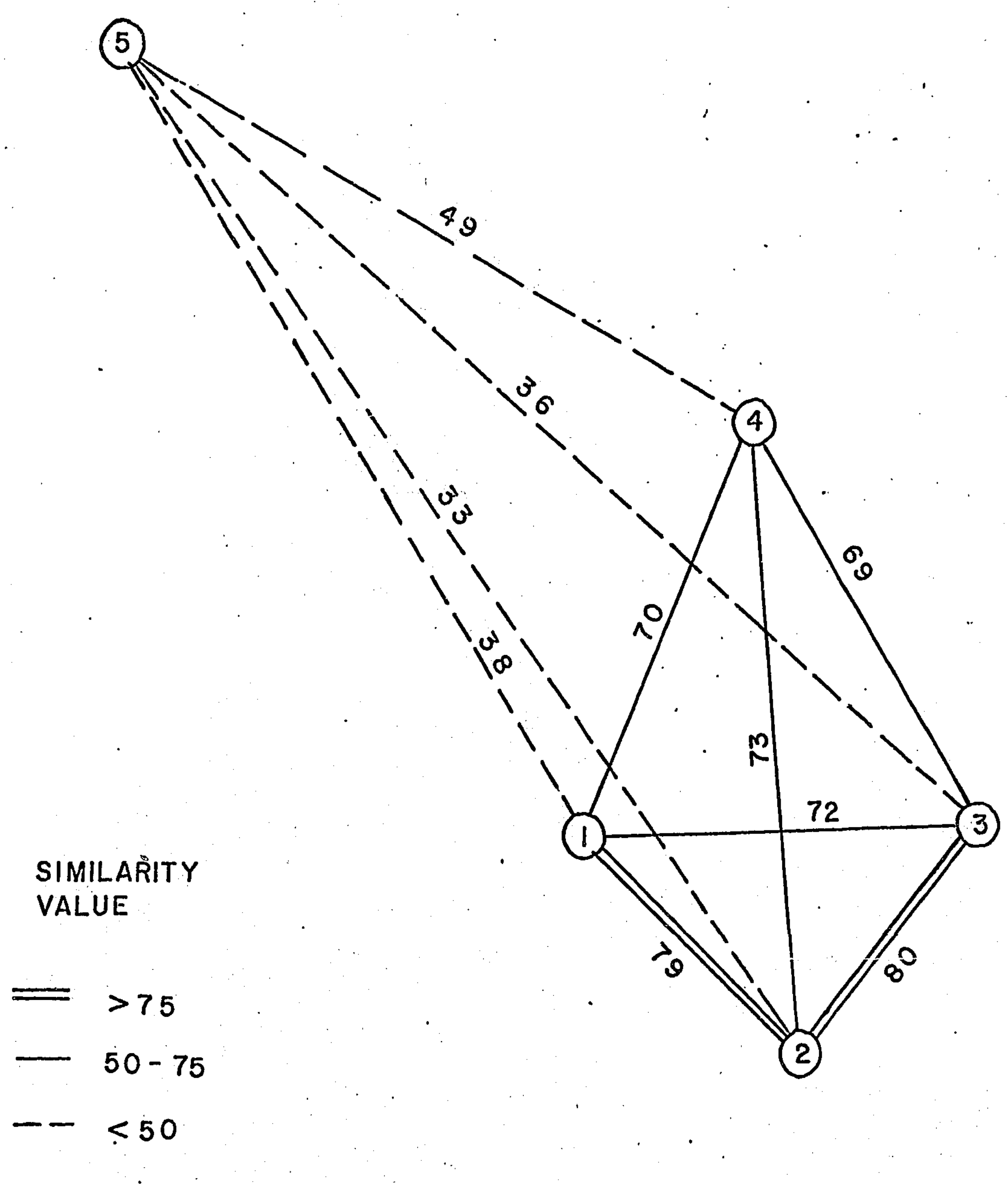


Figure 30 . Constellation showing the similarities between the moss floras of the five regions of northern Ellesmere Island (circled numbers). The greater the similarity the shorter the line joining two regions.

Distribution patterns of mosses within northern Ellesmere Island

The mosses of northern Ellesmere Island can be grouped into seven distinct distribution patterns (Table 4).

Table 4 . Distribution patterns of mosses within northern Ellesmere Island.

Distribution Pattern	Number of Species	Percent of Total
Widespread	31	20.7
Common	40	26.7
Rare:	(79)	(52.6)
North-central + north coast	35	23.3
North-central only	20	13.3
North coast only	14	9.3
High altitude only	10	6.7
Total	150	100.0

The criteria which I use to define the distribution patterns are based only on presence of species at individual northern Ellesmere localities. It should be noted that within each of the distribution patterns some species are abundant at every locality while others are rarely or never abundant where they occur.

Twenty percent of northern Ellesmere mosses are widespread:

Widespread (found in at least 4/5 regions and 9/19 localities):

Barbula icmadophila
Bryoerythrophyllum recurvirostrum
*Bryum argenteum
B. stenotrichum
Cinclidium arcticum
Cyrtomnium hymenophylloides
Desmatodon leucostomus
Distichium capillaceum
Ditrichum flexicaule
Drepanocladus revolvens
D. uncinatus
Encalypta alpina
E. rhaptocarpa
Fissidens arcticus
Hypnum bambergeri
Hypnum revolutum
H. vaucheri
Isopterygium pulchellum
Mnium orthorrhynchum
Myurella julacea
M. tenerrima
Orthothecium chryseum
Orthotrichum speciosum
Philonotis fontana
Pogonatum alpinum
Tetraplodon mnioides
Timmia austriaca
T. norvegica
Tomenthypnum nitens
Tortula muconifolia
T. ruralis

* found in 5 regions, 8 localities

The majority of these are abundant throughout most of the area. The most ubiquitous moss on northern Ellesmere Island is certainly Ditrichum flexicaule, but Hypnum revolutum and Tortula ruralis are almost as widespread and abundant. Although the above three species are the most frequent and abundant mosses none of them produces sporophytes at these high latitudes.

Mosses in this widespread element may have a wide or narrow habitat specificity. Thus Distichium capillaceum, Orthothecium chryseum, and Timmia austriaca occur in almost every habitat on northern Ellesmere, while Desmatodon leucostomus and Tortula mucronifolia grow only on clay or silt and Tetraplodon mnioides only on animal dung. Although widely distributed, Fissidens arcticus, and to a lesser extent Isopterygium pulchellum, are extremely rare at individual localities.

Over one quarter of northern Ellesmere mosses are common there but not really widespread:

Common (found in 3-4 regions, 5-8 localities):

Aloina brevirostris
Anoectangium tenuinerve
*Aulacomnium acuminatum
A. turgidum
Bartramia ithyphylla
Bryum angustirete
B. arcticum
B. calophyllum
B. cryophilum
Calliergon giganteum
Ceratodon purpureus
Cirriphyllum cirrosum
Cratoneuron filicinum
Cyrtomnium hymenophyllum
Dicranella crispa
Dicranum fuscescens
Drepanocladus aduncus
D. brevifolius
Funaria arctica
Grimmia anodon
Grimmia apocarpa
**Gymnostomum recurvirostrum
Haplodon wormskjoldii
Hylocomium splendens
Leptobryum pyriforme
Meesia trifaria
Orthothecium strictum
Platydictya jungermannioides
Pogonatum capillare
Pohlia cruda
Polytrichum hyperboreum
P. juniperinum
Pottia heimii
Rhacomitrium canescens
R. lanuginosum
Scorpidium turgescens
Stegonia latifolia
Tetraplodon paradoxus
Tortella fragilis
Voitia hyperborea

* found in 4 regions, 4 localities
** found in 2 regions, 6 localities

The mosses in this element also vary in abundance at individual localities, habitat specificity, and fertility. Most of the species appear to be very common and abundant at some localities and truly rare or absent at others. For instance, Leptobryum pyriforme, Polytrichum hyperboreum, and Pottia heimii are among the most abundant species at Tanquary Fiord and Lake Hazen, yet are uniformly rare and not at all abundant at most other localities.

Among the more habitat-specific mosses in this element are three species in the Splachnaceae (Haplodon wormskjoldii, Tetraplodon paradoxus, and Voitia hyperborea) and the strongly acidophilic Rhacomitrium lanuginosum. Mosses with a wide range of habitats include Cirriphyllum cirrosum, Pohlia cruda, and Tortella fragilis, although these usually prefer neutral to high pH. Aloina brevirostris is a good example of a strongly basiphilic moss belonging to this element.

The remaining 53% of northern Ellesmere mosses can be considered rare (all found in fewer than 4 regions and fewer than 5 localities). The rare mosses can be grouped into four categories, as listed below.

<u>Rare</u> (found in 2-3 regions, 2-4 localities), and occurring both in the north-central part (Regions 1, 2) and on the northern coastal part (Regions 3, 4, 5):

Amphidium lapponicum
Aulacomnium palustre
Brachythecium turgidum
Bryobrittonia pellucida
Bryum bimum
B. knowltonii
B. nitidulum
Calliergon stramineum
Campylium arcticum
Catoscopium nigritum
Cinclidium latifolium
Dicranoweisia crispula
Dicranum elongatum
Didymodon asperifolius
Distichium hagenii
D. inclinatum
Drepanocladus badius
Encalypta procera
E. vulgaris
Eurhynchium pulchellum
Grimmia alpicola
Hygrohypnum luridum
H. polare
Hypnum cupressiforme
H. procerrimum
Mnium affine
M. blyttii
M. marginatum
M. medium
Pohlia annotina
P. nutans
Polytrichum piliferum
Splachnum vasculosum
Tortella arctica
*Tortula norvegica

* found in 4 regions, 4 localities (some specimens atypical).

<u>Rare</u> (found in 1-2 regions, 1-4 localities), and restricted to the north-central part (Regions 1, 2):

Abietinella abietina
Brachythecium groenlandicum
Bryum neodamense
Desmatodon cernuus
Drepanocladus exannulatus
**D. vernicosus
Funaria polaris
Grimmia plagiopodia
Meesia uliginosa
Mielichhoferia elongata
Mielichhoferia macrocarpa
Oncophorus wahlenbergii
Philocrya aspera
Plagiopus oederiana
Psilopilum cavifolium
Scorpidium scorpioides
Seligeria polaris
S. pusilla
Tayloria acuminata
Timmia bavarica

** also found at Fort Conger (Region 3)

Rare (found in 1-2 regions, 1-4 localities) and restricted to the north coastal part (Regions 3, 4, 5):

Bryum capillare	Drepanocladus fluitans
B. purpurascens	D. lycopodioides
Calliergon sarmentosum	Fissidens viridulus
Dichodontium pellucidum	Grimmia alpestris
Dicranum acutifolium	Hypnum callichroum
D. majus	H. hamulosum
D. scoparium	Mielichhoferia mielichhoferi

Rare (found in 1-2 regions, 1-2 localities) and restricted to altitudes greater than 500 m:

Andreaea rupestris	Grimmia tenera
Arctoa andersonii	G. torquata
Conostomum tetragonum	Hypnum subimponens
Desmatodon latifolius	Pohlia proligera
Grimmia flaccida	P. wahlenbergii

The largest of the four rare floristic elements (23% of the total moss flora) includes species which, although rare, are found in both the north-central part and the north coastal part of northern Ellesmere Island. Some of these species are relatively abundant at one or more localities, e.g. Amphidium lapponicum, Campylium arcticum, Grimmia alpicola, Hypnum procerrimum, and Tortella arctica, but most are not abundant anywhere. Eurhynchium pulchellum has thus far been found only in Regions 1 and 4, a distribution which it shares with no other moss.

Several of the mosses in this element will, I am sure, have to be transferred to the common element as more collections are made on the north coast. Others appear to be truly rare and further collecting is unlikely to alter significantly their known distributions on northern Ellesmere; these include *Aulacomnium palustre*, *Bryobrittonia pellucida*, *Dicranoweisia crispula*, *Hygrohypnum luridum*, *H. polare*, *Polytrichum piliferum*, and *Tortula norvegica*.

Among the species known only from the north-central part of Ellesmere Island (Regions 1, 2) the following are abundant at one or more localities: *Abietinella abietina*, *Drepanocladus vernicosus*, *Oncophorus wahlenbergii*, *Psilopilum cavifolium*, and *Timmia bavarica*. At the other extreme are species known from only a single specimen, among them *Funaria polaris*, *Mielichhoferia elongata*, *M. macrocarpa*, *Philocrya aspera*, and *Seligeria pusilla*.

One factor which undoubtedly influences the composition of this floristic element is the very specific habitat requirements of some of the mosses: *Funaria polaris* grows only on lemming droppings, the *Mielichhoferia* species on high concentrations of heavy metals, *Scorpidium scorpioides* only in deep water, *Seligeria pusilla* only on limestone. The abundance and fertility of *Psilopilum cavifolium* at Tanquary Fiord and Lake Hazen and of *Timmia bavarica* at Tanquary Fiord are difficult to explain when one considers that those two mosses are almost totally absent from other localities on northern Ellesmere.

The 14 mosses known only from the north coastal part of Ellesmere Island are all very sparse and apparently not abundant anywhere. I have been unable to verify the northern Ellesmere occurrence of most of the mosses belonging to this element.

The ten mosses restricted to altitudes greater than 500 m are never abundant, but form a highly interesting group. Six of the ten species in this element are absent in Peary Land, most require a low pH, and one (Grimmia flaccida) in addition to being highly disjunct is the plant which reaches the highest altitude in eastern North America.

Fertility

Table 5 lists, for each order of Musci found on northern Ellesmere Island, the total number of moss species and the total number sporulating.

Sixty-three species (42% of the total moss flora) were found with sporophytes, a higher percentage fertility than in Peary Land, where only 31% of the mosses produce fruit (Holmen 1960). On northern Ellesmere fertility ranges from 41% (Eubryales) to 100% (Andreaeales, Funariales), with the exception of the order Hypnobryales (8%). The species in the Hypnobryales are mostly dioicous and although the order contributes 26% of the total moss flora only three of its 39 species produce fruit.

The over-all high percentage of fertile species is somewhat misleading, however, since only 42 of the 63 fertile moss species (or 28% of the total moss flora) produce sporophytes regularly.

A few mosses are regularly fertile in the north-central regions but always sterile on the outer north coast: <u>Bartramia ithyphylla</u>, <u>Haplodon wormskjoldii</u>, <u>Leptobryum pyriforme</u>, <u>Polytrichum hyperboreum</u>. Only three mosses have been found in fertile condition on the north coast but not in the north-central regions: <u>Amphidium lapponicum</u>, <u>Dicranella crispa</u>, <u>Fissidens arcticus</u>.

Table 5. Fertility of mosses on northern Ellesmere Island

ORDER	Number of species	Number of species with Sporophytes
Andreaeales (Andreaeaceae)	1	1 (100%)
Fissidentales (Fissidentaceae)	2	1 (50%)
Dicranales (Ditrichaceae to Dicranaceae)	18	10 (55%)
Pottiales (Encalyptaceae to Pottiaceae)	21	13 (62%)
Grimmiales (Grimmiaceae)	10	5 (50%)
Funariales (Funariaceae to Splachnaceae)	8	8 (100%)
Eubryales (Bryaceae to Orthotrichaceae)	44	18 (41%)
Hypnobryales (Theliaceae to Hylocomiaceae)	39	3 (8%)
Polytrichales (Polytrichaceae)	7	4 (57%)
Total for northern Ellesmere Island	150	63 (42%)
Total for Peary Land (north Greenland)	134	41 (31%)

Only a few mosses utilize specialized methods of vegetative reproduction on northern Ellesmere: Aulacomnium palustre (gemmae), Bryum argenteum (bulbils), Pohlia annotina (bulbils), P. proligera (bulbils). However, fragmentation, especially in winter when the leaf or shoot fragments can blow for considerable distances, is likely a common means of vegetative dispersal.

Comparisons between the moss floras of northern Ellesmere Island and Peary Land (North Greenland)

Since northern Ellesmere Island and Peary Land are very similar in geographical location (both are northernmost parts of much larger islands, and extend from 80° N to above 83° N), physiography, area (Peary Land has an area of about 80,000 km^2), and proximity (only 200 km separate the eastern part of northern Ellesmere Island from the western limit of Peary Land) one would assume that the moss floras of the two regions would be very similar.

The moss flora of Peary Land has also been well studied (Holmen 1955, 1960).

Comparisons between the species and genera of mosses in northern Ellesmere Island and in Peary Land are given in Table 6.

Table 6 . The numbers of species and genera of mosses on northern Ellesmere Island and in Peary Land.

	Species	Genera
Northern Ellesmere Island	150	71
Peary Land	133	70
Flora of the combined areas of northern Ellesmere Island and Peary Land	177	79
Taxa common to both areas	106	62
Taxa found in northern Ellesmere Island but not in Peary Land	44	9
Taxa found in Peary Land but not in northern Ellesmere Island	27	8

It is apparent that the moss floras of northern Ellesmere Island and Peary Land are more dissimilar than one would at first expect. Northern Ellesmere has 150 moss species, 29% of which are not found in Peary Land; the latter has 133 moss species, 20% of which are absent on northern Ellesmere. Of 71 genera on northern Ellesmere nine are not in Peary Land, and Peary Land has eight genera absent in northern Ellesmere.

The 44 mosses occurring in northern Ellesmere but not in Peary Land are listed below (asterisks indicate genera absent from Peary Land):

*Abietinella abietina
*Aloina brevirostris
*Andreaea rupestris
*Arctoa andersonii
Aulacomnium acuminatum
Bryum capillare
B. knowltonii
B. purpurascens
Calliergon stramineum
Cinclidium latifolium
Cyrtomnium hymenophyllum
Desmatodon leucostomus
*Dichodontium pellucidum
*Dicranella crispa
Dicranum majus
D. scoparium
Distichium hagenii
Drepanocladus aduncus
D. exannulatus
D. fluitans
D. lycopodioides
D. vernicosus
Encalypta vulgaris
Fissidens viridulus
Funaria polaris
Grimmia alpestris
G. anodon
G. flaccida
G. plagiopodia
G. torquata
Hypnum cupressiforme
H. hamulosum
H. procerrimum
H. subimponens
*Mielichhoferia elongata
M. macrocarpa
M. mielichhoferi
Mnium affine
M. blyttii
M. marginatum
*Plagiopus oederiana
Pohlia proligera
*Psilopilum cavifolium
Seligeria pusilla

Of the above mosses Desmatodon leucostomus is among the most widespread and fertile mosses on northern Ellesmere Island, and its absence, along with the rarity of the genus as a whole, in nearby Peary Land is difficult to explain. Five other species are common on northern Ellesmere: Aloina brevirostris, Aulacomnium acuminatum, Cyrtomnium hymenophyllum, Dicranella crispa, and Grimmia anodon; eight others are found both on Ellesmere Island's north coast and in the north-central part. Several are very abundant at individual northern Ellesmere localities, e.g. Abietinella abietina, Cinclidium latifolium, and Hypnum procerrimum at Van Hauen Pass, Drepanocladus vernicosus, Mnium blyttii, and Psilopilum cavifolium at Tanquary Fiord.

Of the 44 species listed above 17 produce sporophytes on northern Ellesmere. Of the ten mosses restricted to high altitudes on northern Ellesmere, six (Andreaea rupestris, Arctoa andersonii, Grimmia flaccida, G. torquata, Hypnum subimponens, and Pohlia proligera) do not occur in Peary Land.

Four mosses which occur in Greenland only on the west coast, around Disco Bay, are present on northern Ellesmere Island. They are Aulacomnium acuminatum and Cinclidium latifolium (whose Greenland distributions were discussed by Holmen (1957)), Hypnum subimponens, and Mielichhoferia macrocarpa. Several mosses whose northern Ellesmere populations are more or less isolated occur again only in the southern part of Ellesmere Island and/or west Greenland: Abietinella abietina, Drepanocladus vernicosus, Funaria polaris, Grimmia torquata, Hypnum procerrimum, Plagiopus oederiana, and others.

Alternately, the moss species that occur in Peary Land but not in northern Ellesmere Island are listed below (genera absent from northern Ellesmere Island are preceded by an asterisk):

*Amblystegium varium
*Anomobryum concinnatum
Barbula ferruginascens
*Blindia acuta
Brachythecium trachypodium
Bryum archangelicum
B. creberrimum
B. pseudotriquetrum s.str.
B. rutilans
B. teres
Calliergon trifarium
*Cynodontium alpestre
Encalypta affinis
Fissidens osmundioides
Funaria microstoma
Oncophorus virens
*Oreas martiana
Orthothecium acuminatum
*Plagiobryum demissum
P. zierii
*Plagiothecium laetum
Pohlia cucullata
P. drummondii
P. ludwigii
Polytrichum jensenii
*Saelania glaucescens
Timmia megapolitana

All of the above mosses are rare in Peary Land, and only six of them produce sporophytes there. Oreas martiana is otherwise known in North America only from Alaska and Colorado, although it probably also occurs in Arctic Canada.

Although none of the above species has been collected on northern Ellesmere Island few are absent from the entire Queen Elizabeth Islands: Barbula ferruginascens, Cynodontium alpestre, Funaria microstoma, Oreas martiana, Plagiobryum zierii, Plagiothecium laetum, Pohlia cucullata, and Polytrichum jensenii.

Part 2. Bryogeography of the Queen Elizabeth Islands

Subdivision of the Queen Elizabeth Islands

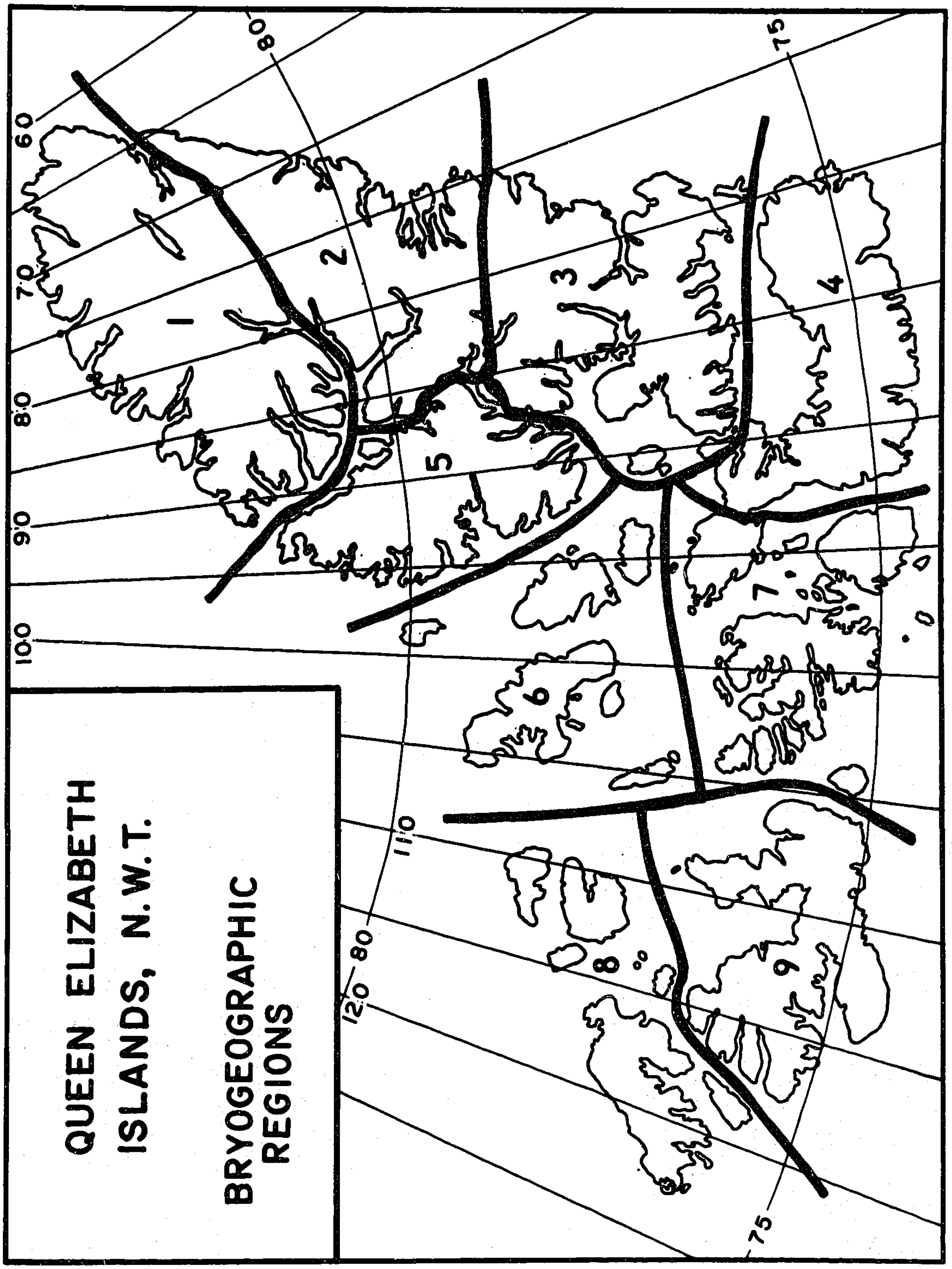
The Queen Elizabeth Islands form a rough triangle north of the Lancaster-Viscount Melville Sound system. They are a very natural geographic unit (Taylor 1955) and at the same time exhibit remarkable diversity in topography, geology and vegetation. Yet, no botanical study has encompassed this group of high arctic islands as a unit. Simmons (1913) considered the Queen Elizabeth Islands distinct, and suggested dividing them into three main groups. I am here proposing a subdivision of the Queen Elizabeth Islands into nine regions as a basis for present and future phytogeographical studies.

Several criteria have influenced my delimitations of boundaries within the islands. The boundaries are natural ones as much as possible, based on the numerous sounds, seas, and minor channels and fiords. Since Ellesmere Island is so much larger than any of the other islands it is divided into three regions. The only other boundary crossing land excludes Grinnell Peninsula from the main part of Devon Island. Although the regions comprising Ellesmere, Devon and Axel Heiberg Islands are larger than the others, they are still largely ice covered.

The number, name, and extent of the nine regions are given below, and the numbers and boundaries are shown in Fig. 31.

Region Number	Name (Extent)
1	Northern Ellesmere (Ellesmere Island north of Nansen Sound, Greely Fiord and Lake Tuborg, cutting across to Archer Fiord)
2	Central Ellesmere (Ellesmere Island south of Region 1, east of Eureka Sound, and north of Bay Fiord and Talbot Inlet)
3	Southern Ellesmere (Ellesmere Island south of region 2, North Kent Island, Coburg Island, Graham Island)
4	Devon (all of Devon Island except the northwest tip, cutting north from Prince Alfred Bay)
5	Axel Heiberg (Axel Heiberg Island, Stor Island, Ulvingen Island)
6	Ringnes (the islands enclosed by Sverdrup Channel, Belcher Channel, Desbarats Strait, and Prince Gustav Adolf Sea, excluding Graham Island but including Lougheed Island)
7	Bathurst (Bathurst Island, Cornwallis Island, the Grinnell Peninsula of Devon Island, west of Prince Alfred Bay, and the smaller islands between Wellington Channel and Byam Martin Channel, including Byam Martin Island and Cameron Island)
8	Prince Patrick (Prince Patrick Island, Eglinton Island, Emerald Island, and all the islands north of Hazen Strait and west of Prince Gustav Adolf Sea)
9	Melville (Melville Island)

Figure 31. The bryogeographic regions of the Queen Elizabeth Islands. The numbers correspond to those on page 176.


QUEEN ELIZABETH
ISLANDS, N.W.T.
BRYOGEOGRAPHIC
REGIONS

Various biological and geographical factors influence the distribution patterns of mosses in the Queen Elizabeth Islands. One of the most significant is the glacial history of the area, which I shall consider in detail in the following chapter.

Many mosses require very specific habitats, and in some cases this determines their large-scale distributions. Plants that grow only on limestone, for instance, would of necessity be absent from the entire Precambrian Shield of Canada. But in most parts of the High Arctic there is a wide enough range of habitats to allow even the most highly specialized mosses to grow. Even obligately nitrophilic mosses occur throughout the Canadian Arctic because their habitats (dung or otherwise very enriched substrates), although nowhere abundant, also occur throughout the region. Likewise strongly acidophilic species usually find suitable sites in which to grow even in overwhelmingly calcareous areas.

One must, therefore, look primarily at geographical factors (e.g. dispersal methods, physical or climatological barriers) in order to explain most large-scale distributions of mosses in the High Arctic; the autecological and synecological requirements of the mosses strongly influence local distribution and abundance, but are of less importance to large-scale bryogeography.

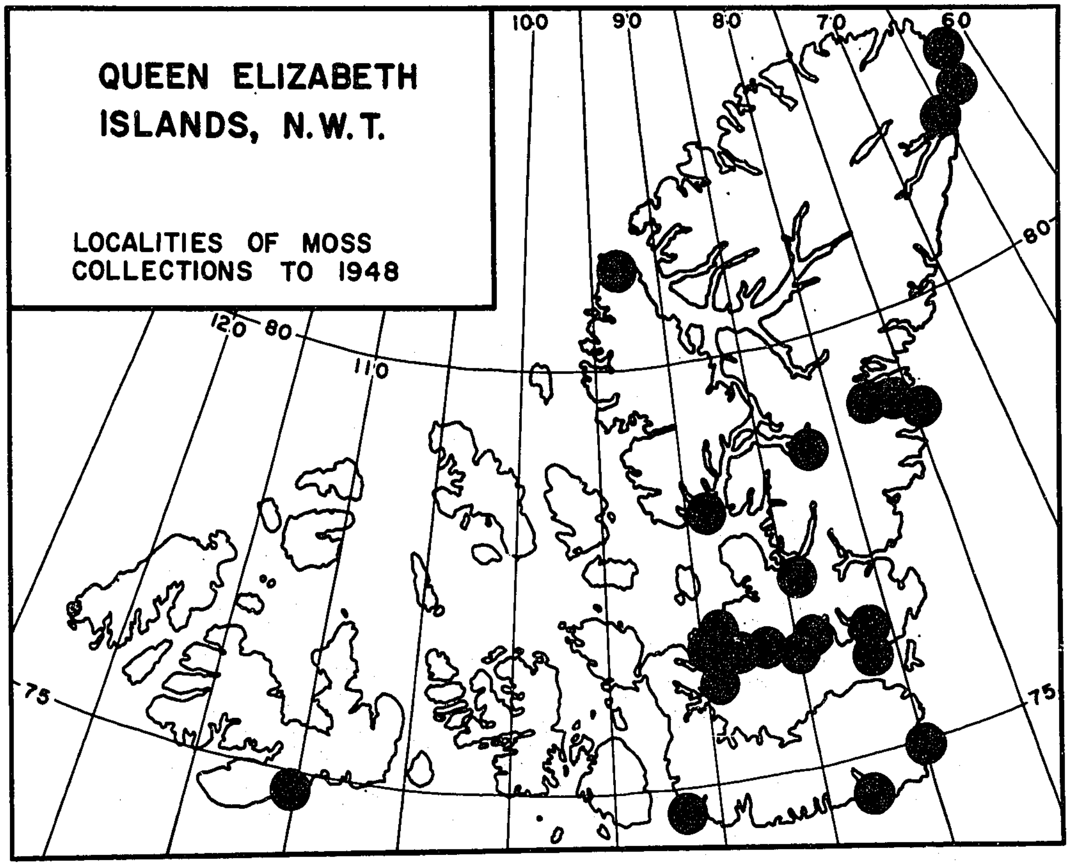
Distribution patterns of mosses in the Queen Elizabeth Islands

The localities at which mosses have been collected in the Queen Elizabeth Islands are shown in Fig. 32.

The mosses which occur (or can certainly be expected) in each of the nine regions of the Queen Elizabeth Islands which I have separated can be grouped into four distribution patterns (Table 7, page 185): ubiquitous (Fig. 33), widespread acidophilic (Fig. 34), widespread calciphilic (Fig. 35) and widespread tolerant (species which grow equally well in calcareous and non-calcareous places) (Fig. 36). These four patterns account for 43% of the total moss flora. Mosses with such distributions in the Queen Elizabeth Islands are generally widespread throughout the Arctic, and practically all are circumpolar.

Less than half of these ubiquitous or widespread mosses produce spores or gemmae at high latitudes, and vegetative reproduction is the rule rather than the exception, even for mosses which occasionally produce spores. It seems likely that most of the ubiquitous or widespread mosses have always occupied much of the available land area in high latitudes, and they have probably survived the latest glaciation (Wisconsin) in several refugia both north and south of the North American ice sheets; their spread during and after deglaciation from these several refugia was probably quite rapid and their "separate" ranges coalesced.

Figure 32 . The localities in the Queen Elizabeth Islands at which mosses have been collected up to 1948 and up to 1969.


QUEEN ELIZABETH
ISLANDS, N.W.T.
LOCALITIES OF MOSS
COLLECTIONS TO 1948
100
90
80
70
60
80
120
80
110
75
75

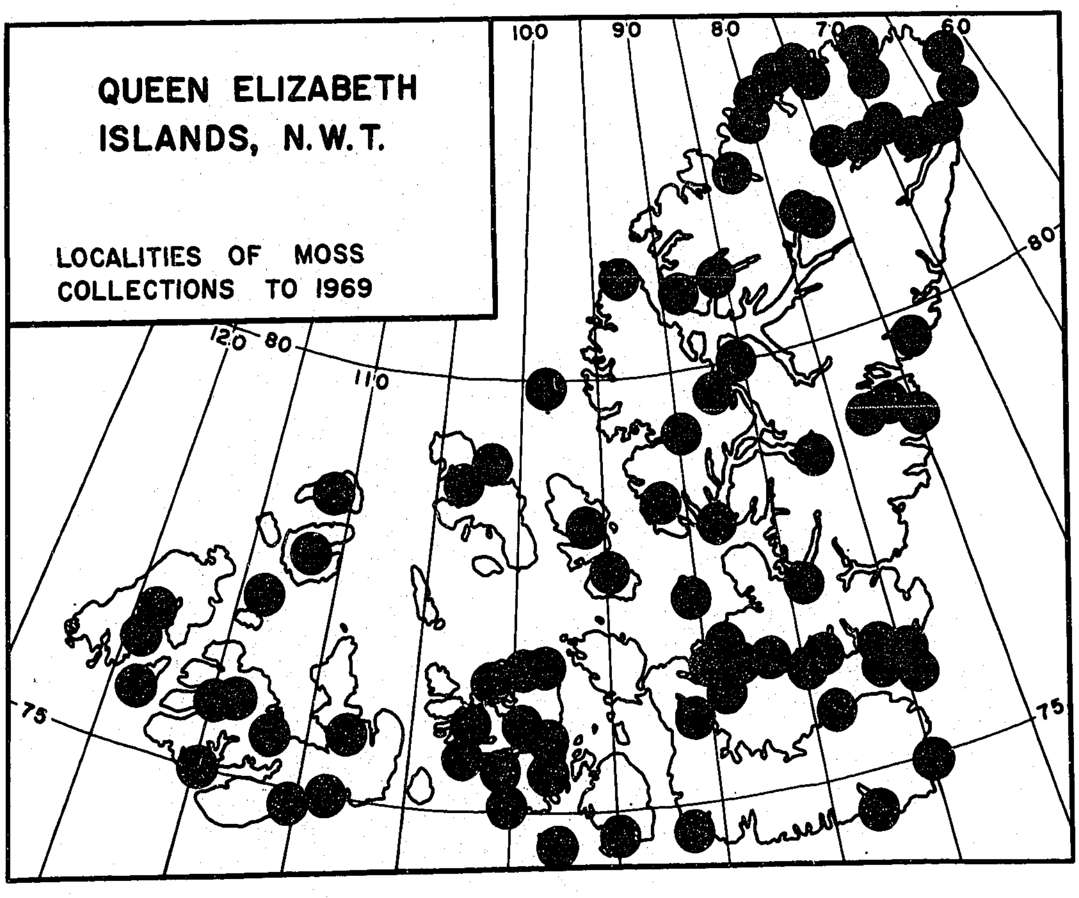
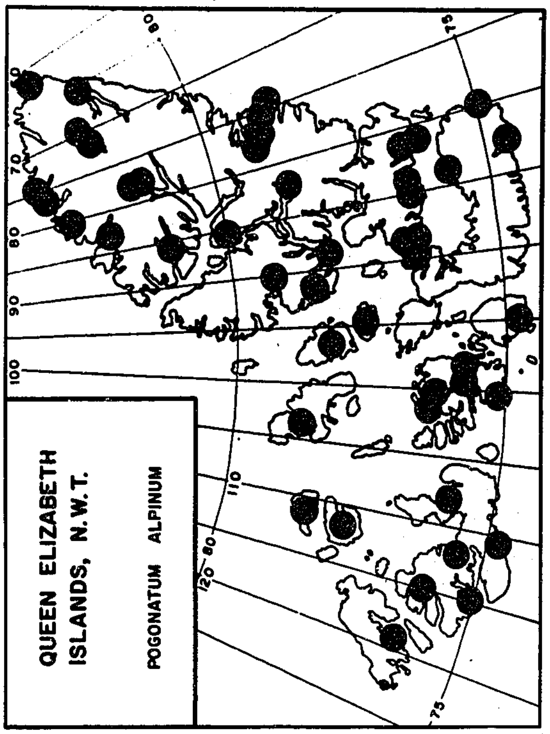
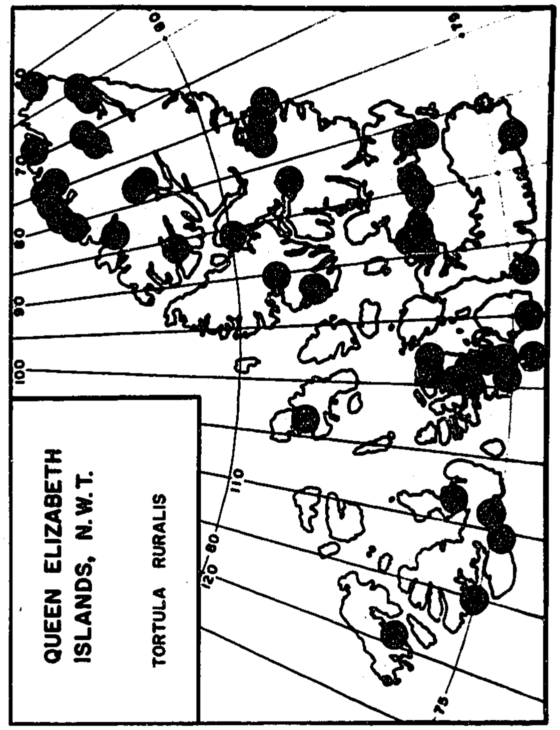
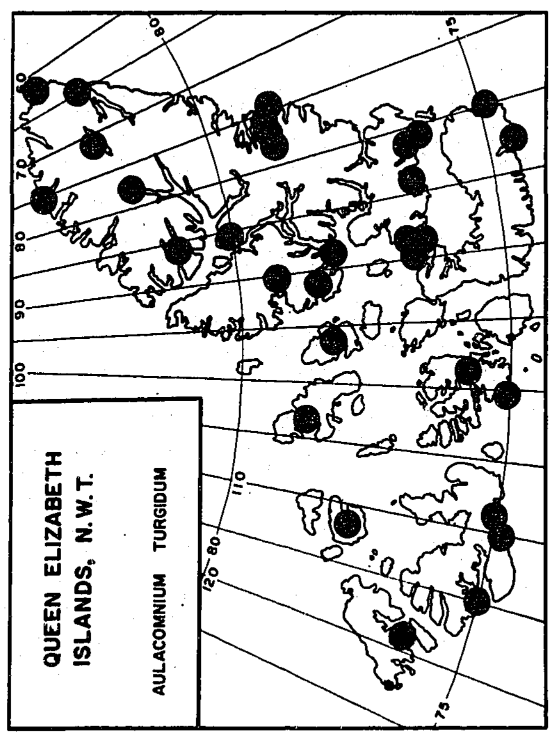

QUEEN ELIZABETH
ISLANDS, N.W.T.
LOCALITIES OF MOSS
COLLECTIONS TO 1969
100
90
80
70
60
80
120
80
110
75
75

Figure 33. The Queen Elizabeth Islands distributions of four ubiquitous mosses: *Aulacomnium turgidum*, *Ditrichum flexicaule*, *Pogonatum alpinum*, *Tortula ruralis*.


QUEEN ELIZABETH
ISLANDS, N.W.T.
POGONATUM ALPINUM


QUEEN ELIZABETH
ISLANDS, N.W.T.
TORTULA RURALIS


QUEEN ELIZABETH
ISLANDS, N.W.T.
AULACOMNIUM TURGIDUM

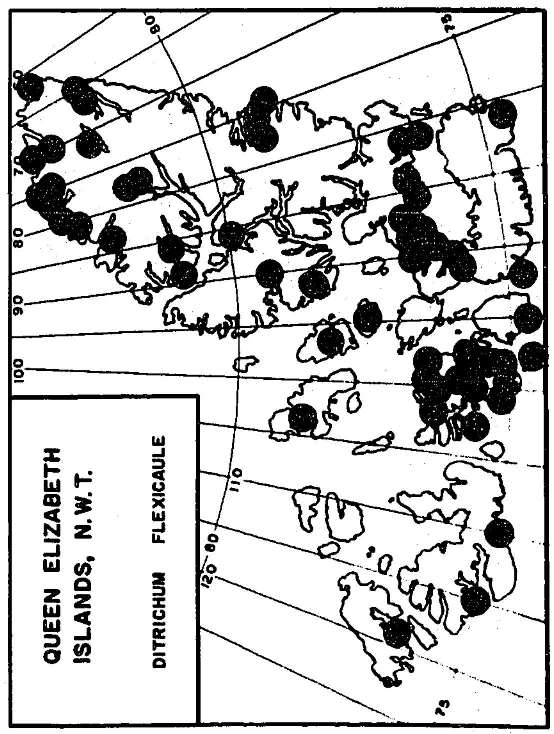
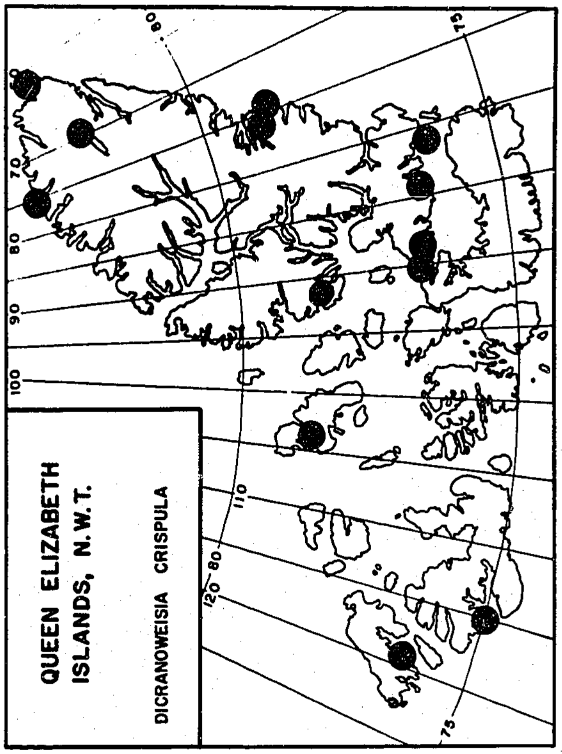
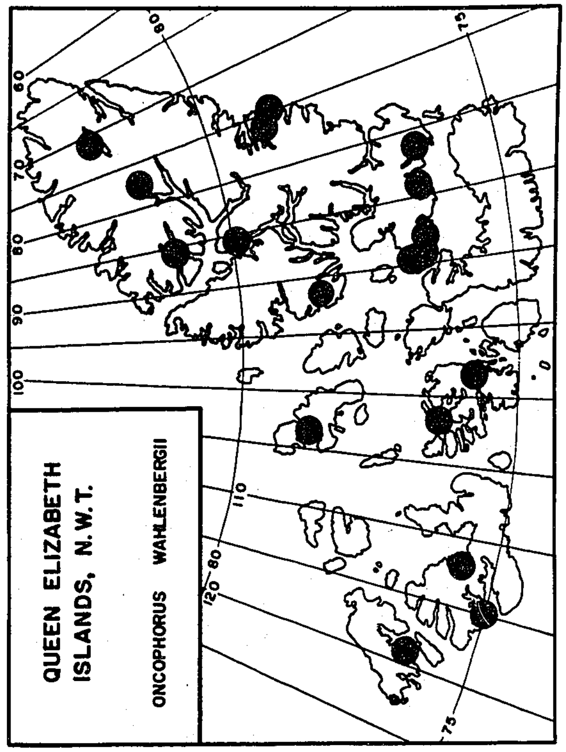
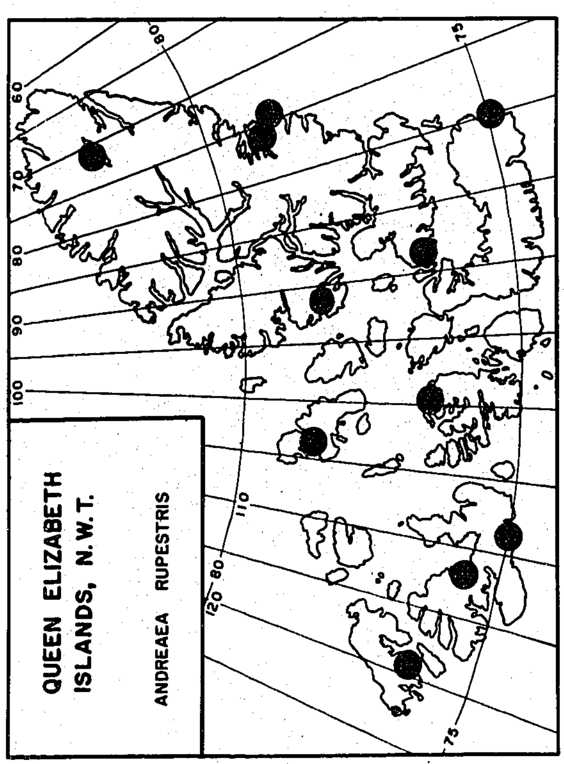

QUEEN ELIZABETH
ISLANDS, N.W.T.
DITRICHUM FLEXICAULE

Figure 34. The Queen Elizabeth Islands distributions of four widespread acidophilic mosses: Andreaea rupestris, Bartramia ithyphylla, Dicranoweisia crispula, Oncophorus wahlenbergii.


QUEEN ELIZABETH
ISLANDS, N.W.T.
DICRANOWEISIA CRISPULA


QUEEN ELIZABETH
ISLANDS, N.W.T.
ONCOPHORUS WAHLENBERGII


QUEEN ELIZABETH
ISLANDS, N.W.T.
ANDREAEA RUPESTRIS

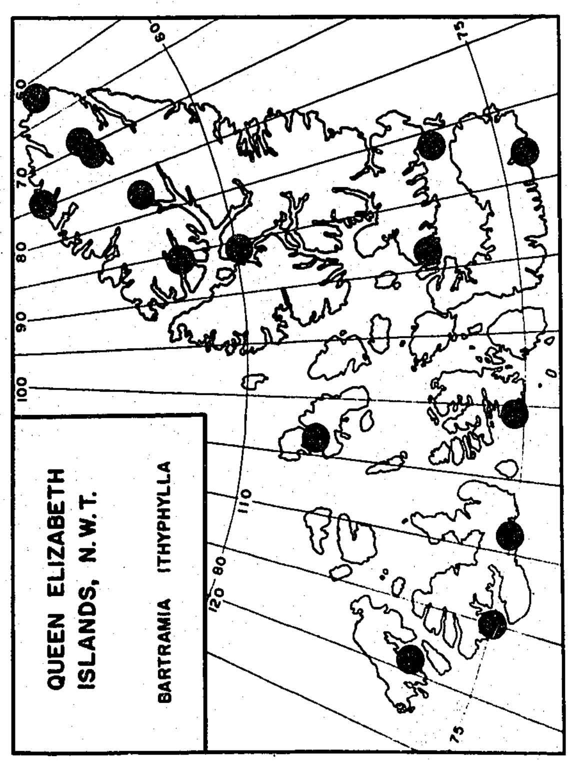
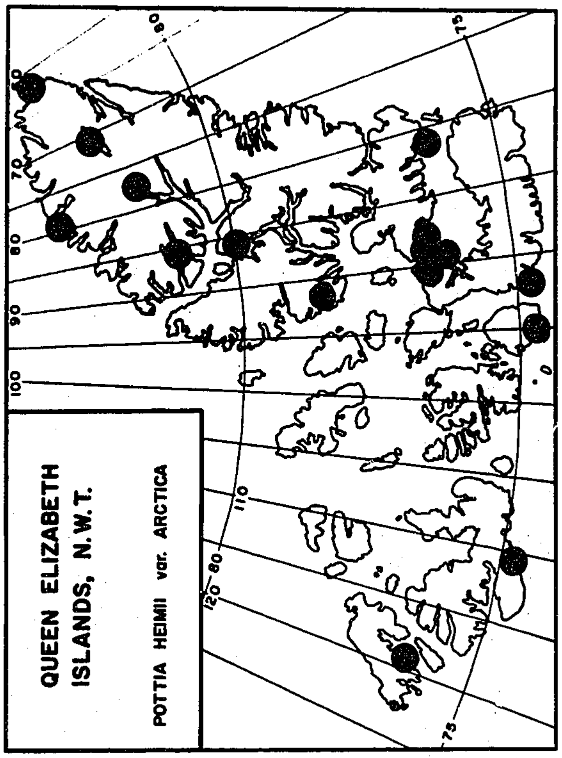
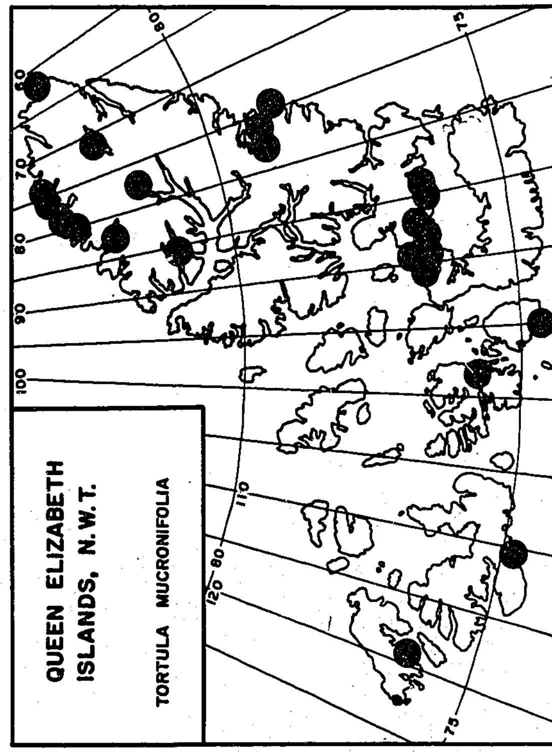
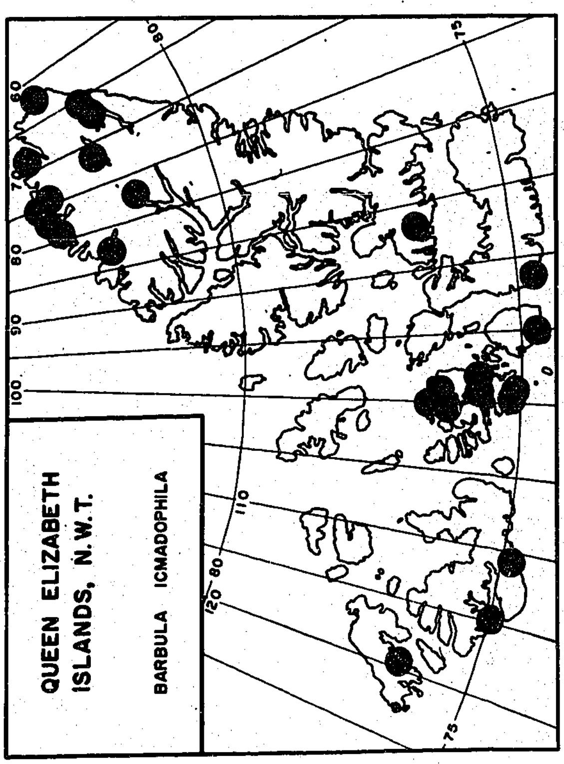

QUEEN ELIZABETH
ISLANDS, N.W.T.
BARTRAMIA ITHYPHYLLA

Figure 35. The Queen Elizabeth Islands distributions of four widespread calciphilic mosses: *Barbula icmadophila*, *Desmatodon leucostomus*, *Pottia heimii* var. *arctica*, *Tortula mucronifolia*.


QUEEN ELIZABETH
ISLANDS, N.W.T.
POTTIA HEIMII var. ARCTICA


QUEEN ELIZABETH
ISLANDS, N.W.T.
TORTULA MUCRONIFOLIA


QUEEN ELIZABETH
ISLANDS, N.W.T.
BARBULA ICMADOPHILA

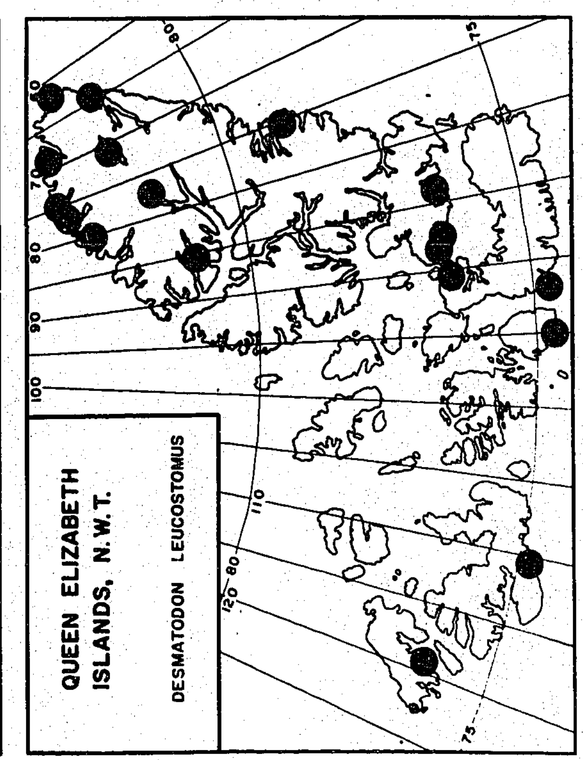
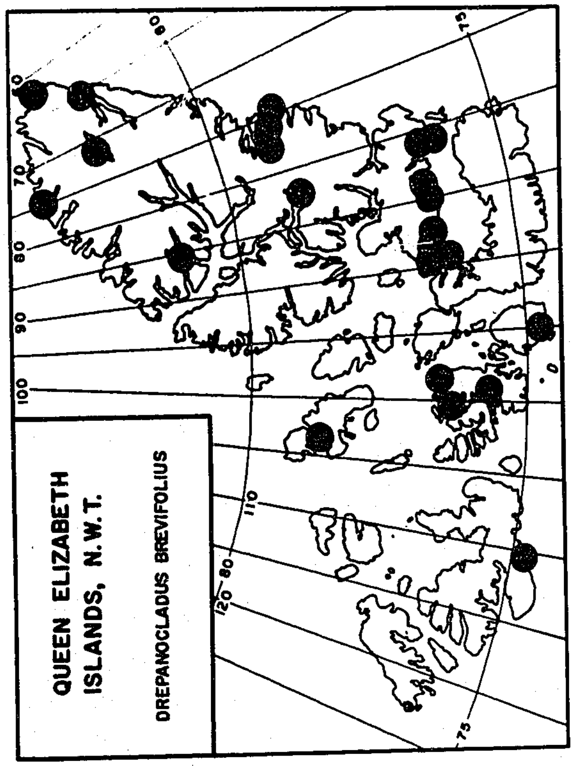
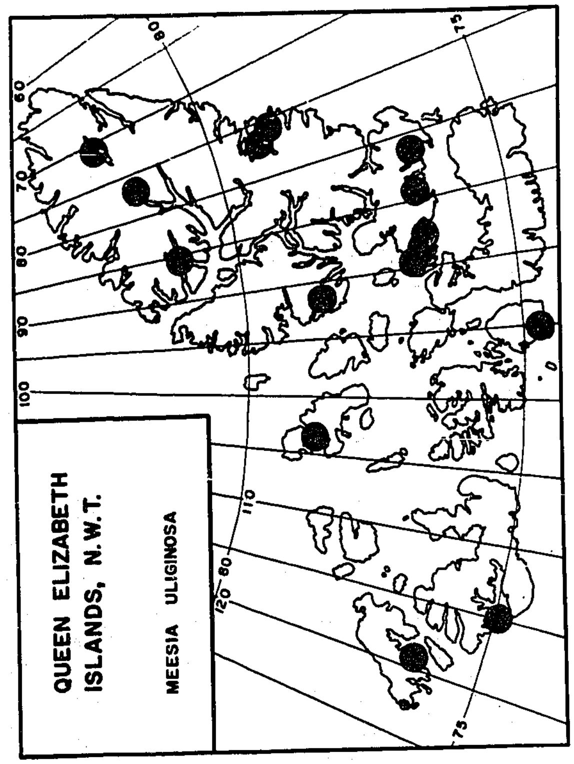
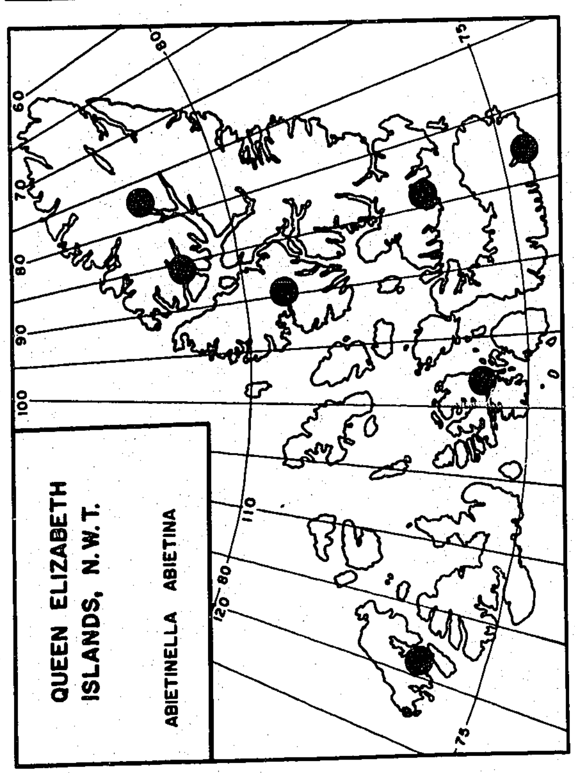

QUEEN ELIZABETH
ISLANDS, N.W.T.
DESMATODON LEUCOSTOMUS

Figure 36. The Queen Elizabeth Islands distributions of four widespread mosses tolerant of both calcareous and non-calcareous soils: *Abietinella abietina*, *Anoectangium tenuinerve*, *Drepanocladus brevifolius*, *Meesia uliginosa*.


QUEEN ELIZABETH
ISLANDS, N. W. T.
DREPANOCLADUS BREVIFOLIUS


QUEEN ELIZABETH
ISLANDS, N. W. T.
MEESIA ULIGINOSA


QUEEN ELIZABETH
ISLANDS, N. W. T.
ABIETINELLA ABIETINA

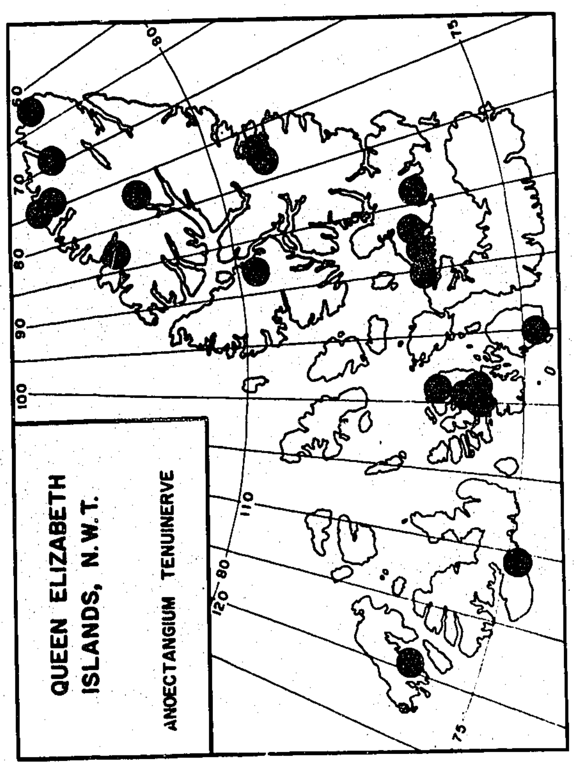

QUEEN ELIZABETH
ISLANDS, N. W. T.
ANOECTANGIUM TENUINERVE

Table 7. The distribution patterns of mosses in the Queen Elizabeth Islands.

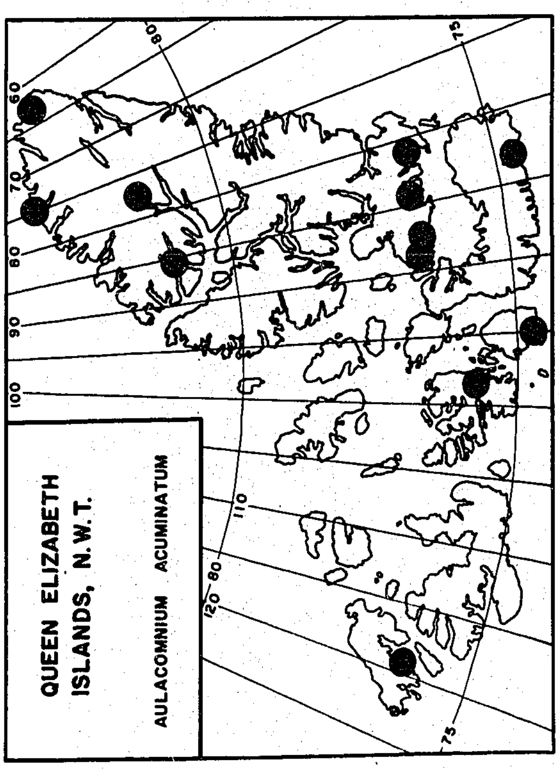
	Number of species	Percent of the moss flora
Ub Ubiquitous	24	10.4
Wa Widespread acidophilic	16	6.9
Wc Widespread calciphilic	18	7.8
Wt Widespread tolerant	41	17.7
R Rare	26	11.3
E Eastern	32	13.9
SW Southwestern	6	2.6
So Southern outliers	13	5.6
Td Temperate disjuncts	5	2.2
-- Unknown	51	21.6
Total	232	100.0

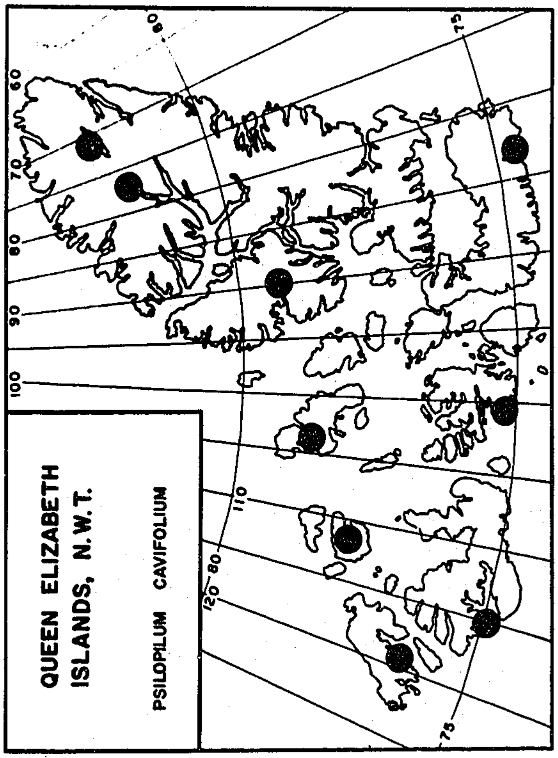
These ubiquitous or widespread mosses also include at least 24 species which are largely confined to the High Arctic (Fig. 37). These are of more significance to bryogeography since in North America they have almost certainly survived the Wisconsin and possibly earlier Glaciations in one or more refugia located north of the main ice sheets. The onset of glaciation and growth of the continental ice sheets was much too rapid to allow these high arctic mosses to "run ahead" of the ice and survive in refugia south of the ice.

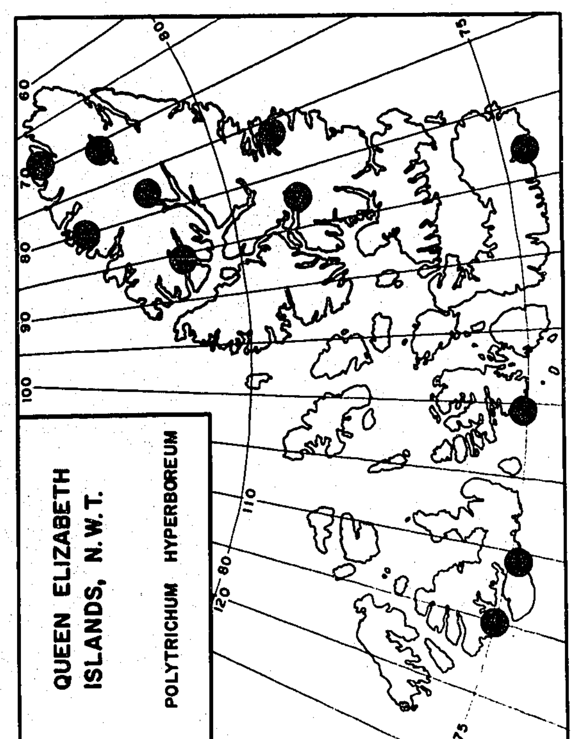
In the Queen Elizabeth Islands there is also an element of rare mosses which does not appear to be associated with any region or groups of regions (Fig. 38). These mosses probably do not occur in all regions although new collections will undoubtedly extend the ranges of some of them to other parts of the Canadian High Arctic. Some, e.g. Arctoa andersonii, are restricted to the islands bordering the Arctic Ocean but others like Calliergon stramineum or Cinclidium latifolium occur in widely separated and very different regions of the Queen Elizabeth Islands.

The high arctic moss flora contains no less than five genera and six species of Splachnaceae as well as Funaria polaris, also an obligate nitrophile. Because the dung or other enriched habitats on which these species grow occur throughout the High Arctic one might expect the nitrophilic

Figure 37. The Queen Elizabeth Islands distributions of four mosses belonging to the high arctic circumpolar element: *Aulacomnium acuminatum*, *Polytrichum hyperboreum*, *Psilopilum cavifolium*, *Tortella arctica*.


QUEEN ELIZABETH
ISLANDS, N.W.T.
AULACOMNIUM ACUMINATUM


QUEEN ELIZABETH
ISLANDS, N.W.T.
PSILOPILUM CAVIFOLIUM


QUEEN ELIZABETH
ISLANDS, N.W.T.
POLYTRICHUM HYPERBOREUM

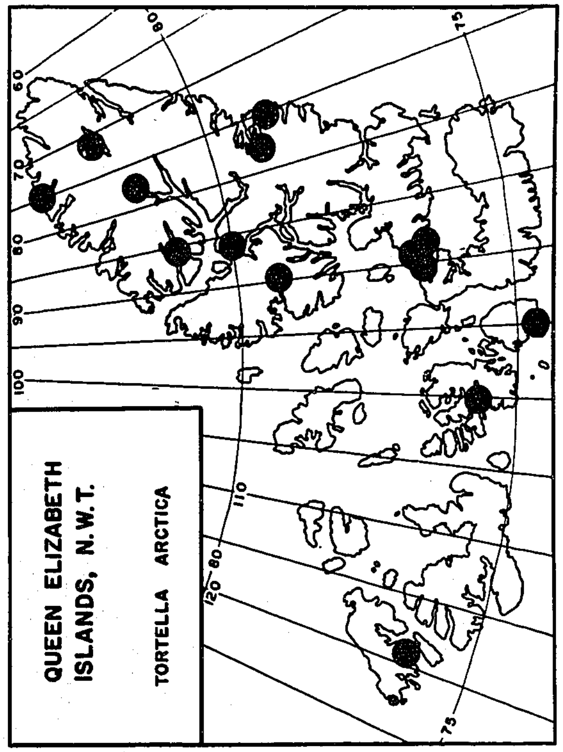
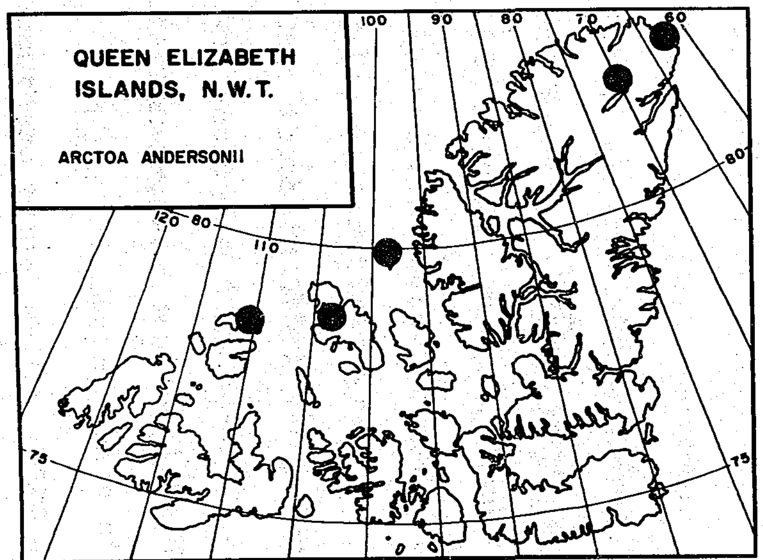
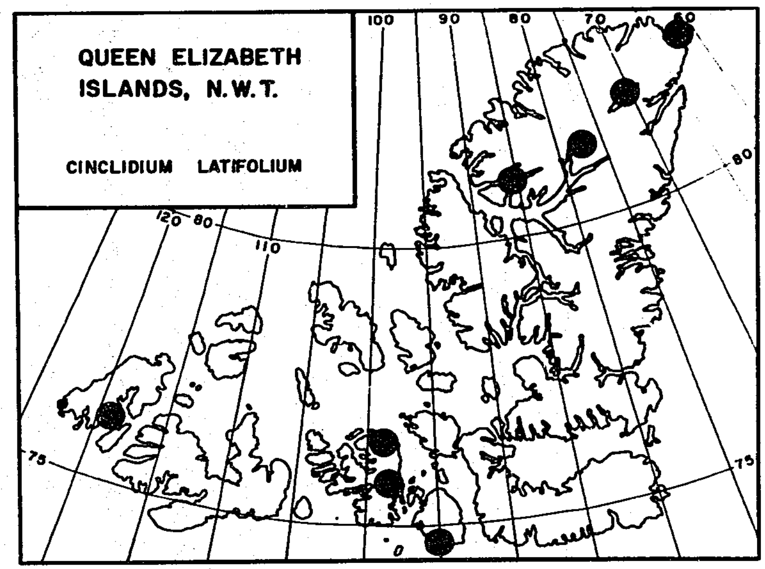
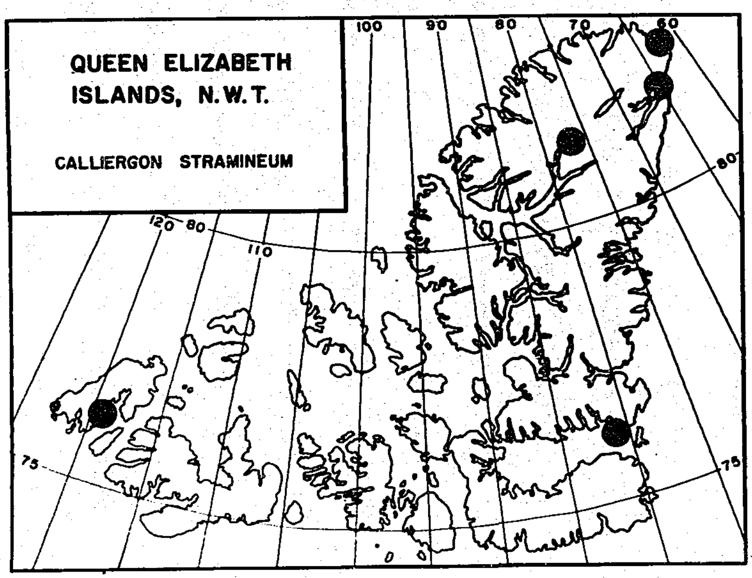
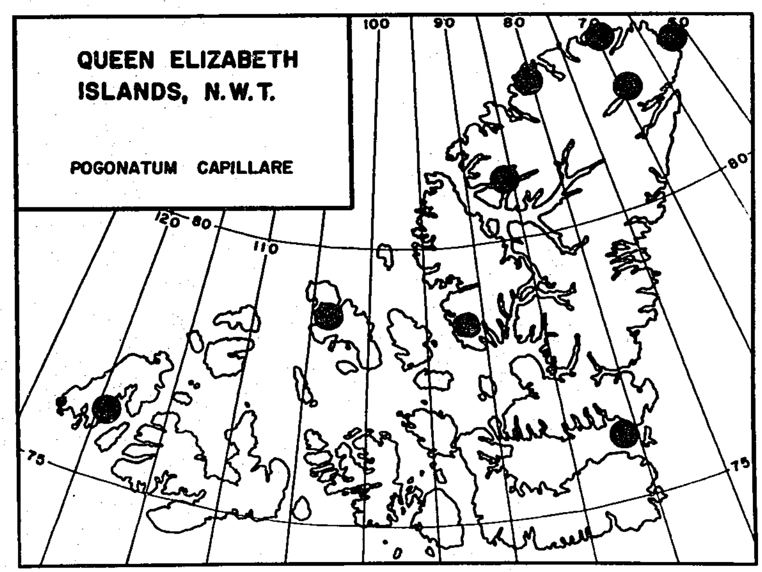

QUEEN ELIZABETH
ISLANDS, N.W.T.
TORTELLA ARCTICA

Figure 38. The Queen Elizabeth Islands distributions of four rare mosses: *Arctoa andersonii*, *Calliergon stramineum*, *Cinclidium latifolium*, *Pogonatum capillare*.


QUEEN ELIZABETH
ISLANDS, N.W.T.
ARCTOA ANDERSONII
100
90
80
70
60
80
120
80
110
75
75


QUEEN ELIZABETH
ISLANDS, N.W.T.
CINCLIDIUM LATIFOLIUM
100
90
80
70
60
80
120
80
110
75
75


QUEEN ELIZABETH
ISLANDS, N.W.T.
CALLIERGON STRAMINEUM
100
90
80
70
60
80
120
80
110
75
75


QUEEN ELIZABETH
ISLANDS, N.W.T.
POGONATUM CAPILLARE
100
90
80
70
60
80
120
80
110
75
75

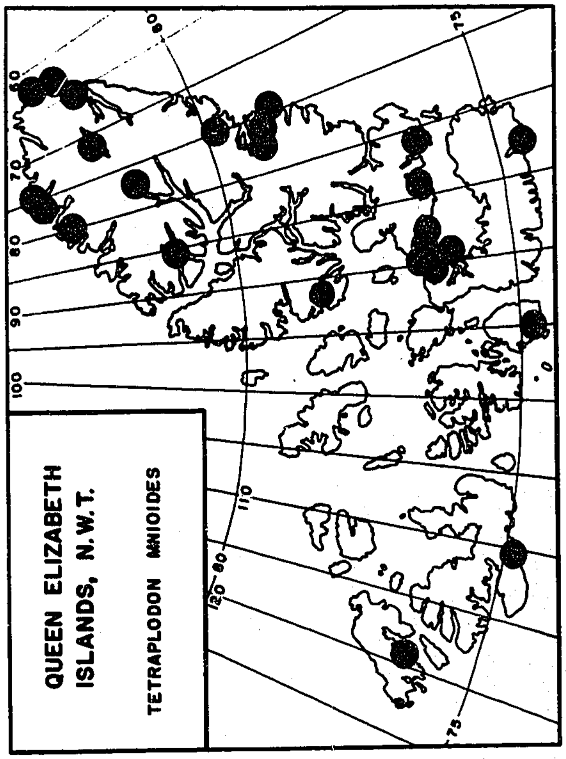
mosses to be all widespread, but such is not the case (Fig. 39). The Queen Elizabeth Islands distributions of the species vary, from the rare and predominantly eastern ranges of *Funaria polaris* and *Tayloria acuminata* to the ubiquitous occurrence of *Tetraplodon mnioides*.

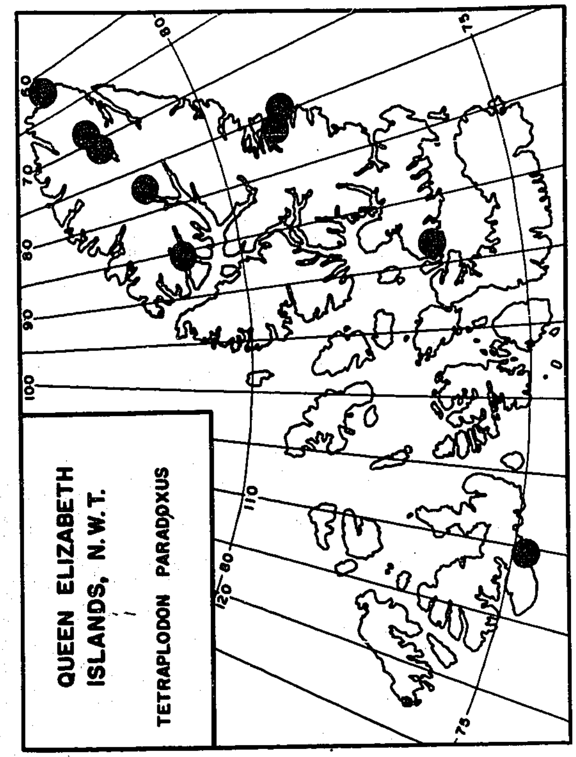
The remaining mosses have a more restricted range in the Queen Elizabeth Islands, and most probably do not occur in all nine regions.

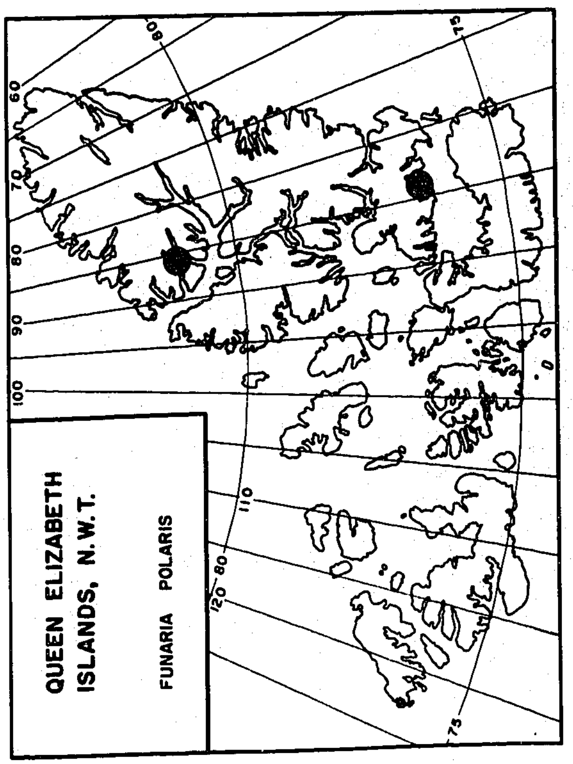
A numerous eastern element of mosses (14% of the total flora) comprises species which are restricted to the mountainous eastern regions (Regions 1 to 5) and do not occur, or barely reach, the low western Queen Elizabeth Islands (Fig. 40). In the High Arctic these species are truly restricted, although south of the Queen Elizabeth Islands they have a broader range. In the Nearctic these mosses (and several vascular plants with identical ranges, (see page217) have a northern limit which closely follows the 4.5° C (40° F) July mean daily temperature isotherm. Both the distributions and that isotherm skirt the western Queen Elizabeth Islands but include a long outlying arm extending up Devon, Ellesmere, and eastern Axel Heiberg Island.

There are two elements of mosses which only reach the southern parts of the Queen Elizabeth Islands.

Figure 39. The Queen Elizabeth Islands distributions of four nitrophilic mosses: *Funaria polaris*, *Splachnum vasculosum*, *Tetraplodon mnioides*, *Tetraplodon paradoxus*.


QUEEN ELIZABETH
ISLANDS, N.W.T.
TETRAPLODON MNIOIDES


QUEEN ELIZABETH
ISLANDS, N.W.T.
TETRAPLODON PARADOXUS


QUEEN ELIZABETH
ISLANDS, N.W.T.
FUNARIA POLARIS

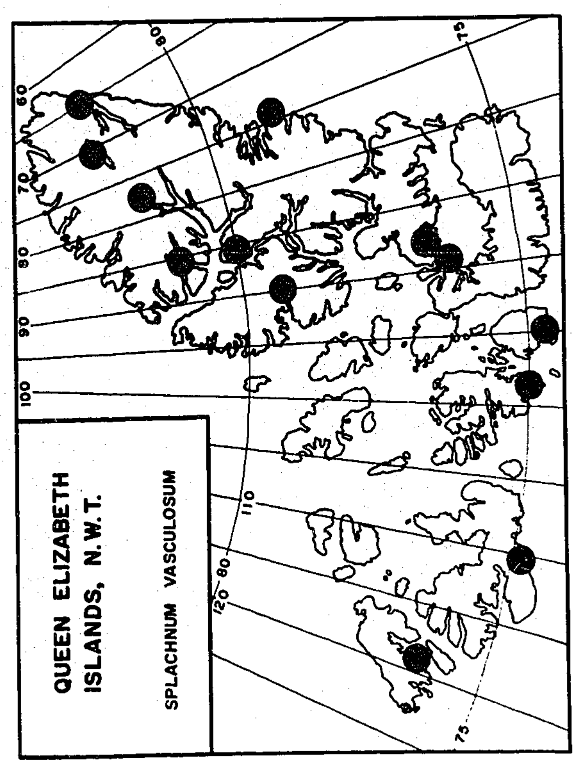
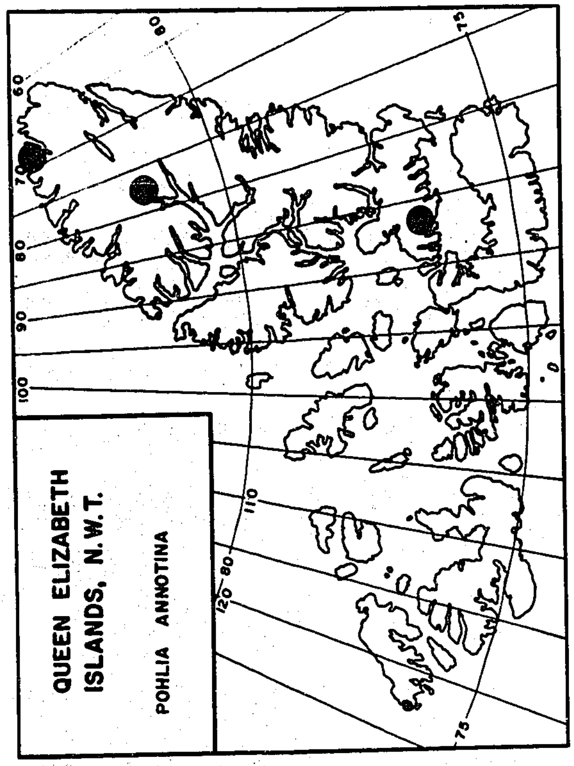
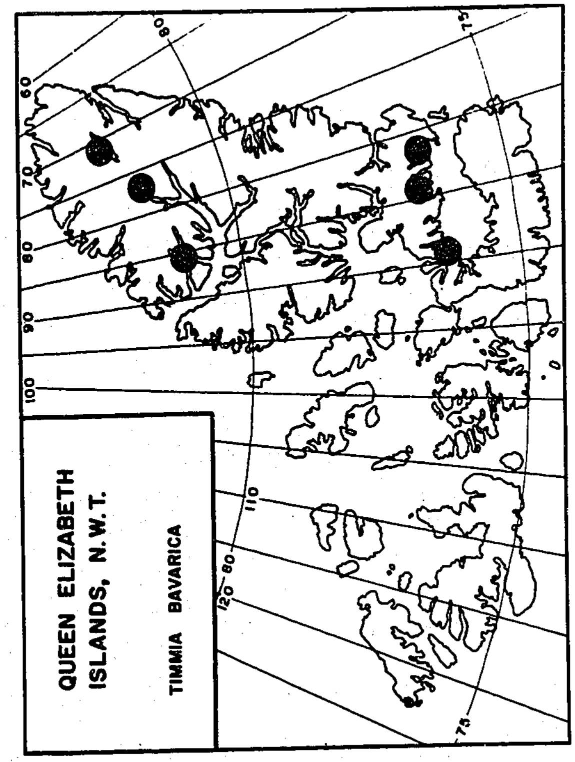
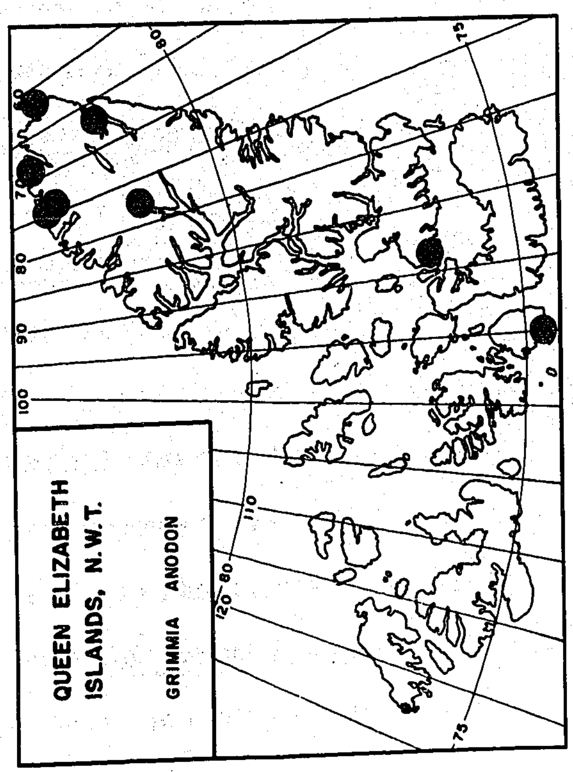
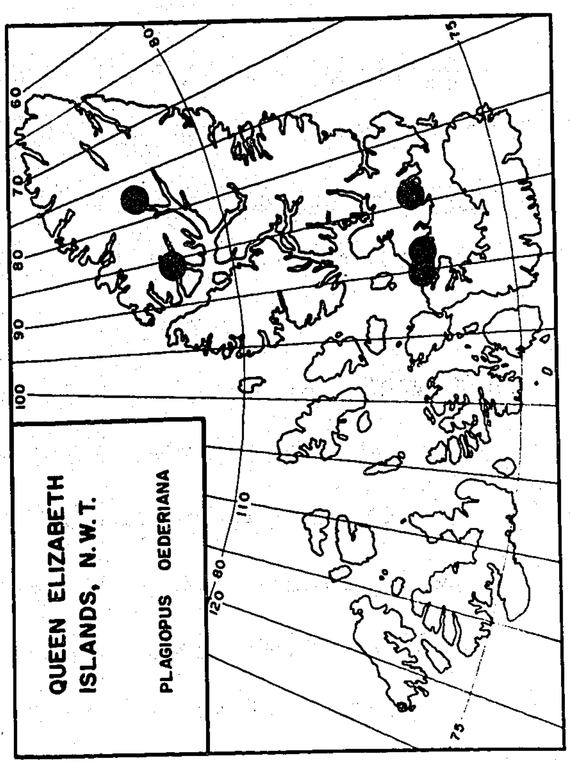

QUEEN ELIZABETH
ISLANDS, N.W.T.
SPLACHNUM VASCULOSUM

Figure 40. The Queen Elizabeth Islands distributions of four mosses restricted to the eastern islands: Grimmia anodon, Plagiopus oederiana, Pohlia annotina, Timmia bavarica.


QUEEN ELIZABETH
ISLANDS, N.W.T.
POHLIA ANNOTINA


QUEEN ELIZABETH
ISLANDS, N.W.T.
TIMMIA BAVARICA


QUEEN ELIZABETH
ISLANDS, N.W.T.
GRIMMIA ANODON

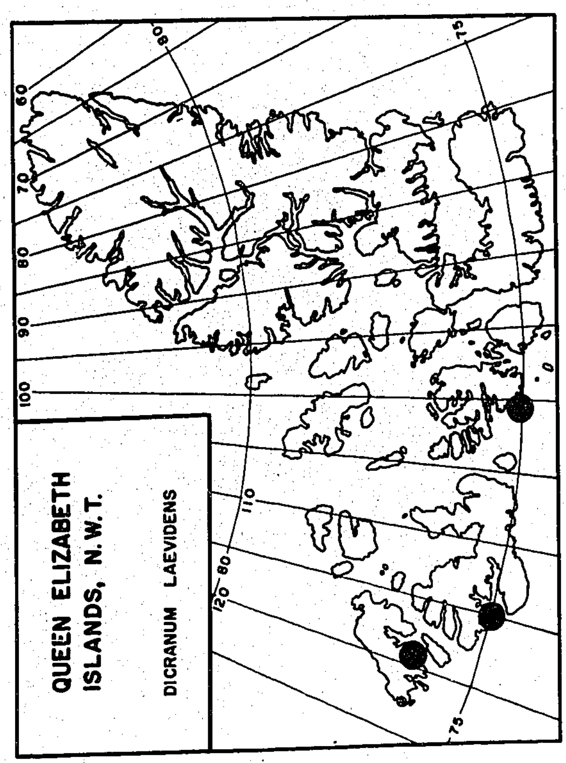

QUEEN ELIZABETH
ISLANDS, N.W.T.
PLAGIOPUS OEDERIANA

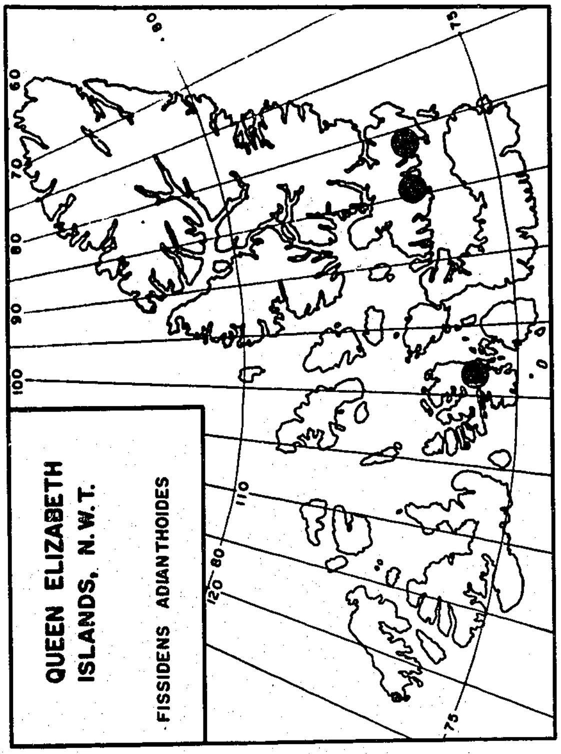
A southwestern element (Fig. 41) encompasses six species which almost certainly have survived the Wisconsin Glaciation in Alaskan or Banks Island refugia, and perhaps also on the west coast of Greenland. These mosses (Barbula johansenii, Ceratodon heterophyllus, Ctenidium molluscum, Dicranum laevidens, Pterigoneurum arcticum, Trichostomum cuspidatissimum) have mostly not penetrated northeastward as far as the mountainous regions, although Barbula johansenii and Pterigoneurum arcticum have reached central Axel Heiberg Island.

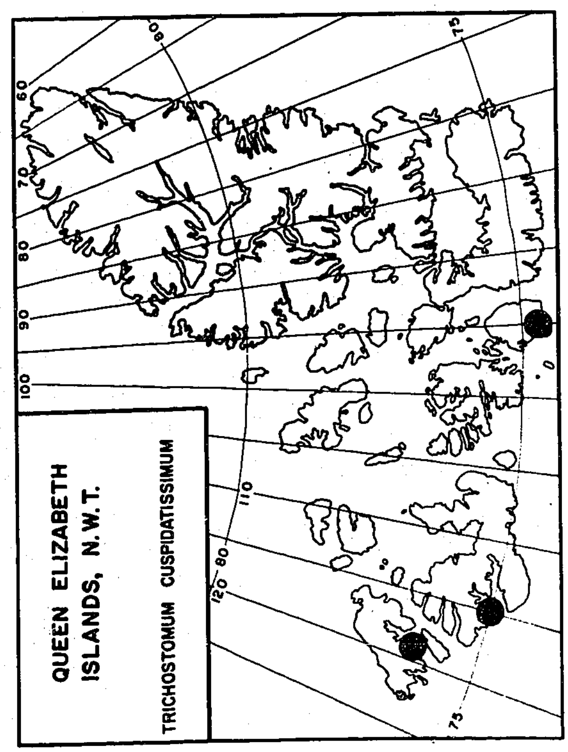
None of the species in this southwestern element are found in northern Greenland. Holmen (1957) documented the localized occurrences in middle-west Greenland of three "west arctic mosses", Aulacomnium acuminatum, Cinclidium latifolium and Trichostomum cuspidatissimum. While the last is certainly of western arctic origin, Aulacomnium acuminatum and Cinclidium latifolium are not western arctic mosses but rather wide ranging high arctic species.

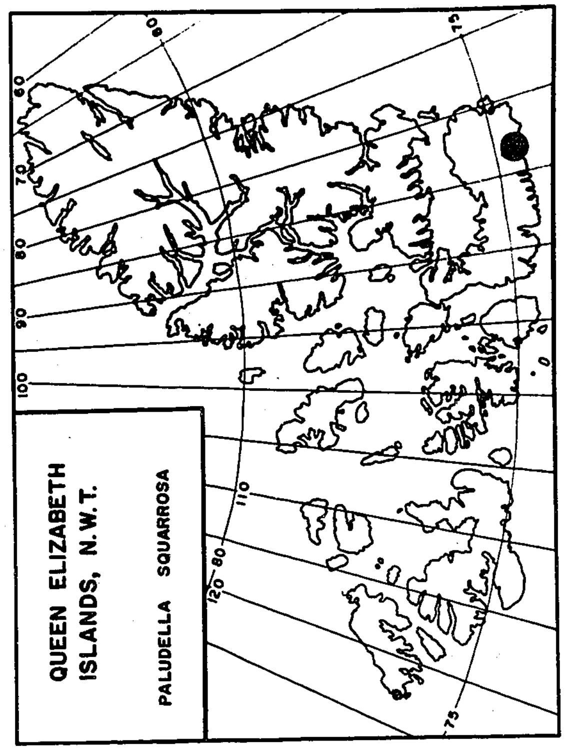
A small number of mosses which are widespread from the boreal forest to the central Arctic barely reach the southermost parts of the Queen Elizabeth Islands (Fig. 41), their northernmost stations. Some of these mosses, e.g. some Sphagnum species, probably have their northern limit determined by climate, but others appear to be slowly advancing northward.

Figure 41. The Queen Elizabeth Islands distributions of two mosses belonging to the southwestern element: *Dicranum laevidens*, *Trichostomum cuspidatissimum*, and two mosses barely reaching the southern islands: *Fissidens adianthoides*, *Paludella squarrosa*.


QUEEN ELIZABETH
ISLANDS, N.W.T.
DICRANUM LAEVIDENS


QUEEN ELIZABETH
ISLANDS, N.W.T.
FISSIDENS ADIANTHOIDES


QUEEN ELIZABETH
ISLANDS, N.W.T.
TRICHOSTOMUM CUSPIDATISSIMUM


QUEEN ELIZABETH
ISLANDS, N.W.T.
PALUDELLA SQUARROSA

Most of these mosses, because they are so widespread everywhere except in the High Arctic, probably survived the last glaciation in several refugia, notably in Alaska, southern Greenland, and south of the main ice sheets.

A small group of primarily temperate mosses (to be treated in more detail in the next chapter) have highly disjunct arctic populations in the Queen Elizabeth Islands, where they have presumably survived at least the Wisconsin Glaciation. Their arctic populations are very localized even today, perhaps indicating the loss of some potential for dispersal in arctic regions.

Of the five species in this element only Mielichhoferia elongata does not produce spores in the Canadian High Arctic. Four of the species are, in the Queen Elizabeth Islands, restricted to northern Ellesmere Island, as follows:

Grimmia flaccida - Barbeau Peak

G. plagiopodia - Tanquary Fiord

Mielichhoferia elongata - Tanquary Fiord

Seligeria pusilla - Van Hauen Pass.

The fifth species, Mielichhoferia mielichhoferi, occurs sterile in at least two adjacent localities on northern Ellesmere Island (Alert and Doidge Bay), and in fruting condition in central Axel Heiberg Island. None of the above species occurs in northern Greenland.

Grimmia plagiopodia and *Seligeria pusilla* also have highly disjunct populations in unglaciated Arctic Alaska (Steere 1965), and *Mielichhoferia mielichhoferi* also re-occurs again in Arctic Alaska.

Of the 232 moss species in the Queen Elizabeth Islands 51 (22%) cannot with certainty be placed in any of the above distribution elements. Most of these species are in poorly understood groups or have only been collected long ago, and it seems best to exclude them from any bryogeographic analysis until further studies outline more precisely their present distribution in the Canadian High Arctic.

In addition, several mosses which I have placed in one distribution element will have to be transferred to another as more specimens either increase their known range or otherwise alter their distributions. Recent field studies in the western Queen Elizabeth Islands, Axel Heiberg Island, and Devon Island should, when published, greatly increase our knowledge of moss distribution patterns in the Canadian High Arctic. I intend here only to present a preliminary bryogeographical analysis of the Canadian High Arctic which can provide a base for future studies.

CHAPTER 6

GLACIAL REFUGIA IN THE CANADIAN HIGH ARCTIC

The possibility that parts of the Canadian High Arctic have been ice-free refugia during the Wisconsin Glaciation (and perhaps during earlier Pleistocene glaciations) has long been a controversial hypothesis among both geologists and biologists. I propose here to consider this hypothesis, with particular attention to northern Ellesmere Island, on the basis of recent zoological and botanical evidence, especially from my own studies on the vascular plants and bryophytes of the area.

Geological evidence

Schei, one of the first geologists to work in the Ellesmere Island area, believed that the present glaciation was more extensive than at any previous time (Schei 1903),

> "After examining the unglaciated parts of the region with the view to discovering whether they may possibly have been subjected to glaciation at some earlier period, I arrived at results of a negative character. I have nowhere observed roches moutonnées, neither did I observe striae or scourings.
>
> "...I believe...that in those regions the existing glaciation represents a maximum, such as has never been attained before, and if this conclusion should turn out to be sound, it is one, I need hardly say, of considerable importance from the point of view of physical as well as biological geography."

Schei was thus well aware of the biogeographical importance of his hypothesis.

However, since then most geologists have rejected this hypothesis, as evidenced by the following remarks.

Christie (1967):

"Ice-caps and numerous glaciers...are active in the Lake Hazen region. Former, more extensive glaciation is indicated by the presence, everywhere, of glacial erratics and by glacial grooves and roches moutonnées.

"...glaciation of these valleys [those along the north coast of Ellesmere] during Pleistocene time cannot be doubted.

"An ice-sheet, formed by the coalescing of many short glaciers draining southeastward from the United States Range, evidently spread southeastward and eastward over the rolling upland surface."

Gadbois and Laverdière (1954):

"Toutefois, à l'époque de la dernière grande activité glaciaire (Wisconsin), l'île Ellesmere, y compris sa partie nordique, subit un râclage glaciaire ne laissant, à son départ du plateau de Floeberg Beach, qu'un sol parsemé tout au plus de débris erratiques."

Hattersley-Smith (1961):

"However, it seems more probable that areas in northern and southern Ellesmere Island, with their high mountains, were centers of glaciation from which glaciers moved outward to join the ice from Greenland, Labrador, and Keewatin, than that the ice invaded these areas from Greenland."

Smith (1961):

"The evidence obtained...shows that the main Ellesmere icecap has been very much more extensive in the past, and from the location of erratics, must have covered all of Grant Land [the northeast part of Ellesmere Island] on at least one occasion in the past."

Other geologists who have favoured complete, or near-complete, glaciation of northern Ellesmere Island during the Pleistocene include Taylor (1956) and Troelsen (1952).

However, none of the above workers maintain that all of Ellesmere Island was covered by ice at the same time or during the same glaciation, and several admit the strong possibility of small ice-free areas along the extreme north coast of Ellesmere or on high nunataks such as exist to-day in the United States Range. The lowering of sea level during the ice ages affords another possibility, that of offshore coastal refugia, which indeed may prove to be the most likely one, at least for the Wisconsin (W. Blake, Jr., pers. comm.).

Biological evidence: Zoology

Recent evidence suggesting a glacial refugium on or near northern Ellesmere Island has come from several studies on animals: Harington (1964) on muskoxen, Leech (1966) on invertebrates, and Macpherson (1965) on tundra mammals. Other unpublished data also suggest a Wisconsin glacial refugium on northern Ellesmere Island. Two comments are worth citing here.

Harington (1964):

> "Tentatively it is assumed that subspeciation of *Ovibos moschatus wardi* occurred in a northern Ellesmere-Greenland refugium or refugia...
>
> "...firm evidence seems to exist for a refugium inhabited by muskoxen, caribou, and lemmings on the northeastern rim of Ellesmere Island during the last glacial period."

Leech (1966):

"I am therefore introducing data from insects and spiders...to support a suggestion that the northern part of Ellesmere Island had ice free areas during the Wisconsin Glacial division (and perhaps for more divisions within the Pleistocene epoch) that served as glacial refugia.

"In summary, it appears that there is one [arthropod] fauna on northern Ellesmere Island that has been there since before the Wisconsin Glaciation and perhaps for the duration of the Pleistocene epoch, and another fauna that may have immigrated to northern Ellesmere Island in post-Wisconsin times."

Biological evidence: Botany

The first botanists who studied the Ellesmere Island flora (Hart 1880, Simmons 1906, 1913) both suggested glacial refugia in northern Ellesmere Island, using botanical evidence.

Hart (1880) concludes, "...indeed this flora [that of north Greenland] as well as that of the whole of Grinnell Land [central Ellesmere], would almost appear to be derived from Discovery Bay [Fort Conger area]."

Simmons (1913), after considering in great detail the geological and biological arguments for and against glacial refugia, concluded that the Ellesmere Island flora is in part relict, "The glaciation of these regions [Ellesmere and Devon Islands] never reached to form large icesheets or continuous inlandices, only isolated glaciers in the valleys and thin icecaps over the summits of some mountains." Speaking about Ellesmere Island, after discussing the plant species which he considers glacial relicts, Simmons (1913) continues, "The southern slopes and rockledges in Harbour Fjord [south coast], in Discovery Harbour [Fort Conger], as well as several other similar ones in other parts of Ellesmereland...are typical relict localities."

More recently, two botanists, Schuster (Schuster et al. 1959) and Savile (1961), have discussed the possibility of glacial refugia on northern Ellesmere Island.

Schuster listed detailed features of the bryophyte flora of the Alert area which suggested a possible glacial refugium in that area. I will deal here with his remarks at some length, especially since recent studies have altered some of the distributions on which he based his conclusions. (in particular, other than my own studies, Holmen 1960, Schuster 1969, and Steere 1965).

Schuster states (Schuster et al. 1959), "Glaciation in the Alert area was very probably local and incomplete, with at best thin ice-sheets that probably left nunataks exposed." and cites the following three types of evidence.

1) The discovery of well-marked endemic (?) new species of liverworts (Lophozia pellucida, Scapania polaris, and Tritomaria heterophylla) and a new moss, Cratoneuron arcticum, which occurred otherwise only in unglaciated Alaska. However, since 1959 Lophozia pellucida and Tritomaria heterophylla have both been found in Greenland, the former

in Sweden, and the latter in Southampton Island (Schuster 1969), and *Cratoneuron arcticum*, even if considered a good species, has a much wider distribution in the High Arctic.

> 2) "Perhaps equally suggestive is that several species of mosses reported largely from the unglaciated or locally glaciated portions of western North America but previously unknown from the Arctic Archipelago, have been found in collections made near Alert."

Here Schuster lists the following mosses: *Fissidens arcticus*, *Grimmia alpestris*, *G. tenera*, *Hygrohypnum alpestre*, *Mielichhoferia mielichhoferi*. Of those, *Fissidens arcticus*, although still known only from North America, is widely distributed in the High Arctic from unglaciated Arctic Alaska to west and north Greenland (Fig. 42). *Grimmia tenera* has also since been collected in northern Greenland. I cannot accept the report of *Hygrohypnum alpestre* without verifying the specimen because of the great variability of the more widespread species *H. luridum*. This leaves only *Grimmia alpestris* and *Mielichhoferia mielichhoferi*, both of which are probably true disjuncts although *M. mielichhoferi* is now also known from Axel Heiberg Island (Fig. 43). Schuster concludes,

> "The fact that a number of these arctic disjuncts also occur on the Greenland coast, of which small portions appear to have escaped continental glaciation, and in unglaciated arctic Alaska may suggest that parts of northern Ellesmere Island may also have escaped 'continental' glaciation, although it appears probable that most of the northern coast was strongly, if locally, glaciated."

> 3) "Perhaps also suggestive is that several of the 'disjunct' species described by the author from the Lake Superior area have been discovered in the Alert area, but are not known elsewhere in North America. Among these species are *Lophozia latifolia* and *Cryptocolea imbricata*."

More recent collections of those two species of liverworts in North America have extended the range of both to north, northwest, and west Greenland, and Lophozia latifolia has also since been found in Alaska, northwestern North America, Labrador and east Greenland. However, the northern Ellesmere populations are still, along with those from northern Greenland, highly disjunct.

Savile (1961), after studying the flora of the northwestern Queen Elizabeth Islands, discussed in detail the evidence for and against glacial refugia in the Canadian High Arctic and concluded, "...no refugia occurred in the Canadian arctic archipelago. The region has been colonized from the Peary Land refuge, the Yukon-Alaska refugia, and from south of the retreating ice sheets."

Savile based his conclusion on six botanical aspects of the flora of the northwestern Queen Elizabeth Islands. Recent botanical studies in the Canadian High Arctic by myself and others have provided much new data which substantially alter Savile's botanical evidence. Some of this new evidence will be presented below, but first I wish to comment in some detail on the six points of Savile's evidence (Savile 1961).

1) Lack of endemic species. Although there are no true endemics in the Queen Elizabeth Islands some plants come very close to being so; Braya thorild-wulffii for instance

is restricted to the Queen Elizabeth Islands and northernmost Greenland. Of much greater phytogeographical significance than the lack of endemics are the highly disjunct Queen Elizabeth Islands-north Greenland populations of numerous flowering plants and bryophytes, which I shall discuss later.

2) "The plants are almost all severely stunted." This may well apply to the impoverished flora of Ellef Ringnes Island but could hardly be more misleading if applied to northern Ellesmere Island or central Axel Heiberg Island, where numerous species are extremely vigorous and obviously well adapted to their environment. Among the vascular plants which grow extremely well at Tanquary Fiord one can mention (Brassard and Beschel 1968): _Calamagrostis purpurascens_ (to 60 cm tall), _Equisetum arvense_ (20-30 cm tall), _Juncus biglumis_ (to 20 cm tall in several places), and _Potentilla rubricaulis_ (to 50 cm tall). Many vascular plants are stunted as protection against the wind, and in protected sites almost all species have the potential to grow vigorously. Also to be considered, is a well-defined high arctic bryophyte element whose species are more vigorously developed in the High Arctic than elsewhere, and which are larger than related species with more southern ranges.

3) The small number of species present. Although the northwestern Queen Elizabeth Islands do have a very impoverished flora, the continental areas of north-central Ellesmere

or Axel Heiberg Islands have a much greater diversity of plants than any of the surrounding areas, including Peary Land (Brassard and Beschel 1968).

4) "Several species are so localized and occur in such small colonies as to suggest that they have reached the region very recently." The limited populations of many species is, in my opinion, not because they are recent arrivals that have not had time to colonize larger areas, but rather because they survived the Wisconsin Glaciation in such small pockets and have not spread much since; other relicts were able to recolonize larger areas much more quickly.

5) "Numerous species that occur throughout the rest of the archipelago are absent from these [northwestern Queen Elizabeth] islands." As mentioned under point three above while this is true for the areas Savile was discussing the reverse is true for other parts of the High Arctic. Obviously the more southern islands of the Arctic Archipelago have more species, but the fact that a high arctic area such as northern Ellesmere Island has such diverse vascular and bryophytic floras is an indication that macroclimate is not the only important limiting factor affecting plant distribution in the High Arctic. A recent paper (Corbet 1969) signals the amelioration of terrestrial microclimate at high latitudes and states,

"...these ameliorating influences will always have been effective in high-arctic localities suitably placed topographically; accordingly their effect should be noted by biogeographers who postulate the existence of far-northern ice-free refugia in which indigenous plants and animals could have survived the Wisconsin Glaciation."

6) The high proportion of peripheral species lacking in the northwestern Queen Elizabeth Islands. Although Savile interprets this very real gap in distribution as evidence against a refugium in the Arctic Archipelago, I suggest that the gap reflects the position of Wisconsin high arctic refugia very precisely: northern Ellesmere Island (which may also have included parts of Peary Land), Alaska-Yukon, Banks Island, and refugia south of the ice sheets. Savile rather arbitrarily limits his supposed refugia to Peary Land, Alaska-Yukon, and southern refugia.

I now wish to elaborate on the botanical evidence which I believe strongly supports the hypothesis of a Wisconsin glacial refugium on northern Ellesmere Island, especially additional evidence which has accumulated from my studies on the mosses of the Canadian High Arctic.

Endemism

Although there are strictly speaking extremely few plants endemic to the Canadian High Arctic, some species have total or Nearctic distributions which are almost or totally restricted to the Queen Elizabeth Islands and northern Greenland.

Braya thorild-wulffii, known only from the Canadian High Arctic and northernmost Greenland, and _Puccinellia poacea_, known only from northern and central Ellesmere Island and Axel Heiberg Island are the most noteworthy of the endemics or quasi-endemics in the vascular flora.

Poa hartzii has two nearctic distribution centres in east and west Greenland and another on northern Ellesmere Island. _Festuca hyperborea_ is known only from north and northeast Greenland, Spitsbergen, northern Ellesmere and Axel Heiberg Islands. _Taraxacum arcticum_ is restricted to Peary Land and northern Ellesmere Island, except for isolated populations on Banks Island and in east Greenland. _Cerastium arcticum_ and _Draba oblongata_ have Nearctic distributions very similar to _Braya thorild-wulffii_ but also occur in a few localities south of the Queen Elizabeth Islands, while _Melandrium triflorum_ also ranges farther south in Greenland.

In a recent analysis Löve (1962) found that of 33 taxa of vascular plants endemic to Arctic Canada and Greenland a higher number (19) are found in the Ellesmere Island-northwest Greenland region than in any other area except the Banks-Victoria Island region. Of those 33 taxa, 15 are found on northern Ellesmere Island but only 10 in Peary Land.

Bryophytes also provide several examples of quasi-endemic species whose high arctic distributions are centred on or have one centre in the Ellesmere Island region. But, since these mosses and liverworts practically all occur also in Arctic Alaska they do not parallel the above vascular plants and are best considered as a distinct high arctic element.

The high arctic bryophyte element

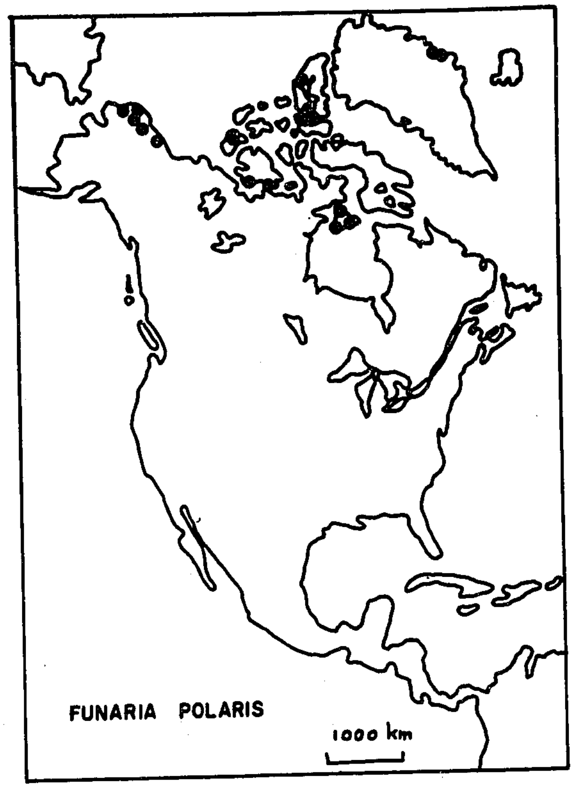
Steere (1953, 1965) presented a carefully-documented list of 65 high arctic circumpolar bryophytes, and although several have not yet been found in the Palearctic they will undoubtedly be discovered there in the future. To his list (Steere 1965) I would add *Campylium arcticum*, *Funaria arctica*, *Mielichhoferia macrocarpa*, *Oreas martiana* and *Tetraplodon paradoxus*.

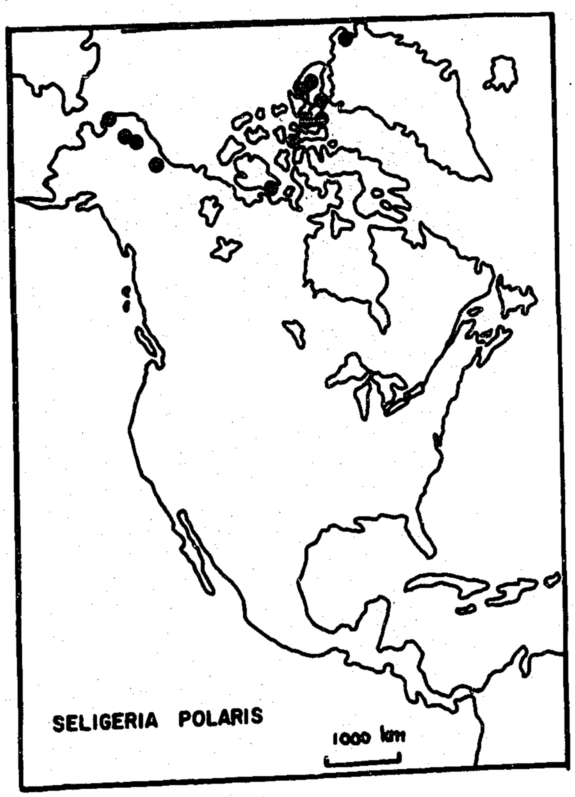
Of the total (70 species) 42 species occur on northern Ellesmere Island, and 29 species in Peary Land.

Most of these high arctic bryophytes have a more or less continuous distribution in the American High Arctic, ranging from Arctic Alaska to east Greenland. Two typical mosses with such continuous high arctic distributions are *Funaria polaris*, still known only from North America (Fig. 42), and the circumpolar *Voitia hyperborea* (Fig. 43). At least four such high arctic circumpolar mosses are common or widespread on northern Ellesmere but entirely absent from the Peary Land area: *Aulacomnium acuminatum*, *Cinclidium latifolium*, *Desmatodon leucostomus* and *Psilopilum cavifolium*.

Figure 42 . The North American distributions of two high arctic endemic mosses (*Fissidens arcticus* and *Funaria polaris*), and of two high arctic circumpolar mosses (*Philocrya aspera* and *Seligeria polaris*).

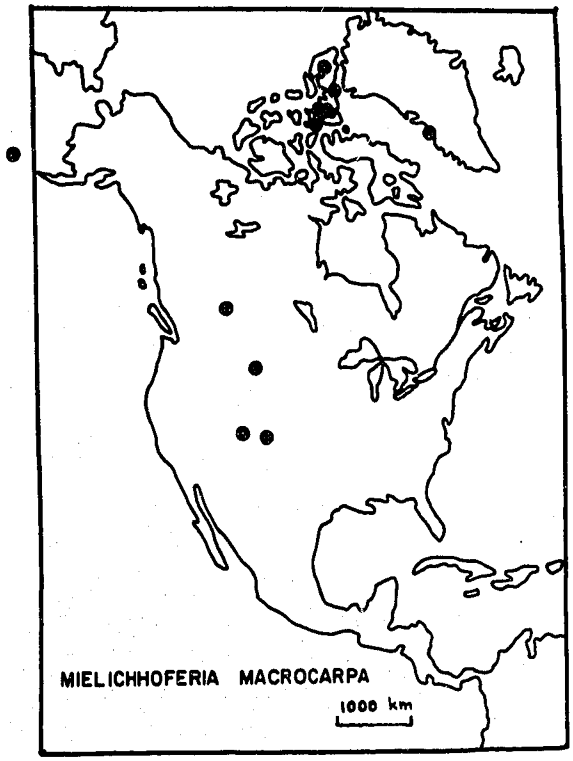

FISSIDENS ARCTICUS
1000 km

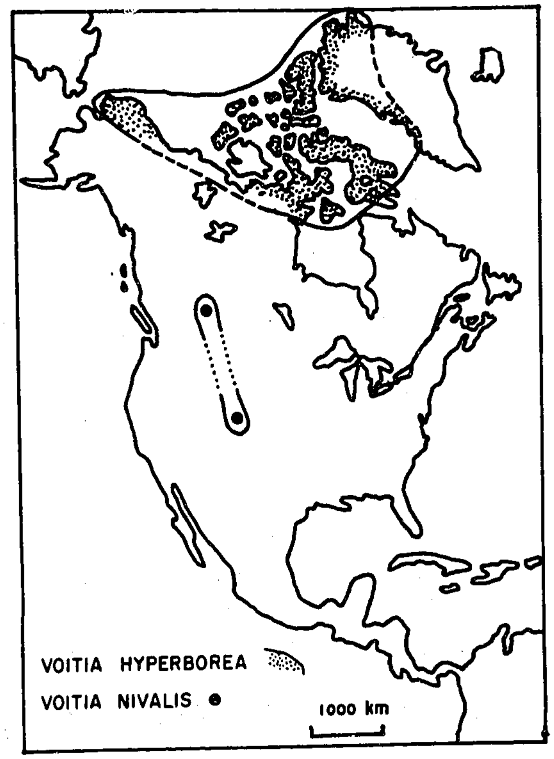

FUNARIA POLARIS
1000 km

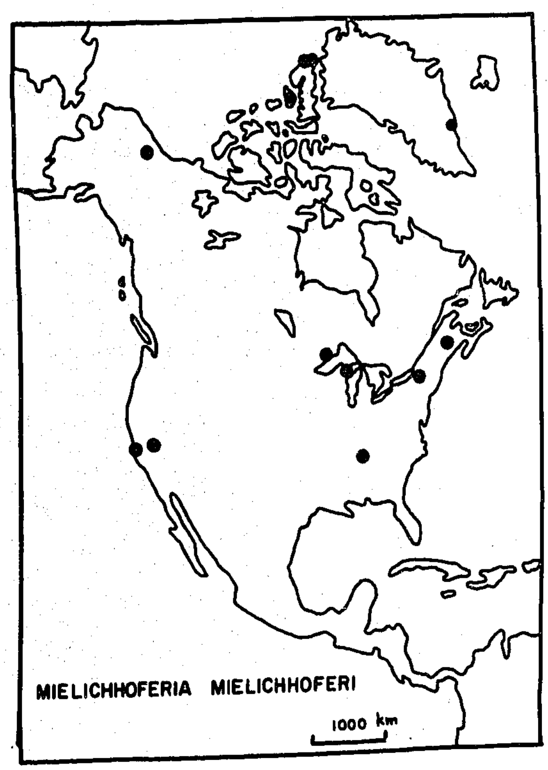

SELIGERIA POLARIS
1000 km


PHILOCRYA ASPERA
1000 km

Figure 43 . The North American distributions of the endemic moss *Mielichhoferia macrocarpa,* two temperate disjuncts occurring in the High Arctic (*Mielichhoferia mielichhoferi* and *Seligeria pusilla*), and of the genus *Voitia* (*V. hyperborea* and *V. nivalis*).


MIELICHHOFERIA MACROCARPA
1000 km


VOITIA HYPERBOREA
VOITIA NIVALIS
1000 km


MIELICHHOFERIA MIELICHHOFERI
1000 km


SELIGERIA PUSILLA
1000 km

Ellesmere Island and Arctic Alaska are the two areas richest in high arctic circumpolar mosses. Of particular significance to bryogeography are the species whose high arctic distributions in North America are separated into two distinct ranges, one centred in Arctic Alaska, the other centred on northern Ellesmere Island. *Fissidens arcticus* still has two such centres (Fig. 42) but will likely be found in intervening areas, as well as in the Palearctic. More definite examples of mosses with two such distinct centres of distribution are *Philocrya aspera* (Fig. 42) and *Seligeria polaris* (Fig. 42). These separate high arctic populations strongly suggest that the species survived the Wisconsin Glaciation both in Arctic Alaska and in a refugium on northern Ellesmere Island.

Mosses belonging to the high arctic element also tend to be large and very well adapted to their environment. *Aulacomnium acuminatum* is a much more robust species than *A. palustre*; arctic specimens of *Campylium arcticum* are generally much larger than arctic material of *C. stellatum*; *Polytrichum hyperboreum* is many times larger than the stunted arctic plants of the related *P. piliferum*; and *Seligeria polaris* is by far the largest species in the genus and the only one restricted to the High Arctic.

Some mosses (e.g. Oligotrichum falcatum and Pterigoneurum arcticum) appear to have survived Wisconsin glaciation primarily in western arctic refugia (Alaska, Banks Island) since they are absent from both Ellesmere Island and northern Greenland. They do, however, range eastward as far as central Axel Heiberg Island, and some vascular plants with similar western arctic affinities reach the western part of northern Ellesmere Island (Van Hauen Pass); Geum rossii and Potentilla pulchella var. gracilicaulis are two examples.

Mielichhoferia macrocarpa presents a unique distribution (Fig. 43). This moss is known in the Arctic only from the Ellesmere Island-northwest Greenland region, but has another centre of distribution in the western cordilleran region and a very isolated station in the Aleutian Islands. It is completely absent from all other supposed high arctic refugia (Alaskan arctic slope, Yukon, Banks Island, Peary Land) and its relative abundance in the Ellesmere Island region can only be satisfactorily explained by invoking a Wisconsin glacial refugium in that area.

Other taxa within the high arctic bryophyte element that are of special interest are those closely related to taxa with more southern distributions. A list of such mosses was published by Holmen (1960) and I include here an expanded list of well-marked examples.

High arctic taxon	Related southern taxon
Arctoa andersonii	A. fulvella
Aulacomnium acuminatum	A. palustre
Barbula icmadophila	B. acuta
Distichium hagenii	D. inclinatum
Drepanocladus brevifolius	D. lycopodioides
Funaria arctica	F. hygrometrica
Hylocomium splendens var. alaskanum	H. splendens var. splendens
Philonotis fontana var. pumila	P. fontana var. fontana
Pogonatum capillare	P. urnigerum
Polytrichum hyperboreum	P. piliferum
Pottia heimii var. arctica	P. heimii var. heimii
Psilopilum cavifolium	P. laevigatum
Seligeria polaris	S. subimmersa
Splachnum vasculosum var. heterophyllum	S. vasculosum var. vasculosum
Tortella arctica	T. tortuosa
Voitia hyperborea	V. nivalis

In North America Voitia hyperborea and V. nivalis provide excellent examples of such closely related taxa, in this case with totally separate ranges (Fig. 43).

It is also significant that several mosses belonging to the high arctic circumpolar element are "old" taxa which evolved long ago and have either no close living relatives or ones which are found in distant parts of the world. Several are monotypic genera (Bryobrittonia, Haplodon, Oreas, Philocrya), well-defined subgenera or isolated genera (Mielichhoferia subgen. Acropus, Seligeria subgen. Blindiadelphus, Psilopilum, Voitia), or distinct subgeneric taxa (e.g. Cinclidium latifolium, Funaria polaris, Oligotrichum falcatum, Tortella arctica, and possibly Grimmia apocarpa var. nigrescens).

Temperate disjuncts

Five mosses that occur on northern Ellesmere Island are remarkable because their distributions are otherwise almost entirely temperate, and their Ellesmere Island occurrences are extreme disjunctions thousands of kilometers from their main range.

Seligeria pusilla is primarily a temperate species (Fig. 43) that grows on limestone and has not been reported in Canada north of central Ontario. The species is most unlikely to occur in the vast Precambrian Shield area of northern Canada, but since it is such a tiny moss it may have been overlooked in other parts of Canada where limestone occurs.

Nevertheless, the discovery of S. pusilla in Arctic Canada has important geobotanical significance. The possibility of a Wisconsin glacial refugium on northern Ellesmere Island is considerably strengthened by the isolated occurrence, almost 4,000 km north of its main range, of this tiny epipetric moss, a species ideally suited to survive glaciation in a restricted area. Reinforcing this are the morphological differences between the arctic and temperate specimens of Seligeria pusilla, which suggest lengthy separation of the temperate and arctic populations. The similar relict occurrence of S. pusilla and other temperate mosses in Arctic Alaska prompted Steere (1965) to consider them glacial relicts, part of what he called the "Umiat syndrome".

Two copper mosses, Mielichhoferia elongata and M. mielichhoferi, also have highly disjunct populations in the High Arctic. M. elongata occurs in North America only at Tanquary Fiord, northern Ellesmere Island and is otherwise known only from Europe (Brassard 1969). Mielichhoferia mielichhoferi has a wider North American distribution (Fig. 43) but is still primarily a temperate species and the northern Ellesmere-Axel Heiberg populations are almost 3,500 km from the southern populations and 2,000 km from the arctic populations in Alaska. The Nearctic distribution of M. mielichhoferi is strikingly similar to that of the well-documented glacial relict Bryoxiphium norvegicum (see map in Steere 1965).

The distributions of Mielichhoferia elongata and M. mielichhoferi, the fact that the plants are uniformly sterile in almost all localities and their specific requirements for substrates rich in heavy metals provide further botanical evidence favouring a Wisconsin refugium on northern Ellesmere Island.

Grimmia plagiopodia has a distribution almost identical to Seligeria pusilla (see map in Steere 1965) and is also now known from northern Ellesmere. Grimmia flaccida occurs on a high altitude northern Ellesmere nunatak but otherwise only in southern Canada (Jones 1933), central Europe and Fennoscandia (Nyholm 1956).

In 1967 I also collected on northern Ellesmere (Tanquary Fiord) a discomycete fungus, Trichophaea woolhopeiae (Cke. & Phill.) Boud., (determined by J. W. Groves) which was hitherto known only from Europe.

Low arctic disjuncts

Two flowering plants, Juncus arcticus and Ranunculus subrigidus, occur on northern Ellesmere highly disjunct from their main range, which is below 70° N. Other low arctic vascular plants whose only Queen Elizabeth Islands occurrence is on northern Ellesmere and/or central Axel Heiberg Island are Androsace septentrionalis, Antennaria compacta, Arenaria sajanensis, Braya humilis ssp. arctica, Draba cinerea, D. glabella, Epilobium arcticum, Eriophorum angustifolium s.str., Halimolobos mollis, Hippuris vulgaris, and Potentilla nivea ssp. chamissonis.

Indeed, 27% of the northern Ellesmere vascular flora have low arctic affinities, that is have their main range below 75° N and only isolated or outlying occurrences north of that latitude.

Low arctic disjuncts among the bryophytes include one moss, Grimmia tenera, and three species of liverworts: Lophozia latifolia, Leiocolea rutheana, and Cryptocolea imbricata (Schuster et al. 1959, Brassard 1968a, Schuster 1969).

In addition, a species of basidiomycetous fungi, *Telephora ? intybacea* Fr., occurs at Tanquary Fiord but is otherwise extremely rare in Arctic Canada, as evidenced by the following comment (D. B. O. Savile, pers. comm.), "...it is an extraordinary record. We have [National Mycological Herbarium of Canada] one arctic record of another [*Telephora*] species but only a short way beyond treeline on the Mackenzie coast."

Floristic diversity

Northern Ellesmere Island has a more diverse flora of both vascular plants and bryophytes than any of the areas adjacent to it. The whole of Peary Land, for instance, has only 106 vascular species while some single localities on northern Ellesmere have between 100 and 125 species.

Northern Ellesmere has a rich flora because it contains:

1) almost all the high arctic species which one expects in such high latitudes,

2) most wide-ranging arctic species, and,

3) an unexpectedly large number of low arctic or even subarctic-boreal species.

Among the vascular plants found on northern Ellesmere 13% are high arctic (with ranges mostly north of 75° N), 27% are low arctic species (i.e. with ranges largely below 75° N), and the remainder wide-ranging arctic species.

Some low arctic vascular plants occur on northern Ellesmere as disjuncts (discussed above) but others have an outlying arm of their range which extends north up the mountainous eastern Queen Elizabeth Islands and quite often reaches all the way to northern Ellesmere Island. Plants with this type of distribution include *Calamagrostis purpurascens*, *Carex atrofusca*, *C. bigelowii*, *Chrysanthemum integrifolium*, *Empetrum nigrum*, *Juncus albescens*, *J. castaneus*, *Kobresia simpliciuscula* and *Vaccinium uliginosum*.

Many mosses belonging to the eastern element in the Queen Elizabeth Islands have similar distributions, usually, but not always, reaching northern Ellesmere. *Plagiopus oederiana* and several others are good examples of mosses with ranges of this type which do extend as far as northern Ellesmere Island, but others, although following the same pattern do not quite reach northern Ellesmere (e.g. *Rhytidium rugosum*, whose Canadian arctic range was recently mapped in Kuc 1969).

To find a flora as diverse as that of northern Ellesmere Island one has to go as far as Banks Island in the western Arctic or to the Thule region of northwest Greenland.

Survival of mosses in glacial habitats

That mosses can grow quite well, and even produce sporophytes, in glacial habitats is amply demonstrated by the following data.

1) At least 10 moss species were collected in a moraine area on an ice lobe at the head of Baad Fiord, southern Ellesmere Island: Bryum sp., ?Cynodontium alpestre, Distichium sp., Ditrichum flexicaule, Encalypta procera (with sporophytes), Oncophorus virens, Philonotis fontana, Pohlia annotina, Timmia norvegica, and Tortula mucronifolia (also with sporophytes).

2) Three mosses have been collected on the Ellesmere Island Ice Shelf about 15 km northwest of Ward Hunt Island: Grimmia alpicola (with fruit), Myurella julacea, and Timmia norvegica. These mosses are undoubtedly blown onto the ice shelf from the adjacent land but can remain viable for some time. Polunin (1958) reported that a living moss was collected on Ice Island T-3 when far out in the Arctic Ocean even though the moss cushion (Hygrohypnum polare) had obviously been blown from land onto the ice island.

3) Mosses also grow on high-altitude nunataks very close to the ice margin: Grimmia flaccida (with fruit) on Barbeau Peak, Hypnum vaucheri and Tortula ruralis 30 cm from the ice on a nunatak above Gilman Glacier (Powell 1967).

Long-distance dispersal

Long-distance dispersal of plants and animals has also been used to explain the composition of diverse or anomalous biota. The following points, I believe, indicate that long-distance dispersal by itself does not explain the composition of the northern Ellesmere Island flora satisfactorily.

1) Most moss species (60%) never produce spores in arctic latitudes, and even those that do are not necessarily more widespread than sterile ones.

2) Long-distance dispersal does not explain the absence of a highly disjunct species from intermediate areas. Why should <u>several</u> species be spread by long-distance dispersal to one area only, hundreds or thousands of kilometers from the closest populations?

3) The floristically most diverse area (northern Ellesmere Island) is located exactly where both migration via natural means (i.e. through the dispersal potential normally available to the species) and long-distance dispersal would encounter the most serious and lengthy obstacles — high, ice-covered mountains.

4) Long-distance dispersal would, since it is entirely random, over a long period of time (hundreds or thousands of years) tend to "even out" floristic differences and not enrich the flora of one area repeatedly.

5) Some of the most highly-disjunct plants are the ones with the most specific habitat requirements. Long-distance dispersal is even less probable for these species.

Summary

My studies on the floristics and bryogeography of northern Ellesmere Island have shown that most localities have between 50 and 100 moss species, and that the extreme north coast has a less diverse moss flora than the north-central parts. Tanquary Fiord is the richest locality, with 117 of the 150 species found on the whole of northern Ellesmere.

Almost half of the moss species are either widespread or common on northern Ellesmere, the remainder rare. There appears to be little correlation between fertility and commonness, and habitat specificity restricts only a few species. Forty-two percent of northern Ellesmere mosses produce sporophytes, but only 28% do so regularly.

Northern Ellesmere has a somewhat different moss flora than Peary Land, North Greenland, which is rather unexpected in view of the great similarities between the two regions.

The Queen Elizabeth Islands are subdivided into nine regions for studies on distribution patterns. Forty-three percent of the 232 moss species found there are ubiquitous or widespread. The remainder are rare, restricted to the eastern or southern parts, or occur in the Queen Elizabeth Islands as temperate or low arctic disjuncts.

Although geological evidence indicates heavy glaciation of Ellesmere Island in the past, some northern parts of

the island could have remained free of ice and acted as refugia for plants and animals, at least during the last Pleistocene Glaciation (Wisconsin).

Biological evidence (both zoological and botanical) supports the hypothesis of a high arctic glacial refugium on northern Ellesmere Island during the Wisconsin Glaciation.

Recent studies on bryophytes and vascular plants (especially the presence of endemics, the high arctic bryophyte element, and temperate or low arctic disjuncts) strongly favour a glacial refugium on northern Ellesmere. Floristic diversity, the survival of plants in glacial habitats, and the low probability of long-distance dispersal as an explanation of these anomalous distributions provide further corroborative evidence supporting the hypothesis.

The available evidence indicates that the high arctic refugium postulated for Peary Land was much more likely to have been located on northern Ellesmere Island.

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APPENDIX 1

The species of mosses and vascular plants entering the moss communities of northern Ellesmere Island.

1. Dominant moss species, or those restricted to the community.
2. Moss species commonly occurring in the community.
3. Associated vascular plants, if any.

Hygrohypnum Community

1. Cirriphyllum cirrosum
   Hygrohypnum luridum
   H. polare
   Mielichhoferia macrocarpa
2. Amphidium lapponicum
   Grimmia alpicola
   Seligeria polaris
   Tortella fragilis
3. none

Bryum cryophilum Community

1. Bryum cryophilum
   Grimmia alpicola
   Orthothecium chryseum
   Philonotis fontana
2. Calliergon giganteum
   Timmia norvegica
3. none

Scorpidium scorpioides Community

1. Calliergon giganteum
   Scorpidium scorpioides
   S. turgescens
2. Drepanocladus spp.
3. Carex stans
   Ranunculus hyperboreus

Drepanocladus brevifolius Community

1. Calliergon giganteum
   C. stramineum
   Campylium arcticum
   Drepanocladus aduncus
   D. brevifolius
   D. revolvens
   D. vernicosus
   Grimmia apocarpa var. nigrescens
   Scorpidium turgescens

2. Cinclidium arcticum
   C. latifolium
   Meesia trifaria
   Mnium medium

3. Carex stans
   Draba lactea
   Eriophorum scheuchzeri
   E. triste
   Melandrium apetalum
   Pedicularis sudetica
   Pleuropogon sabinei
   Saxifraga hirculus

Orthotrichum speciosum Community

1. Hypnum procerrimum
   Orthotrichum speciosum

2. Abietinella abietina
   Drepanocladus uncinatus
   Hypnum revolutum
   Orthothecium chryseum
   Tortula ruralis

3. Dryas integrifolia
   Saxifraga oppositifolia

Hylocomium splendens Community

1. Aulacomnium acuminatum
   Drepanocladus uncinatus
   Hylocomium splendens

2. Abietinella abietina

3. Cassiope tetragona
   Dryas integrifolia
   Geum rossii

Aulacomnium-Abietinella Community

1. Abietinella abietina
   Arnellia fennica
   Aulacomnium acuminatum
   A. palustre
   A. turgidum

2. Campylium arcticum
   Ditrichum flexicaule
   Encalypta alpina
   Myurella tenerrima
   Orthothecium chryseum
   Philonotis fontana
   Tomenthypnum nitens

3. Carex misandra
   Cassiope tetragona
   Dryas integrifolia
   Kobresia myosuroides
   Pedicularis capitata
   Salix arctica
   Vaccinium uliginosum

Haplodon wormskjoldii Community

1. Bryum spp.
   Haplodon wormskjoldii
   Leptobryum pyriforme
   Splachnum vasculosum
   Tetraplodon mnioides
   T. paradoxus
   Voitia hyperborea

2. Cinclidium latifolium
   Desmatodon leucostomus
   Encalypta spp.
   Funaria polaris
   Pottia heimii
   Tayloria acuminata

3. none

Bryum argenteum Community

1. Bryum argenteum
   Hypnum revolutum
   Tortula ruralis

2. Abietinella abietina
   Encalypta rhaptocarpa
   Stegonia latifolia

3. Cerastium alpinum
   Draba subcapitata
   Papaver radicatum
   Saxifraga cernua
   Stellaria edwardsii
   S. monantha

Tortella arctica Community

1. Amphidium lapponicum
   Anoectangium tenuinerve
   Bryum calophyllum
   Cinclidium arcticum
   Orthothecium chryseum
   Pogonatum alpinum
   Timmia austriaca
   Tortella arctica
   T. fragilis

2. Bryoerythrophyllum recurvirostrum
   Cirriphyllum cirrosum
   Dicranum elongatum
   Hypnum bambergeri
   Mnium orthorrhynchum
   Scorpidium turgescens
   Seligeria polaris

3. Epilobium arcticum
   Juncus biglumis
   Oxyria digyna
   Ranunculus sulphureus
   Saxifraga caespitosa
   S. flagellaris

Pogonatum alpinum Community

1. Bartramia ithyphylla
   Oncophorus wahlenbergii
   Plagiopus oederiana
   Polytrichum juniperinum
   Tortella fragilis

2. Aulacomnium turgidum
   Conostomum tetragonum
   Timmia austriaca

3. Phippsia algida
   Ranunculus nivalis
   R. sulphureus
   Saxifraga cernua
   S. oppositifolia

Grimmia apocarpa Community

1. Anoectangium tenuinerve
   Grimmia anodon
   G. apocarpa s.l.

2. Orthotrichum speciosum

3. none

Polytrichum hyperboreum Community

1. Polytrichum hyperboreum
   Psilopilum cavifolium

2. Funaria arctica
   Mielichhoferia elongata
   Pohlia annotina
   Pottia heimii

3. none

Pottia heimii Community

1. Desmatodon leucostomus
   Distichium capillaceum
   Pottia heimii
   Tortula mucronifolia

2. Barbula icmadophila
   Bryum spp.
   Distichium hagenii
   Funaria arctica
   Stegonia latifolia

3. Arctagrostis latifolia
   Carex maritima
   Cochlearia officinalis
   Dupontia fisheri
   Equisetum arvense
   Puccinellia phryganodes
   Stellaria humifusa

Bryum-Encalypta Community

1. Barbula icmadophila
   Bryum angustirete
   B. bimum
   B. stenotrichum
   Distichium capillaceum
   Encalypta alpina
   E. rhaptocarpa
   Leptobryum pyriforme
   Pogonatum capillare
   Polytrichum piliferum
   Stegonia latifolia

2. Aloina brevirostris
   Desmatodon leucostomus
   Encalypta procera
   E. vulgaris
   Timmia norvegica
   Tortula mucronifolia

3. Androsace septentrionalis
   Carex nardina
   Draba spp.
   Poa glauca
   P. hartzii
   Potentilla rubricaulis
   Taraxacum spp.

Philonotis-Timmia Community

1. Ditrichum flexicaule
   Philonotis fontana
   Timmia austriaca
   T. bavarica

2. Cinclidium arcticum
   Cyrtomnium hymenophyllum
   Mnium spp.
   Timmia norvegica

3. Luzula nivalis
   Poa arctica
   Salix arctica
   Saxifraga nivalis
   S. oppositifolia
   S. tricuspidata

Rhacomitrium lanuginosum Community

1. Dicranoweisia crispula
   Grimmia apocarpa
   Orthotrichum speciosum
   Rhacomitrium canescens
   R. lanuginosum

2. Hypnum revolutum
   Tortula ruralis

3. none

Cyrtomnium hymenophylloides Community

1. Bryoerythrophyllum recurvirostrum
   Cyrtomnium hymenophylloides
   Dicranella crispa
   Fissidens arcticus
   Isopterygium pulchellum
   Myurella julacea
   M. tenerrima
   Platydictya jungermannioides
   Pohlia cruda

2. Desmatodon leucostomus
   Eurhynchium pulchellum
   Meesia uliginosa
   Mnium orthorrhynchum

3. none

APPENDIX 2.

Distribution of Mosses in the Queen Elizabeth Islands

This appendix documents the distributions of mosses in the Queen Elizabeth Islands. The numbers refer to the regions listed on page 176 and in Fig. 31. Species preceded by an asterisk belong to the high arctic circumpolar element. An abbreviation of the distribution pattern of each species in the Queen Elizabeth Islands is also given, as follows: Ub - ubiquitous, Wa - widespread acidophilic, Wc - widespread calciphilic, Wt - widespread tolerant, E - eastern, SW - southwestern, So - southern outlier, R - rare, Td - temperate disjuncts, —— - unknown.

Species	Region 1	2	3	4	5	6	7	8	9	Distribution Pattern
Sphagnum capillaceum	-	-	-	4	5	-	-	-	-	So
S. fimbriatum	-	-	-	4	-	-	-	-	-	So
S. girgensohnii	-	2	-	-	-	-	-	-	-	——
S. teres	-	-	-	4	-	-	-	-	-	So
Andreaea rupestris	1	2	3	4	5	6	7	8	9	Wa (Fig. 34)
Fissidens adianthoides	-	-	3	-	-	-	7	-	-	So (Fig. 41)
*F. arcticus	1	2	3	-	-	-	7	-	-	Wc (Fig. 42)
F. exiguus	-	-	3	-	-	-	-	-	-	——
F. osmundioides	[illegible]	2	-	-	5	-	-	-	-	R
F. viridulus	1	2	3	-	-	-	-	-	-	E
Ditrichum flexicaule	1	2	3	4	5	6	7	8	9	Ub (Fig. 33)
*Saelania glaucescens	-	2	3	-	-	-	-	-	-	E
*Ceratodon heterophyllus	-	-	-	-	-	-	-	8	-	SW
C. purpureus	1	2	3	4	5	-	7	8	9	Wt
Distichium capillaceum	1	2	3	4	5	6	7	8	9	Ub
*D. hagenii	1	2	3	-	5	-	-	8	-	Wc
D. inclinatum	1	2	3	4	5	-	7	-	9	Wt
*Seligeria polaris	1	2	3	-	-	-	7	-	-	E (Fig. 42)
S. pusilla	1	-	-	-	-	-	-	-	-	Td (Fig. 43)
Blindia acuta	-	2	-	-	5	-	-	-	-	R

Trematodon brevicollis	-	-	-	-	5	-	-	-	-	R	
Dicranella cerviculata	-	-	3	-	-	-	-	-	-	—	
D. crispa	1	-	-	-	-	-	-	-	-	R	
Amphidium lapponicum	1	2	3	-	-	-	7	8	-	Wa	
Cynodontium alpestre	-	-	3	-	-	-	-	-	-	—	
C. gracilescens	-	2	-	-	-	-	-	-	-	—	
C. polycarpum	-	-	-	4	-	-	-	-	-	—	
C. schisti	-	2	-	-	-	-	-	-	-	—	
Dichodontium pellucidum	1	2	3	-	-	-	-	-	-	E	
Dicranoweisia crispula	1	2	3	-	5	6	-	8	9	Wa	(Fig. 34)
Oncophorus virens	-	2	3	-	5	-	-	-	-	E	
O. wahlenbergii	1	2	3	-	5	6	7	8	9	Wa	(Fig. 34)
*Arctoa andersonii	1	-	-	-	-	6	-	8	-	R	(Fig. 38)
Dicranum acutifolium	1	-	-	-	-	-	-	-	-	R	
D. elongatum	1	2	3	4	5	-	7	-	9	Wa	
D. fuscescens	1	2	3	4	5	6	-	8	-	Wa	
D. groenlandicum	-	-	3	4	5	-	-	-	-	E	
D. laevidens	-	-	-	-	-	-	7	8	9	SW	(Fig. 41)
D. majus	1	-	-	-	-	-	-	-	-	—	
D. muehlenbeckii	-	2	3	4	-	-	-	-	-	E(?)	
D. scoparium	1	-	-	4	-	-	-	-	-	E(?)	
D. spadiceum	-	2	3	-	-	-	-	-	-	—	
D. undulatum	-	2	-	-	-	-	-	-	-	—	
Encalypta affinis	-	-	3	-	5	-	-	-	-	R	
E. alpina	1	2	3	4	5	-	7	8	9	Ub	
E. ciliata	-	-	-	-	-	-	7	-	-	So	
E. procera	1	2	3	4	5	-	7	8	9	Wt	
E. rhaptocarpa	1	2	3	4	-	-	7	8	9	Ub	
E. vulgaris	1	-	3	-	-	-	-	-	-	E	
*Bryobrittonia pellucida	1	-	-	-	5	-	-	8	-	R	
Anoectangium tenuinerve	1	2	3	-	-	-	7	8	9	Wt	(Fig. 36)
Gymnostomum recurvirostrum	1	2	3	-	-	-	7	-	-	Wt	
*Trichostomum cuspidatissimum	-	-	-	-	-	-	7	8	9	SW	(Fig. 41)
*Tortella arctica	1	2	3	-	5	-	7	8	?	Wt	(Fig. 37)
T. fragilis	1	2	3	4	5	-	7	-	-	Wt	
*Didymodon asperifolius	1	2	3	-	-	?	7	8	9	Wt	
Bryoerythrophyllum recurvirostrum	1	2	3	4	5	6	7	8	9	Ub	

Barbula icmadophila	1 - 3 4 - - 7 8 9	Wc (Fig. 35)
*B. johansenii	- - - - 5 - - - -	SW
*Pottia heimii (var. arctica)	1 2 3 4 5 - 7 8 9	Wc (Fig. 35)
Stegonia latifolia	1 2 3 - 5 - 7 8 -	Wc
*Pterigoneurum arcticum	- - - - 5 - 7 - -	SW
Desmatodon cernuus	1 - - - - - - - -	—
D. latifolius	1 2 3 4 - - 7 - -	E (?)
D. laureri	- 2 3 - - - - - -	—
*D. leucostomus	1 2 3 4 - - 7 8 9	Wc (Fig. 35)
D. systylius	- 2 3 - 5 - - - -	—
Aloina brevirostris	1 - 3 - 5 - - - -	Wc
Tortula mucronifolia	1 2 3 4 - - 7 8 9	Wc (Fig. 35)
T. norvegica	1 2 3 4 - - 7 - -	—
T. ruralis	1 2 3 4 5 6 7 8 9	Ub (Fig. 33)
Grimmia alpestris	1 - - - - - - - -	R
G. alpicola	1 - - 4 - - 7 - -	E
G. anodon	1 - 3 - - - - - -	E (Fig. 40)
G. apocarpa	1 2 3 4 5 6 7 8 9	Ub
G. elongata	- 2 - 4 - - - - -	E
G. flaccida	1 - - - - - - - -	Td
G. ovalis	- 2 3 - - - - - -	E?
G. plagiopodia	1 - - - - - - - -	Td
*G. tenera	1 - - - - - - - -	—
G. torquata	1 2 - - - - 7 - -	R
Rhacomitrium canescens	1 2 3 4 5 6 7 8 9	Wa
R. heterostichum	- - - ? - - - 8 -	—
R. lanuginosum	1 2 3 4 5 6 7 8 9	Wa
*Funaria arctica	1 - 3 - 5 - - - -	E
*F. polaris	1 - 3 - - - - - -	E (Figs. 39, 42)
*Voitia hyperborea	1 2 3 - - - 7 8 9	Wt (Fig. 43)
Tayloria acuminata	1 2 3 - - - 7 - -	R
Tetraplodon mnioides	1 2 3 4 5 - 7 8 9	Ub (Fig. 39)
*T. paradoxus	1 2 3 - - - - - 9	Wt (Fig. 39)
*Haplodon wormskjoldii	1 2 3 4 5 - 7 8 9	Wt
Splachnum vasculosum	1 2 3 4 - - 7 8 9	Wt (Fig. 39)
Mielichhoferia elongata	1 - - - - - - - -	Td
*M. macrocarpa	1 2 3 4 - - - - -	E (Fig. 43)
M. mielichhoferi	1 - - - 5 - - - -	Td (Fig. 43)
Pohlia annotina	1 - 3 - 5 - - - -	E (Fig. 40)
P. cruda	1 2 3 4 5 6 7 8 9	Ub
P. crudoides	- - - - - 6 - - -	—
P. drummondii	- 2 3 - - - - - -	—
P. gracilis	- - - - 5 6 - - -	—

Pohlia ludwigii	- - - 4 - - - - -	—
P. nutans	1 2 3 4 5 6 - 8 -	Wt
P. proligera	1 - - - - - - - -	—
P. wahlenbergii	1 - - - 5 6 - - -	R
Anomobryum concinnatum	- 2 - - - - - - -	—
Plagiobryum demissum	- 2 - - - - - - -	—
Leptobryum pyriforme	1 2 3 4 - 6 7 8 -	Wc
Bryum angustirete	1 2 3 4 - - 7 8 9	Wt
*B. arcticum	1 2 3 4 - - - - 9	Wt
B. argenteum	1 2 3 4 5 - - - -	E
B. bimum	1 2 3 4 5 6 7 - -	Wt
B. brachyneuron	- - 3 - - - - - -	—
B. calophyllum	1 2 3 4 - - 7 - 9	Wc
B. capillare	1 2 3 4 - - - - -	E
B. creberrimum	- 2 - - - - 7 - 9	R
*B. cryophilum	1 2 3 4 5 6 7 8 -	Wt
B. knowltonii	1 2 3 - - - 7 - -	R
B. lonchocaulon	- 2 3 - - - - - -	—
B. neodamense	1 - - - - - - - -	—
B. nitidulum	1 2 - 4 - - - - 9	Wt
B. pallens	- 2 3 4 - - - - -	E(?)
B. pallescens	- 2 3 - - - - - -	—
B. pseudotriquetrum	- 2 3 4 5 - - - -	E(?)
B. purpurascens	1 2 3 4 - 6 7 - 9	Wt
B. salinum	- 2 3 - - - 7 - -	—
B. stenotrichum	1 2 3 - - - 7 - -	Wt
B. teres	- 2 3 4 - - - - -	—
B. tortifolium	- 2 3 - - - ? - -	—
B. turbinatum	- 2 - - - - - - -	—
B. weigelii	- - - - - - - 8 -	—
*B. wrightii	- - 3 - - - 7 - -	So
Mnium affine	1 2 3 4 - - 7 8 -	Wt
*M. andrewsianum	- - - - - - 7 - -	So
*M. blyttii	1 - 3 - - - 7 8 -	Wt
M. marginatum	1 - - - 5 - - - 9	—
M. medium	1 2 3 4 - - - - 9	Wt
M. orthorrhynchum	1 2 3 4 - - 7 8 -	Wt
M. pseudopunctatum	- 2 3 4 - - - - -	—
M. punctatum	- 2 3 - - - - - -	—
*Cyrtomnium hymenophylloides	1 2 3 4 5 - - 8 -	Wt
*C. hymenophyllum	1 2 3 4 5 - 7 8 -	Wt
*Cinclidium arcticum	1 2 3 4 5 - 7 - 9	Wt
*C. latifolium	1 - - - - - 7 8 -	R (Fig. 38)
C. stygium	- - 3 - - - 7 8 -	So
C. subrotundum	- 2 3 4 - - 7 8 -	Wt
*Aulacomnium acuminatum	1 - 3 4 - - 7 8 -	Wt (Fig. 37)
A. palustre	1 2 3 4 - - 7 8 -	Wa
A. turgidum	1 2 3 4 5 6 7 8 9	Ub (Fig. 33)
Paludella squarrosa	- - - 4 - - - - -	So (Fig. 41)
Meesia trifaria	1 2 3 4 - - 7 8 9	Wa

	1	2	3	4	5	6	7	8	9	
Meesia uliginosa	1	2	3	-	5	6	7	8	9	Wt (Fig. 36)
Catoscopium nigritum	1	2	3	4	-	-	7	8	-	Wa
Plagiopus oederiana	1	-	3	-	-	-	-	-	-	E (Fig. 40)
Bartramia ithyphylla	1	2	3	4	-	6	7	8	9	Wa (Fig. 34)
Conostomum tetragonum	1	2	-	4	5	6	-	8	-	Wa
Philonotis caespitosa	-	-	3	-	-	-	-	-	-	—
P. fontana	1	2	3	4	5	6	7	8	9	Ub
Timmia austriaca	1	2	3	4	5	6	7	8	9	Ub
T. bavarica	1	-	3	4	-	-	-	-	-	E (Fig. 40)
T. comata	-	-	-	-	5	-	?	-	-	—
T. megapolitana	-	-	-	4	-	-	-	-	-	—
T. norvegica	1	-	3	4	-	-	7	8	9	Wt
Orthotrichum alpestre	-	-	3	-	-	-	-	-	-	So
O. microblepharum	-	-	-	4	-	-	-	-	-	So
O. speciosum	1	2	3	4	-	-	7	8	9	Ub
Myurella julacea	1	2	3	4	5	6	7	8	9	Ub
M. tenerrima	1	2	3	4	5	6	7	8	9	Ub
Leskeella nervosa	-	-	3	-	-	-	7	-	-	—
Abietinella abietina	1	-	3	4	5	-	7	8	-	Wt (Fig. 36)
Cratoneuron filicinum	1	2	3	4	5	-	7	8	9	Wc
*Campylium arcticum	1	2	3	-	-	6	7	8	9	Wt
C. hispidulum	-	-	-	4	-	-	-	-	-	—
C. polygamum	-	2	3	4	5	-	-	-	-	—
C. stellatum	-	2	3	4	-	-	-	-	9	—
Amblystegium varium	-	-	-	-	-	-	7	8	-	—
Platydictya jungermannioides	1	2	3	4	5	-	7	8	9	Ub
Drepanocladus aduncus	1	2	3	4	-	-	7	-	9	Wc
*D. badius	1	2	-	-	5	-	7	-	-	E
D. berggrenii	-	-	3	-	-	-	-	-	-	—
*D. brevifolius	1	2	3	4	-	6	7	-	9	Wt (Fig. 36)
D. exannulatus	1	2	-	-	-	6	7	-	-	R
D. fluitans	1	-	-	4	-	-	-	-	-	E(?)
*D. lycopodioides	1	-	-	-	-	-	7	8	-	—
D. revolvens	1	2	3	4	5	6	7	8	9	Ub
D. tundrae	-	2	3	4	-	6	-	-	-	R
D. uncinatus	1	2	3	4	5	6	7	8	9	Ub
D. vernicosus	1	-	3	-	-	-	-	-	-	E
Hygrohypnum luridum	1	-	3	-	-	-	-	-	-	E
*H. polare	1	2	3	-	5	6	-	8	-	Wt
Calliergon cordifolium	-	-	-	-	-	-	-	8	?	—
C. giganteum	1	2	3	4	-	-	7	8	9	Wt
C. richardsonii	-	-	3	-	5	-	7	-	9	R
C. sarmentosum	1	2	3	4	5	6	7	8	9	Wt
C. stramineum	1	-	3	4	-	-	-	8	-	R (Fig. 38)
C. trifarium	-	2	3	4	-	-	7	-	-	R
Scorpidium scorpioides	1	2	-	4	-	-	7	-	-	E?
S. turgescens	1	2	3	4	5	-	7	8	9	Wt
Tomenthypnum nitens	1	2	3	4	5	-	7	8	9	Ub?
Brachythecium groenlandicum	1	-	-	-	-	-	-	-	9	—
B. turgidum	1	-	3	4	-	-	7	-	9	Wt

	1	2	3	4	5	6	7	8	9	
Cirriphyllum cirrosum	1	2	3	4	5	6	7	8	9	Ub
Eurhynchium pulchellum	1	2	3	4	5	-	7	8	-	Wc
Pterigynandrum filiforme	-	-	3	-	-	-	-	-	-	—
Orthothecium acuminatum	-	2	3	-	-	-	-	-	-	E
O. chryseum	1	2	3	4	5	6	7	8	9	Ub
O. intricatum	-	2	3	4	-	-	7	-	-	R
O. strictum	1	2	3	4	-	-	7	8	9	Wt
Hypnum bambergeri	1	2	3	4	-	-	7	8	9	Ub
H. callichroum	1	-	-	-	5	-	7	8	-	R
H. cupressiforme	1	-	-	-	-	-	7	8	-	R
H. hamulosum	1	2	3	4	5	-	-	-	-	E
H. lindbergii	-	-	-	4	-	-	-	-	-	—
H. pallescens	-	-	-	4	-	-	-	-	-	—
H. pratense	-	-	-	4	-	-	7	8	-	R
H. procerrimum	1	-	3	4	-	-	7	8	-	Wt
H. revolutum	1	2	3	4	5	6	7	8	9	Ub
H. subimponens	1	-	-	-	-	-	-	-	-	E
H. vaucheri	1	2	3	4	-	-	7	-	9	Wt
Isopterygium pulchellum	1	2	3	4	-	-	-	8	-	Wc
Ctenidium molluscum	-	-	-	-	-	-	-	8	-	SW
Rhytidium rugosum	-	-	-	4	5	-	-	-	-	So
Hylocomium splendens	1	2	3	4	5	6	7	8	9	Wa
*Oligotrichum falcatum	-	-	-	-	5	-	-	-	-	R
*Psilopilum cavifolium	1	?	?	4	5	6	7	8	9	Wc (Fig. 37)
*Philocrya aspera	1	-	-	-	-	-	-	-	-	R (Fig. 42)
Pogonatum alpinum	1	2	3	4	5	6	7	8	9	Ub (Fig. 33)
P. capillare	1	-	3	-	5	6	-	8	-	Wt (Fig. 38)
P. urnigerum	-	-	3	-	5	-	-	-	9	So
*Polytrichum hyperboreum	1	2	-	4	-	-	7	-	9	Wc (Fig. 37)
P. juniperinum	1	2	3	4	5	6	-	8	9	Wa
P. piliferum	1	-	3	4	5	6	-	8	9	Wa
P. swartzii	-	2	-	-	-	-	-	-	-	—

Totals:

Region 1 (Northern Ellesmere)	150 species
Region 2 (Central Ellesmere)	138 species
Region 3 (Southern Ellesmere)	155 species
Region 4 (Devon)	117 species
Region 5 (Axel Heiberg)	79 species
Region 6 (Ringnes)	46 species
Region 7 (Bathurst)	113 species
Region 8 (Prince Patrick)	96 species
Region 9 (Melville)	76 species
Total (Queen Elizabeth Islands)	232 species

APPENDIX 3

Excluded species

The following records must be considered doubtful, for one reason or another, and I have not included them in my bryogeographical analysis of the Queen Elizabeth Islands. The number(s) following the name indicates the region(s) from which the species was reported.

Barbula rigidula 4 (see Steere 1948)
Brachythecium albicans 4
B. glareosum 7 (see Crum et al. 1965)
B. salebrosum 2, 3, 4, 7, 8
B. trachypodium 9
Dicranella heteromalla 3 (see Steere 1948)
Camptothecium lutescens 7 (see Crum et al. 1965)
Gymnostomum rupestre 3
Hygrohypnum alpestre 5
H. cochlearifolium 5
H. eugyrium 7
H. ochraceum 4
Hypnum bridelianum 3
H. plicatulum 7
Kiaeria blyttii 4
Oreoweissia serrulata 8 (see Crum et al. 1965)
Orthothecium rufescens 7
Pohlia bryoides 9 (see Andrews 1940)
P. longicolla 2
Rhacomitrium brevisetum 2
Tortella tortuosa 5
Tortula muralis 3

The following reports have been included under other species, as indicated.

Andreaea papillosa 2, 3 (A. rupestris)
Cratoneuron curvicaule 5 (C. filicinum)
Dicranum congestum 5 (D. fuscescens)
Drepanocladus latifolius 2, 3, 4 (D. brevifolius)
D. latinerve 2 (D. brevifolius)
Encalypta streptocarpa 2, 3, 4 (E. procera)
Grimmia conferta 2 (G. apocarpa)
Pohlia camptotrachela 5 (P. annotina)
Polytrichum fragile 2, 5 (Pogonatum alpinum)
P. strictum 2, 3, 4, 5 (P. juniperinum)
Pottia papillosa 3 (P. heimii var. arctica)
Sphagnum rubellum 5 (S. capillaceum)

I have also omitted many older reports of poorly-known Bryum species, in most cases accepting the synonymy cited in Andrews (1940), Crum et al. (1965) or Nyholm (1958).