THE BOGS OF CENTRAL LABRADOR-UNGAVA:

an examination of their physical characteristics.

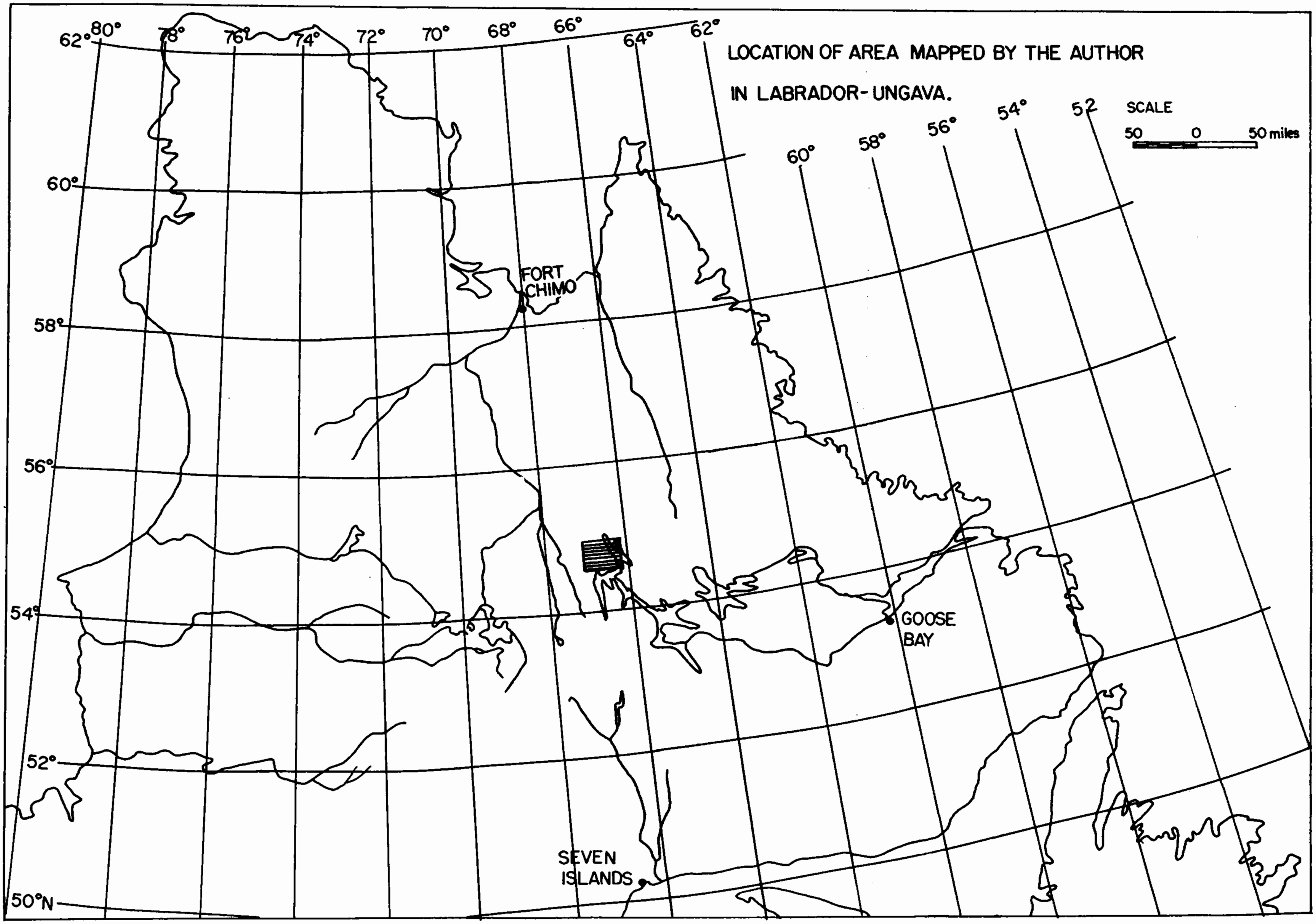
by

Kathleen R. Allington

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfilment of the requirements for the degree of Master of Science.

Department of Geography,
McGill University,
Montreal.

June 1959


LOCATION OF AREA MAPPED BY THE AUTHOR
IN LABRADOR-UNGAVA.
SCALE
50 0 50 miles
FORT CHIMO
GOOSE BAY
SEVEN ISLANDS
62°
80°
78°
76°
74°
72°
70°
68°
66°
64°
62°
60°
58°
56°
54°
52
60°
58°
56°
54°
52°
50°N

"On all sides are patches of Caribou Moss, bog and hundreds of small lakes .... the general impression being one of bleak monotony and uselessness in which the silence of primordial time reigned supreme"

Tanner.

ACKNOWLEDGEMENTS

This study was made possible by the Defence Research Board of Canada, who granted financial assistance for one field season at Knob Lake, Quebec; and in addition, two residential sessions at McGill University.

The author is indebted to Mr. R. N. Drummond, sometime Director of the McGill Sub-Arctic Research Laboratory at Knob Lake, who accompanied her in the field on several occasions. Thanks are also due to Dr. N. W. Radforth, with whom the author exchanged ideas during a brief visit to the laboratories at Macmaster University, and to M. Paul Simard who was an excellent guide and provided transport during a four day stay in Seven Islands, Quebec, where bogs were examined for comparative purposes.

Lastly the author is most grateful for all the assistance given by students at the McGill Sub-Arctic Research Laboratory, during the summer of 1957. In particular, thanks must go to Mr. Alan Cooke, who was a long-suffering companion on many occasions, yet managed to retain considerable interest in the phenomena of bog vegetation.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

a. Purpose of the Study

The material presented in this thesis is drawn from investigations made during a three month field season at the McGill Subarctic Research Laboratory. During May, June and September, 1957, a study of the bogs in the Knob Lake area was made. The primary objective was to make a field check on a classification which had been made from air photographs during the winter of 1956-57. It is not intended as a Botanical study, but is a consideration of the physical characteristics and surface features, in an attempt to explain their mode of occurence. It is hoped that the study may provide useful material in a large scale study which is being made at McGill University, namely that of the radiation and moisture balances of Labrador-Ungava.

Five main categories were established, and one of these, the string bog, presented several interesting problems. W. H. Drury of Harvard (13) has made a study of bogs in the Kuskokwim River region of Alaska and many of the observations made at Knob Lake are similar. At the time of these field investigations, no work on this subject had been done in North Eastern Canada, but the author was interested in making this a comparative study. However, in October 1957 a paper was published by Hamelin (18) in which he describes these phenomena in the Knob Lake area.

It would be impossible to try and reach any definite conclusions as to the reasons for the formation of these different types of bog, during such a short field season, but it is hoped that this thesis will provide an introduction to further study on the problem.

b. Previous work in this field

Tanner (51, 1944) has said that ...."an analysis of the types of plant communities of swampy ground based on aeropictures would be interesting". Since then more detailed studies of muskeg in the Sub-Arctic have been made, but up to the time when the author became interested in the problem, no research of this kind had been done in Labrador-Ungava. Both Tanner (op.cit.) and Wenner (58, 1947) describe the string bog phenomena in some detail, but neither were concerned directly with the problem of their formation. Botanists and Paleobotanists have been interested in the area, but as bog formation is so much more widespread in the Hudson Bay Lowlands and westwards, botanical studies are more abundant for those areas (e.g. Sjors, 50). Hustich includes a description of muskeg vegetation in his discussion of Forest Classification in Labrador-Ungava, although again he was not primarily concerned with their origin (24). Potzger and Courtemanche (41) working in the same area, discussed the distribution of muskeg and correlated this with the depth of the permafrost table, but like Wenner, Pollen Analysis was their main field of interest.

Outside Labrador-Ungava, botanical work in muskeg areas is abundant. For example, Lewis and Dowding (31) and Moss (37) have all studied the peat regions of Alberta, whilst the interests of Dachnowski (8), Dansereau (9) and Rigg (47) are more geographically widespread in North America. In all these cases however, the authors have been primarily interested in the description of plant communities in these wet areas and the problems involved. These studies have been useful for comparative purposes, but they are essentially different from the present study which was intended an an investigation of physical relationships rather than a botanical study. Most of these authors discuss the different species growing in different bog habitats, and the reasons for their distribution, but rarely are any attempts made to account for the bog types.

Attempts to explain the relationship between the vegetation and subsurface characteristics, and an interpretation of the latter from aerial photographs have been made by Dr. Radforth of McMaster University (44) and Benninghoff (3). Again these studies were made west of Hudson Bay, and the object was primarily to predict the subsurface conditions for engineering purposes, rather than to explain their occurrence.

The intended study for Labrador-Ungava was similar to those made elsewhere by Auer (1), Drury (13) and Von Post (39). Auer described peat bogs in South Eastern Canada, and was mainly concerned with the surface features and types of peat. Drury, working in Alaska, applied Auer's theory of bog formation to his area and his conclusions provide an interesting comparison to the present work, as he was dealing with an area intermittently underlain by Permafrost. Von Post, working mainly in Northern Europe made a classification of bogs based on climate and water supply. Similar work has also been done in Russia by Katz (29) who established three main categories of bog formation, again based on water supply.

It is apparent therefore, that while similar work has been done in this field, little study has been done in the area east of Hudson Bay. Hamelin, in the paper mentioned above (18) considered that the mode of occurence of String Bog was mainly a geomorphological problem. This work was coincident with these investigations, and although the author was unaware of it at the time, it is the only study of a similar kind in this area.

c. Method of Research

The most important task to be undertaken before the summer field work could be carried out, was the mapping of bog vegetation from air-photographs. A classification was established, and each type was mapped separately so that the total area covered by each could be measured. It was desirable that a fairly accessible area should be chosen for mapping, in order that summer field work would provide an accurate check. The choice of the Knob Lake area was originally made because McGill University has excellent facilities at its Sub-Arctic Research Laboratory. Also, from a practical standpoint, field work in this area of the Labrador trough is facilitated by the presence of roads which have been constructed for the iron ore development. Subsequent reading has shown, however, that this area does not in fact show muskeg development at its best: both the lower reaches of the

Hamilton river and the area to the west of James Bay display more extensive and spectacular muskeg areas. However, a brief examination of the aerial photographs utilised by workers in these areas (Coombs, 6 and McKay, 36) showed that the muskeg in the vicinity of Knob Lake did not appear to differ significantly in surface characteristics.

The selection of air-photographs was made during a two day visit to the National Air Photograph Library in Ottawa. Those chosen were from a special flight series (taken from 9500 ft.) which was made east and west from Knob Lake itself, but covering a relatively small area, as the series was intended to aid the siting of communications for the town. In all, 56 photographs from this series were obtained, covering an area of 144 square miles to the east of Knob Lake. It was not necessary to use a stereoscope to map the surface vegetation, and therefore a complete cover could be obtained by using alternate photographs on each flight line. The photographs were ordered at normal size, but with a glossy finish, as this helped to bring out the detail. The photographs were of excellent quality, only one or two of the set having slight traces of cloud obscuring the landscape features. Previous mapping of vegetation in this area (in the Geography Department at McGill University) had been made from high altitude photographs with the objective of classifying vegetation as a whole. This study, concerned fundamentally with subdivision in the muskeg type, was accomplished more easily from these low altitude photographs.

The base map used was a blueprint of the Knob Lake area showing water and contours only. As the purpose of the study was to produce a detailed map on a large scale, this provided an admirable base. The template method was employed for the mapping, that is, a square was cut in a piece of polythene, having the exact size of the area covered by an air-photograph at the scale of the map. The detail from each photograph was then drawn in the appropriate position on the base map. This method was used to complete about a third of the map, which was the accessible area for the field check.

The remainder of the map had to be completed by a different method because the special series of low altitude photographs did not cover the whole area. The northern part of the map has only been photographed from 17,000 feet. From this height it is difficult to distinguish divisions in the muskeg with the same accuracy as from the photographs at 9,500 feet. Further, the template method could not be used as the scale of the photographs was smaller than that of the map. The mapping had to be done by eye, using the small lakes as co-ordinates when mapping the muskeg areas near to them. The accuracy of mapping in this way was reasonable, though obviously not as great as by the template method. In this way, the total map area of 311 square miles was completed.

The mapping being completed, it was necessary that a field study should be made to check the validity of the classification. During May and June, a period of six weeks was spent in the field, during which time as many bogs as possible were examined. A surface study was made of each, and notes were made according to the system suggested by

MacFarlane (34), but with some additional observations. The most important of these was a note of how each bog had originally been mapped from air-photographs, and any errors in this mapping revealed by the field investigation. This field check included observations of cover type, surface topography and the situation of the bogs. A copy of the MacFarlane field system and description of some of the bogs visited, may be found in the Appendix.

At the end of June the ground was still frozen to a depth of about a foot, and it was impossible to do any sub-surface investigations. By the end of August, the bogs were unfrozen and more detailed studies could then be made. Ice lenses were found in September in two bogs, being about three inches thick and a foot below the surface, but these were probably merely a result of local micro-climatological conditions.

A Hillel Corer[1] was used, and borings were made along transverse and longitudinal sections of the bogs. The object was to determine the bog's depth and sub-surface topography and to examine the type of material at various depths. The author was interested not so much in the content of the organic material as in its percentage water-content

---

1. Samples could be taken fairly quickly with this type of borer, but it proved to be rather cumbersome when long distances had to be covered on foot. The aluminum type described by Potzger and Courtemanche (41) would undoubtedly be more satisfactory for this type of work.

The author with the help of fellow students from the McGill Subarctic Research Laboratory, using the Hillel Bog Borer to study the characteristics of the subsurface material. These photographs were taken in June when the bogs were still firm owing to the presence of ice near to the surface. Holes were made in the ice (in some cases) in order that borings could be made.

Section cut through well consolidated peat. The total depth is 6'6". The material at the base of the peat is thick plastic clay, about 6" in depth, overlying grey shale. Quantities of shattered shale had been dumped on the surface of the bog by the mechanical shovel,and can be seen at the top of the photograph. The surface cover of this bog is *Sphagnum* with a dense shrubby growth.

by weight and its consistency. Samples of this material were dried in the laboratory in order that the comparitive quantities of water might be measured in the types of peat under different surface conditions.

At the end of June, the surface of the bogs was still frozen, but it was found that in several places there were gaps in the ice and it was possible to make borings through these gaps. This was of necessity random sampling, and for this study was of little value. An ice borer was used to measure the thickness of the ice and also to prove that the base of the bog was bedrock rather than permafrost. In two cases the author is indebted to the Iron Ore Company of Canada who had excavated on the margin of bogs in order to lay drains. The channels were both about three yards across and exhibited a 7 ft. vertical section in the peat, down to the bedrock.

Measurements were also made of the angle of slope on the bogs because it was thought that there might be some relationship between the slope and the surface topography. These were made with an Abney level and measuring pole.

This more detailed work was only carried out on a few bogs which were selected as being representative of their type according to the classification outlined below. The writer was working on the assumption that similar sub-surface and hydrographic conditions had resulted in the same type of bog vegetation. A great amount of work remains to be done in this field before any definite answers can be given, but the author hopes that the observations of this one field season will be the beginning of further study on the problem in this part of Canada.

PHYSIOGRAPHIC DIVISIONS OF LABRADOR-UNGAVA

Horsts. Faulted uplifted blocks

1.	Torngats	2.	Mealy Mountains

Folded Belts

3.	Belcher Nastopoka	4.	Labrador Trough
5.	Mistassini		

Plateau Peneplain

6.	Ungava Peninsula	7.	Northern Atlantic Labrador
8.	Southern Atlantic Labrador	9.	Lake Plateau
10.	Laurentide Scarp	13.	East Main Slope

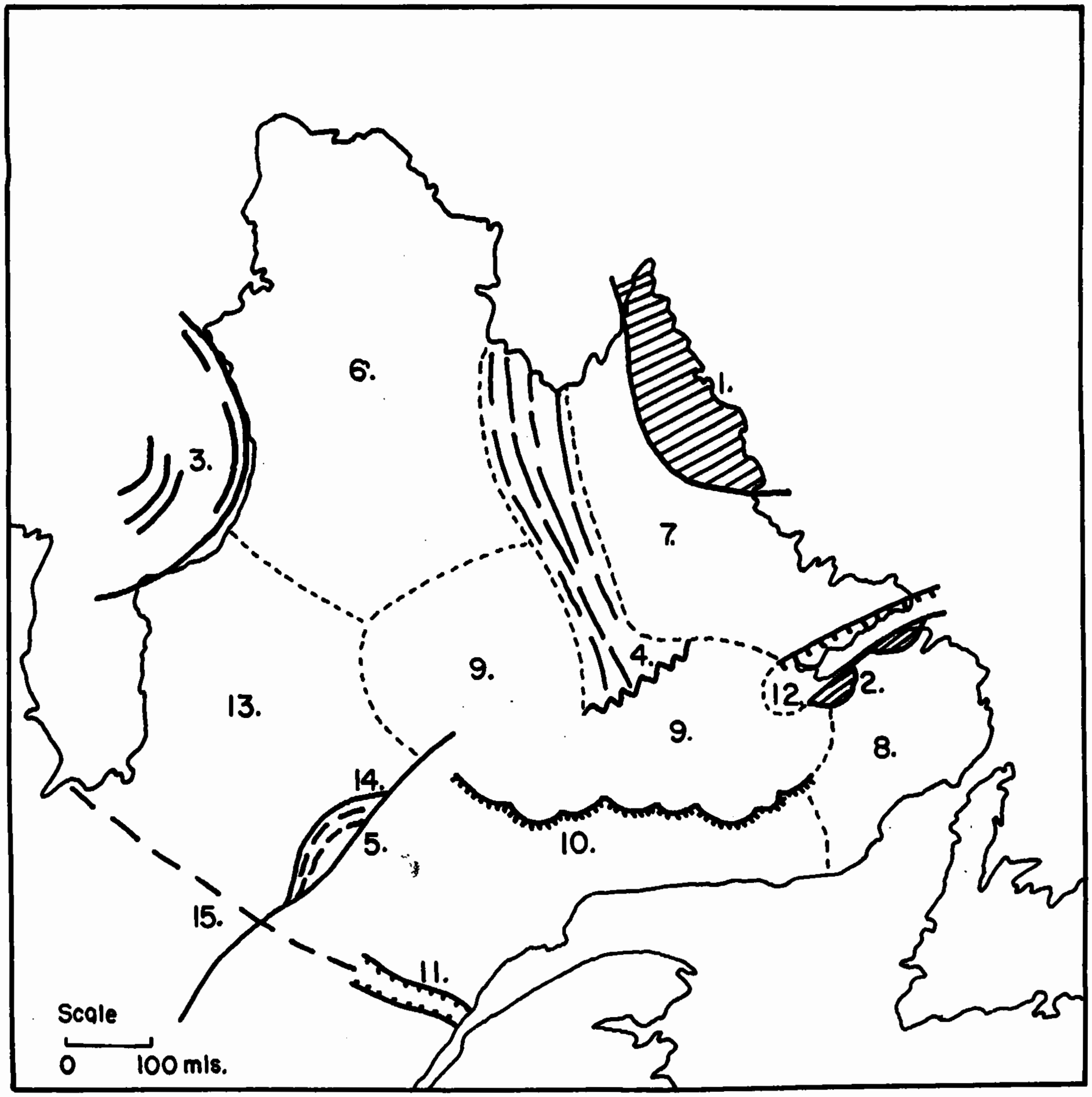
Graben. Structural Depression

11.	Saguenay - Lake St. John	12.	Lake Melville

Miscellaneous

16.	Mistassini Watershed	15.	Southern Boundary

Fig. I PHYSIOGRAPHIC DIVISIONS OF LABRADOR-UNGAVA. (after Hare)



CHAPTER II

PHYSICAL CHARACTERISTICS

a. Geology and Geomorphology

The peninsula of Quebec-Labrador is almost entirely composed of Pre-Cambrian shield. The area has been subjected to a long and complex history of uplift and peneplanation, and is at present in a state of gradual emergence, subsequent to the last glaciation. As a result, the area at present consists of a high interior plateau which rises to a maximum height in the south and south-east. The areas of lowest elevation are in the west, around Hudson's Bay and in the north around Ungava Bay. There are two main regions of uplift (see fig. 1) in the north-west, and the Torngat Mountains in the north-east. Apart from these, the plateau has an undulating surface of low relief and seemingly unending monotony. The edge of the plateau in the south is marked by an abrupt scarp, about 30 miles inland from the north shore of the St. Lawrence Gulf. Rivers flowing south, in the opposite direction to the slope of the plateau, have made deep incisions into this scarp edge, so that when seen from the coast, it appears as a range of mountains.

Knob Lake is situated about 350 miles north of this plateau rim at latitude 54° 48' N. and longitude 66° 48' W. Fifteen miles to the west of the town is the junction of the Pre-Cambrain granite-gneiss and the younger interbedded sedimentary and volcanic rocks of the Labrador Trough. There are then two main rock series in the Knob Lake area, the older basement complex or granite-gneiss and a younger series of Sedimentary rocks. The latter were deposited in an arm of the sea which invaded the land in late Pre-Cambrian times. This trough is about 400 miles long trending north west to south east, in which about 2000 ft. of shales and sandstones were deposited. Subsequent compression from the northeast resulted in a complex series of folds and faults but with an overall synclinal structure. Hence the term 'Trough' is used as a description of the area's structure and not on account of its lower elevation. Apart from the trough, the remainder of the district is remarkably uniform, being a seemingly endless, undulating plateau of low rounded hills.

In their work on the Physiographic regions of Labrador-Ungava, Douglas and Drummond (11) distinguish between areas of drift and bare rock outcrops. Amongst the latter is the Upper Hamilton River area of Central Quebec-Labrador and the Trough. The survey, however, only distinguishes between early rocks, Pleistocene Deposits and later sediments. More recently geological surveys have been carried out by the Iron Ore Company of Canada as a result of the discovery of ore in the rocks of the trough (e.g. Gustafson and Moss 1953, 16). It is not intended here, however, to discuss the geology of the area any further as the two broad divisions already described above are sufficient to account for the forms of bog vegetation which are to be described. The results of the Glaciation have considerable importance. There is no evidence to suggest that the plateau has been submerged since Palaeozoic times and hence we may assume that since that time it has been subject to subaerial erosion. The history of the denudation is complex as it was interrupted by periods of uplift and warping, but in general the resulting landscape prior to the development of an ice sheet was an undulating area which was cut into by rejuvenated streams in the east and south. This was the surface which was modified by the ice.

In North America, four major periods of Glaciation are generally recognised, the Nebraskan being the first, followed by the Kansan, Illinoian and Wisconsin. Within the latter, four substages have been distinguished, the Iowan, Tazewell, Cary and Valders (see Flint 1947, 14). There is reason to believe that more than one glaciation has been experienced in the area under consideration, although Lougee (33) finds there is little support for the theory of multiple glaciation. The date for the retreat of the ice will be discussed in more detail later, as it is obviously of fundamental importance in the history of the vegetation in the area. It is thought, however, from Carbon 14 dating that the Knob Lake area became free of ice about 7000 years ago. The retreat of the ice unveiled a new landscape dominated by the presence of glacial till. The pre-glacial landscape was modified to such an extent that the resultant drainage system had become chaotic. Former river valleys had become choked with debris and new, shallow lakes had been formed. This provided the starting point for the disorganised drainage system of today, which is characterised by the widespread occurence of swamps and bogs. Glacial till is common in Knob Lake area, evidence suggesting that even the highest hills were submerged beneath the ice, and hence its distribution is widespread.

The landscape can then be described as being the result primarily of the two major geologic units; the ridge and valley country with the NW-SE lineation, developed on sedimentary rocks, and the rounded hills and small ridges of the crystalline rocks. Within the trough, the lake and bog studded lowlands are, generally speaking, developed on the shales and slates which are the more easily weathered sediments. Conversely Dolomites and Quartzites are the predominant rocks composing the ridges. One of the outstanding features of the trough is the prevalence of lakes, which Hare (21) estimated as covering 18% of the surface area. These generally show an elongated shape, and are usually parallel, reflecting the folded and faulted structure of the underlying rocks. This contrasts by all accounts with those of the shield which seem to be related to the fault structure. It will be shown in a later chapter that the contrast between the shield and the trough is mirrored not only in the topography but also in the predominance of different types vegetation. Tanner (52) postulates a much richer vegetation cover for the trough as a whole.

The keynote of the Knob Lake area is monotony. Looking east from Irony Ridge low ridges and shallow troughs strewn with numerous lakes and bogs, stretch as far as the eye can see. This complex ridge (Irony Ridge) broadens northwards to form Sunny Mountain, the highest point in the area (2821 ft.), the ridge tops themselves having an average height of c.2250 ft. Lying to the west of this ridge and forming the boundary between the sedimentary rocks and the granite-gneisses is the Howells Valley, a major feature in the area. This region to the west was studied from air photographs but was not visited in the field by the author. The town of Knob

View to the west from Dolly Ridge, showing the broad valley in which the town of Knob Lake is situated, and illustrating the contrast between the vegetation of the ridges and that of the shallow valley. In the background is the complex ridge which broadens northwards to form Sunny Mountain.

Lake is situated in a broad valley lying between 1600 and 1650 ft. which is about five miles across and is bordered to the west by Irony Ridge and to the east by Dolly Ridge. The latter is a fairly narrow ridge separating the Knob Lake valley from the much broader valley to the east in which the old air strip is situated. This valley is remarkable for the number of lakes and bogs it contains, and it was in these two valleys that the author carried out the field check on the classification of bog vegetation.

b. Climate

It is only in more recent years that climatological data has been available for Labrador-Ungava and records for Knob Lake only go back to 1948. The Hollinger-Ungava Transport began to operate a station at the old air-strip to the east of the town in 1948, but it was moved to the present air-strip in 1953. It was relocated to its present site of the McGill Sub-Arctic Laboratory in 1954 and records have been kept there since then. Although the station has been moved thus three times, the present site is only 131 feet above the original station and as the sites are so similar, there can have been little effect on the annual and monthly means. Stations elsewhere in Labrador-Ungava which have been keeping records for a longer period, supply definite evidence of the periglacial climate which is experienced in the area, and which, it is believed, is responsible for some of the forms of bog vegetation. Hare's work (20) on the whole peninsula is extremely valuable in a climatological study, although the material is presented on a regional basis and does not deal with the Knob Lake area directly. In one of the early chapters of his work, Hare presents a detailed discussion of the predominant air masses which move across the area, because as he says, the major air masses are the main climatic controls. They will not be considered in any detail here, however, as some of the resulting climatic elements are of more direct importance in the control of vegetation types.

Continental air dominates the region, and once Hudson's Bay has frozen in winter, these stable and very cold dry air masses move over the Knob Lake area. Although Knob Lake lies in the centre of the lake plateau, there are no water bodies large enough to modify the severe climate. There are only two months with a mean temperature over 50 degrees F. (see table 1) and the mean annual temperature is 14 degrees below the latitudinal average for 50° N. The winters have long periods of bitterly cold weather in which the maximum temperature may not be above 4° F. and there may be frequent minima of -40°F. During the summer the air masses originate over areas of waterlogged land and thawing ice and bring cool weather to the inland area with showers and clouds building up during the day. Rain and cloud are characteristic of the summer months inland and they result from the Continental Polar flow which is travelling around the flanks of an anticlone and forms the warm sector of a travelling cyclone. Continental Polar air travelling westwards brings clear bright days in winter and cumulus development in summer. Maritime Polar air which is dry and stable, comes as the warm sector of Alberta cyclones. Both these are fairly common in summer and winter. There are occasional penetrations of

TABLE 1

MEAN MONTHLY TEMPERATURES FOR KNOB LAKE 1948 - 1957
(in degrees Fahrenheit)

	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.
1948	M	M	M	M	M	M	M	M	44.6	36.0	21.3	0.0
1949	-9.7	-15.0	2.5	18.8	30.3	50.0	54.4	50.0	43.9	32.1	10.1	0.3
1950	-19.4	-18.4	3.9	20.3	36.2	45.1	53.0	52.7	40.2	27.4	15.6	2.0
1951	-14.0	-1.0	9.8	30.0	33.2	50.6	53.7	53.4	44.0	28.5	11.8	-4.3
1952	-12.3	-4.0	13.1	21.5	40.4	48.1	58.8	52.1	41.4	26.0	14.7	9.4
1953	-9.7	-4.0	8.3	31.8	35.2	46.9	55.8	51.0	41.6	31.6	19.2	-7.8
1954	-20.4	-1.1	5.2	8.4	37.8	54.2	55.6	51.2	43.8	30.9	12.6	0.6
1955	-2.3	-6.9	2.4	20.5	37.4	54.3	54.4	53.7	40.8	32.9	22.8	6.3
1956	3.1	-4.4	-0.4	20.3	25.5	41.2	54.0	49.0	39.4	32.7	13.1	-13.9
1957	-22.2	-5.0	16.3	19.1	28.8	47.2	55.9	49.4	42.9	32.3	18.1	3.6
Mean	-11.9	-6.7	6.8	20.3	33.9	48.6	55.1	51.4	42.3	31.0	15.9	-0.4

TABLE 2

MEAN PRECIPITATION FOR KNOB LAKE 1948-1957
(in inches)

	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.	Annual
Rainfall	0.01	0.0	0.06	0.16	0.43	2.69	3.46	3.59	2.20	1.36	0.32	0.09	14.37
Snowfall	14.5	15.6	18.3	12.3	7.5	3.2	0.0	0.1	8.9	12.8	20.3	15.5	129.0
Total	1.46	1.56	1.89	1.39	1.18	3.01	3.46	3.60	3.19	2.64	2.35	1.64	27.27

TABLE 3

FROST DATA FOR KNOB LAKE

Mean date of last Spring Frost	Mean date of first Fall Frost	Frost Free Season	Longest F.F. Season	Shortest F.F. Season
June 16	August 30	75 days	89 days	40 days

The Growing Season is when the Daily Temperature is more than 43 degrees, having a mean length of 102 days beginning on June 4 and ending on September 14.

TABLE 4

GROWING SEASON

	Day when mdt. is 43°F.	Day when mdt. falls to 43°F.	Growing Season (days)
1948	M	Sept. 13	M
1949	June 9	Sept. 16	99
1950	May 22	Sept. 9	111
1951	June 9	Sept. 17	100
1952	May 20	Sept. 12	116
1953	May 7	Sept. 14	100
1954	June 2	Sept. 22	113
1955	May 28	Sept. 5	101
1956	June 28	Sept. 6	71
1957	May 31	Sept. 3	95
Mean	June 4	Sept. 13	102

Maritime Polar and Maritime Tropical air, but they are by no means common and could not have any overall effect on the vegetation.

Various influences combine to keep the temperatures low all the year round. Firstly the air masses which continually import cold air from high latitudes. Any warm spells which might arise in summer are more likely to arise from atmospheric circulation, rather than any local influence. Hudson's Bay cools the air masses passing over it in summer and warms them in the fall until it freezes. This affects the temperature at Knob Lake between November when the mean is 15.7° F. and January when it is -10.6°F. Secondly, the plateau of Labrador-Ungava slopes gently inland, northward from the scarp rim along the north shore of the St. Lawrence Gulf. The high level of the land tends to increase the effect of radiative exchange and together with the high percentage of bare rock, accelerates the radiative cooling. However, Knob Lake itself is in a sheltered position and there is more vegetation in the trough, so that the climate here is a little milder than on the granite-gneisses. There is no data from the area to the west of Knob Lake and although the writer has not visited the area, reports of patterned ground, stunted vegetation and a later thaw of the lakes, would seem to indicate more severe climatic conditions (Lotz, 32). Lastly, there is the influence of the sea, or rather the lack of it. The peninsula has continental characteristics with cool summers partially resulting from the cool offshore Labrador current. The offshore freezing in winter reduces the marine influence. Hare has computed a series of means over the whole area, for which he uses the standard period 1930 - 1947. It would be scientifically unreliable to compare the data from other stations with that from Knob Lake, without standardizing the means of the latter from some other station, owing to the possibility of climatic fluctuation during the last decade. This, however, would be a tedious task, to be undertaken perhaps by someone with more specific climatological interests. For the present purpose, the writer feels it sufficient to say that the Knob Lake means would appear to indicate further the monotony of the periglacial climate throughout the interior plateau of Labrador-Ungava. The minimum temperature of -11.9°F. occurs in January and the maximum of 55°F. in July, illustrating the lack of marine influence. The thaw season, when the mean temperature rises above 32°F. comes in mid May and the frost period begins in early October, the earliest and latest freeze-up being September 30th and October 21st.

In any discussion concerning Sub-Arctic vegetation, probably the greatest influencing climatic factor is the frost occurrence. Table 5 gives the frost data for Knob Lake. The period during which the mean daily temperature is above 32°F. at Knob Lake is 147 days and we can consider this to be approximately equal to the period when the ground is unfrozen. The lag between the day when the temperature rises above 32°F. and the thawing of the ground will be about equal to that of the freezing in the fall. The growing season is generally considered to be that period when the mean daily temperature rises above 43°F. and this at Knob Lake begins on June 4th and ends on September 14th with a mean length of 102 days. However, it is probably considerably less than

TABLE 5

Frost Season and Thaw

	Day when mdt. is above 32°F.	Day when mdt. is below 32°F.	Thaw Season (days)
1948	M	Oct. 18	M
1949	May 24	Oct. 18	147
1950	May 16	Oct. 4	141
1951	May 18	Sept. 30	135
1952	May 2	Oct. 10	161
1953	May 13	Oct. 5	145
1954	May 2	Oct. 3	154
1955	May 3	Oct. 21	169
1956	May 26	Sept. 23	121
1957	May 25	Sept. 27	124
Mean	May 13	Oct. 10	147

this in fact, in bog areas because the ground remains frozen within a few inches of the surface until the early part of July and this will prevent sub-surface growth of plants. On the day when the mean daily temperature falls below 32°F. the penetration of soil frost begins and biotic activity in the soil is ended for the year. In the spring, the first few days with daytime thaw melt the snow, but not until the hours of thaw exceed the hours of frost does the soil itself begin to thaw. The critical date is again determined by the course of mean daily temperature which must rise above 32°F. for appreciable soil thaw. The two critical dates for the thawing out of the ground are given in figs. 2 and 3. The third map (fig.4) shows the duration of the season of persistent thaw. Lotz has plotted the mean monthly temperatures against those from other stations in Labrador-Ungava (32) thus illustrating the fact that the cool summer is a regional characteristic and not merely a local one. Close correlation between climate and vegetation in the Knob Lake area might certainly be applicable elsewhere.

The frost free season is on the average 74 days (table 6), the longest being 85 and the shortest 63 days, but this does not take into account random summer frosts. As was mentioned earlier, a rise of the mean daily temperatures above 32°F. does not necessarily mean a rise at ground level. Benninghoff (3) points out that a vegetation cover acts as an insulating blanket, particularly mosses, which decrease air circulation and retain moisture. Hence in a bog the surface under the Sphagnum may be frozen while the surface air temperatures are quite high and there may be a lag of six weeks or more before the peat has thawed out.

FIG. 2 START OF SEASON WITH MEAN DAILY TEMPERATURE ABOVE 32°F.

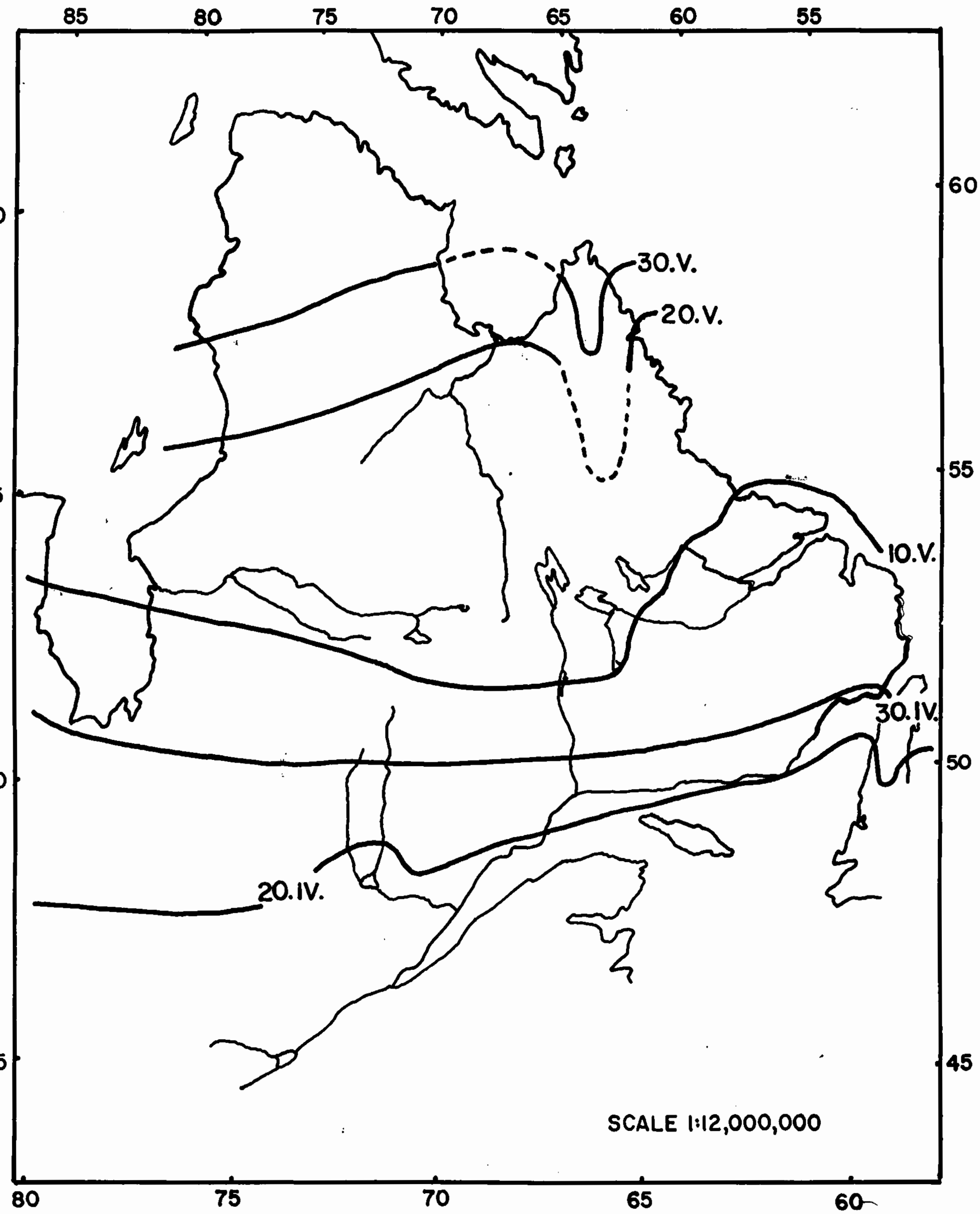


FIG. 3 END OF SEASON WITH MEAN DAILY TEMPERATURE ABOVE 32°F.

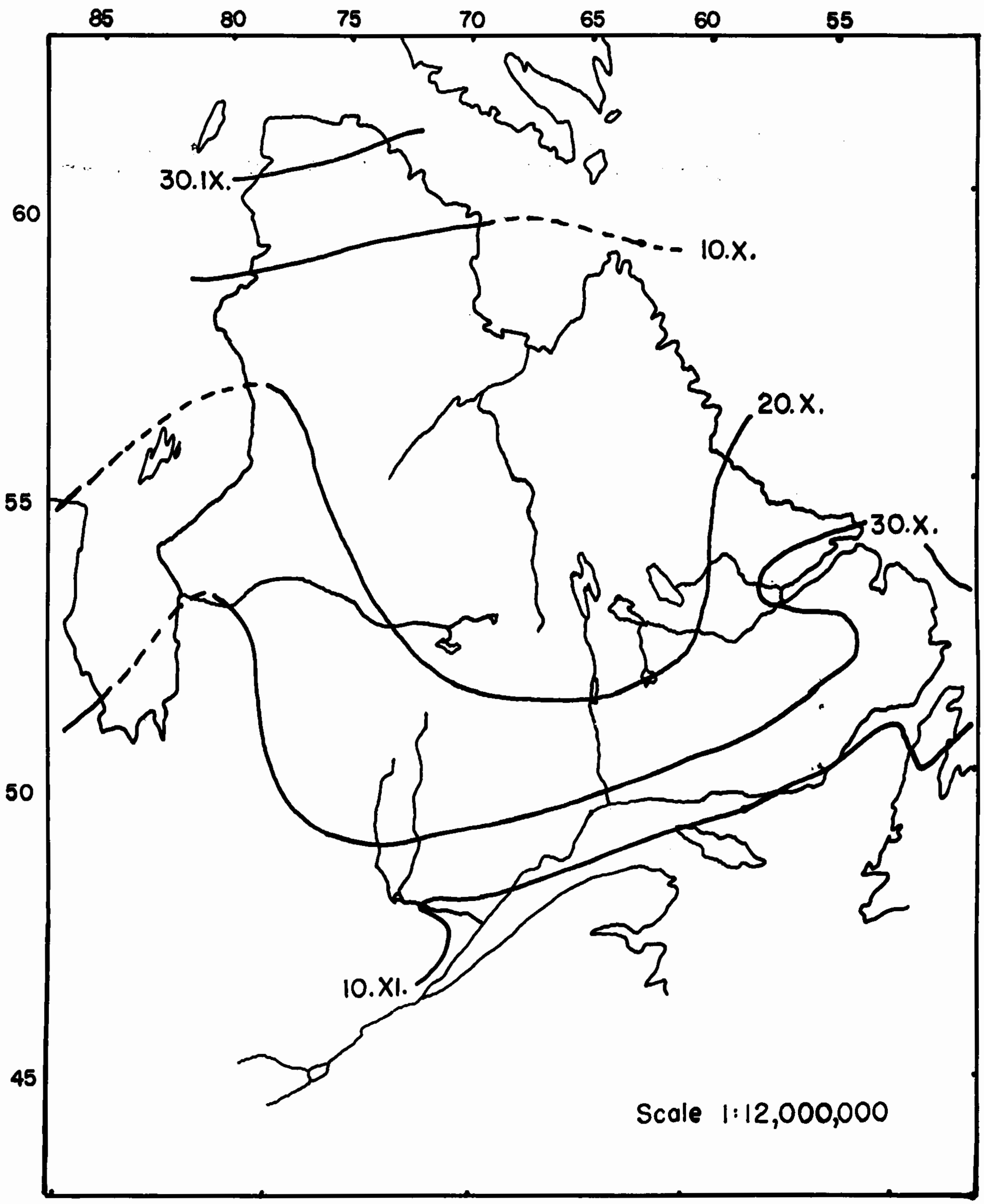


FIG. 4 NUMBER OF DAYS WITH MEAN DAILY TEMPERATURE BELOW 32°F.

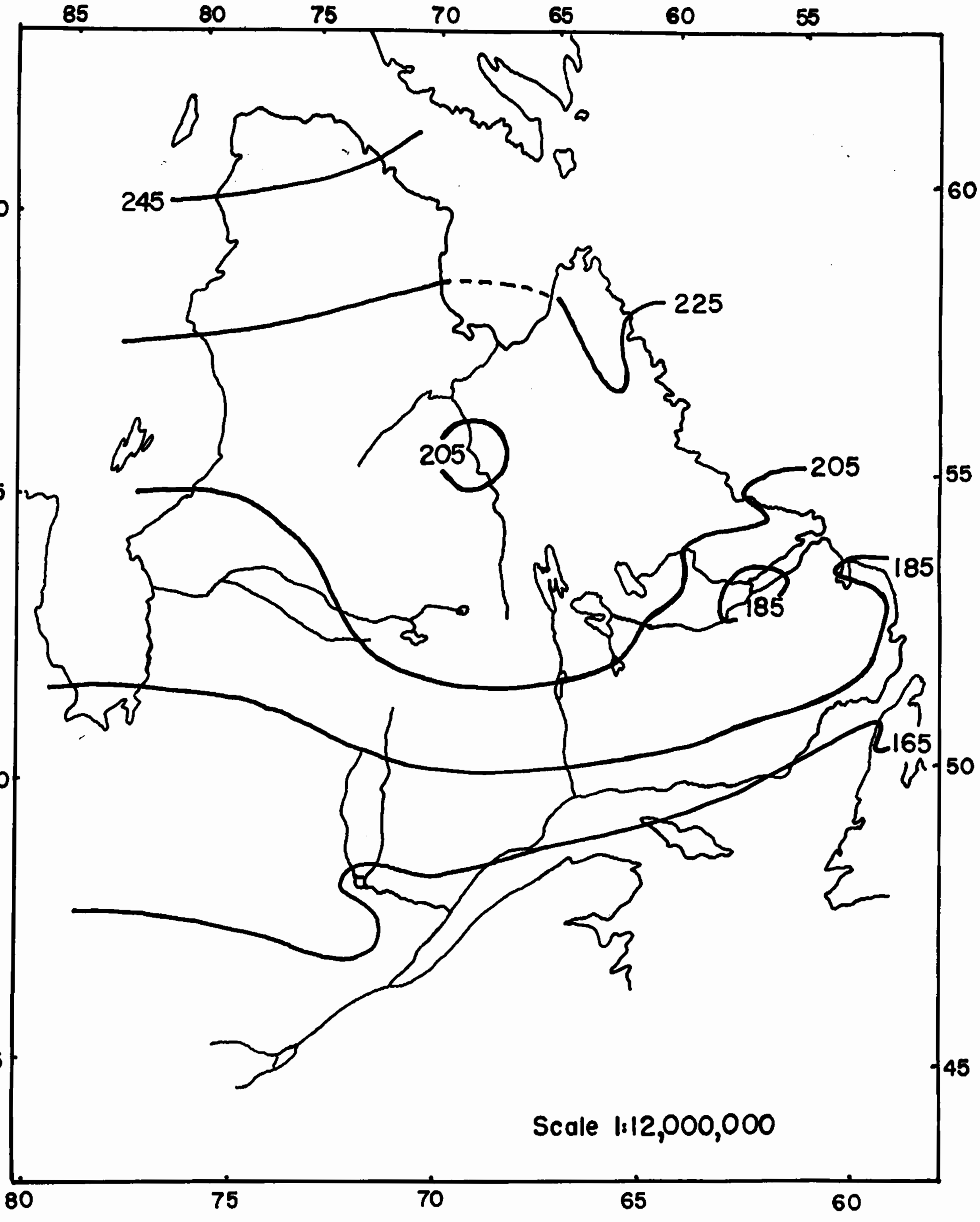


TABLE 6

FROST DATA

Frost is considered as screen temperature of 32°F or below

	Last Frost in Spring	First Frost in Autumn	Frost Free days	Greatest No. of days Without Frost
1948	M	Sept. 1	M	M
1949	June 15	Aug. 18	63	63
1950	June 23	Sept. 2	70	70
1951	June 10	Aug. 22	72	40
1952	June 14	Sept. 6	83	50
1953	June 11	Sept. 4	84	70
1954	June 13	Aug. 31	89	89
1955	June 15	Aug. 28	73	73
1956	June 25	Sept. 9	75	75
1957	June 11	Sept. 6	86	86
Mean	June 15	Aug. 31	76	68

TABLE 7

DAYS WITH FROST

Year	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.
1948	M	M	M	M	M	M	M	M	10	25	30	31
1949	31	28	31	30	28	9	0	1	12	24	30	31
1950	31	28	31	27	24	7	0	0	15	26	30	31
1951	31	28	30	26	25	9	1	1	11	30	30	30
1952	31	29	31	30	17	2	0	1	12	27	30	31
1953	31	28	31	28	28	9	0	0	12	28	29	31
1954	31	28	31	30	26	4	0	1	15	24	30	31
1955	31	28	31	30	25	1	0	1	11	26	30	31
1956	31	29	31	24	29	12	0	0	15	24	29	27
1957	31	28	31	29	27	5	0	0	6	21	29	31

The relief of Labrador-Ungave introduces variety into the fairly simple advance of thaw in spring. The high ground on the southern rim effectively halts northward spread of thaw for a few days. Once the thaw reaches the crest of the scarp, the northward slope of the plateau favours rapid advance and there is a general spread across the whole plateau by about May 18 - 20. Over most of the plateau the persistent frost begins sometime in October.

The second major feature which effects the growth and formation of bogs in the area is the precipitation. The seasonal distribution is here very marked with a distinct summer maximum. The mean number of days with a measurable precipitation is 182, and Hare says this region has the most reliable rainfall in the world due to the steady passage of cyclones. The amount and even distribution of rainfall throughout the summer favours the persistence of peat bogs in the area, and this is augmented by the fact that the evaporation is generally low. Most of the precipitation falls as snow (see table 2) and by November half the precipitation is snow, and is at a maximum in this month. This is probably due to the movement of air masses over the still unfrozen waters of Hudson's Bay. The snow does not accumulate to great depths, however, owing to the persistence of the prevailing wind from the north-west. It tends to accumulate in hollows and in drifts in the woods. In the spring the bogs clear first in the valleys and the snow may remain in the woods until the early part of June.

Sunshine records have been kept at Knob Lake only since 1955, but they emphasize the cloudiness of the area and this also ultimately effects the evapotranspiration. Studies were only carried out for the first time at Knob Lake in 1956 by Walter Nebiker (38). He found a good correlation between temperature, latent evaporation and measured potential evaporation, but found that the Thornthwaite formula overestimated the actual evaporation by three times. There are, then, three contributory factors to the formation of bog vegetation, low sunshire, high latitude and a cloudy climate. On the heavy clay soil, percolation is reduced to a minimum and as most of the bogs accumulate little snow, or it is blown clear, the heavy winter snow is of little benefit. Thus the surfaces of the open bogs will tend to be more subjected to the influence of freeze and thaw than the areas of more dense vegetation.

There is no permafrost at Knob Lake; it only persists in small patches and these are in the ridges of high ground to the north-west of the town. The bog borings which were taken in September did not reveal permafrost in any of the bogs in the valleys. Fraser (15) however, reports permafrost beneath a bog at 2200 feet in the Snowy Lake area to the north-west. The significant factor here then, as will be pointed out in a later chapter, is that the presence of bog vegetation is not indicative of permafrost. It has been suggested that they may represent relic permafrost patches but the author has reason to believe that this is not so and will discuss the origin of the bogs in the next chapter. Ice lenses were found in one or two bogs as late as September, 1957, at about one foot below the surface. These must have been isolated cases and may be accounted for by the persistence of cold

Ice mounds,with different types of vegetation,in the Knob Lake area. In the upper photograph, the lichens and shrubs growing on the mound are in marked contrast with the Sedge Fen surrounding it.In the lower photograph, the similarity between the vegetation of the mound and the surrounding bog would suggest that it was originally a frost blister, but now it is suffuciently stable to have been colonised by Betula sp.

weather during that summer. There were still three and a half feet of ice on the lakes at the end of April and there was a late break-up with a very poor August. As it is believed that in this particular type of bog, thawing is from the bottom upwards, as in a lake, the cool weather added to this factor might account for the ice near the surface.

c. Soils

A soil survey has been made in the Knob Lake area (Lotz 1956, 32) and it has been found that the different types of soil are easily detected by the surface vegetation.

The cool, wet climate of Knob Lake with its high P.E. ratio would suggest the development of a podsol which is characterised by the downward movement of water, removing soluble salts downward. Lotz found this to be so, but he suggests the term Sub-Arctic podsol, as they exhibit characteristics which are peculiar to the Sub-Arctic climate. Unfortunately, this term is generally applied in Canada to areas having permafrost and continuous woodland. Here at Knob Lake the podsols are not as well developed as those described by Drummond (12) in the Romaine River Valley, where there is a well developed litter from the trees, and where the porous sandy soil is well leached. On the other hand it is more fully developed than the Arctic Brown soils of Alaska, described by Tedrow (54) which are not well leached, owing to the presence of permafrost and the small amount of rainfall on the Arctic slope of Alaska.

The Knob Lake podsols are derived from glacial till, and one of the most striking features is the high clay fraction. Often the deposits have a plastic nature and can be moulded, and it was this type of stiff clay which was found underlying most of the basin bogs in the area. One of the outstanding features is the high acidity of the soils in the area. Lotz reports pH values from 4.0 - 6.5, and the present author found that the bog soils rarely exceeded 5.4. The uniform acidity of the soils would seem to reflect the lack of downward percolation.

The slow decay of organic matter in the area, is associated with the low temperature, poor aeration and consequent low bacterial activity. Also the frequency of fires limits the occurrence of a long period for the accumulation of organic matter.

Lotz suggests several reasons for the absence of a leached horizon in the Knob Lake soils. The clays hold much water and are frozen for most of the year, the average period of thaw being 150 days. Also the clays are very impervious, which decreases percolation, especially in comparison with other sandier areas of the Sub-Arctic. Another reason he suggests is the protective nature of both lichen and moss, which retain moisture and prevent penetration below the surface.

In this area, then, the soils are mainly distinguished according to their drainage, although the different types often grade into one another. Broadly speaking, however, they can be divided into dry till, wet till and excessively wet till after Lajoie (30). The distinction between the latter two can be detected from the surface bog vegetation.

The wet till usually supports the bog forest or spruce muskeg on a layer of Sphagnum peat and the parent material can be reached by digging, unlike that underlying the bogs. The excessively wet tills are covered by peat and frequently have pools of standing water. Lotz says that he found profile cutting impossible in the bogs, but the present author made borings with observations at various intervals. The soil underlying the peat was seen to consist of a thick glacial clay underlain by a grey shaley material.

In the Knob Lake area the wet till corresponds with the imperfectly drained till as described from Fort Chimo by Lajoie (30). They are less acid than the dry tills. In wetter parts of the spruce muskeg, the mineral soil accumulates around the bases of the trees on slight rises. Ground cover is essentially peaty and sometimes Sphagnum directly overlies the parent material. The Sphagnum and moss cover is always wet and probably prevents downward percolation because there is generally an absence of a leached layer. The profile is usually permanently saturated. When drainage is very poor, gleyisation takes place under conditions of low temperature and poor aeration.

Peat bogs or basin bogs are usually deep, with very few trees at the surface and are generally very acid. The thick layer of peat provides excellent insulation and the base is frequently very cold but none are permanently frozen at Knob Lake, although they may only be thawed out for three or four months of the year. They were still frozen at the end of June in 1957, but the first thick falls of snow in the fall insulate them again, so that the tendency is for ice formation at the end of November or December (personal communication with members of the McGill Laboratory).

CHAPTER III

VEGETATION

Several authors have worked out a zonal classification of the vegetation of Quebec-Labrador, but in each, the Knob Lake area lies on the boundary of the two zones. The nature of the topography makes this especially clear, as the tops of the hills and ridges are covered only with a treeless tundra, while the forest is restricted to the broad valleys which also contain many lakes.

Halliday (17) made the earliest classification, but in North Eastern Canada he only distinguishes between forests and tundra. He subdivides the forest into the Boreal Forest and the Great-Lakes-St. Lawrence region but these both lie well to the south of the area to be considered. Of the more recent studies, there are three of importance. South of the tundra, Hustich (27) describes the Forest Tundra as a transition zone between the tree-line and the most northern limit of the continuous forest (see fig. 5). Within the continuous forest he recognises two divisions; in the north, the Taiga, extending to the southern limit of the Lichen Forest, and between this and the Great Lakes-St. Lawrence region, the Southern Spruce Forest. Thus by this classification the Knob Lake area lies on the boundary of the Taiga and the Forest Tundra. Within these broad zones, Hustich has ten categories of forest which are grouped under three headings, Dry, Moist and Wet series. Two of these categories, both in the wet series, correspond to categories of bog vegetation suggested by the author as a result of the study of air photographs. These are his Black Spruce Muskeg, which he describes as an acid bog in which the regeneration of the spruce is quite good, and the Rich Swamp Forest, which he says indicates a better quality soil. The latter is called the Tamarack Forest in the present classification.

Hare (21) bases his classification on that of Hustich but he lumps together those of the wet series and calls them the Muskeg Type. According to the zonal divisions of Hare, Knob Lake falls in the Open Boreal Woodland which he describes as consisting mainly of Lichen Woodland with Muskeg and Bogs in the hollows on the lower ground (see fig.6). To the north, he describes an area of transition between the tundra and the Open Boreal Forest, in which the woodland is found only in the valleys, but the ridges are treeless tundra. To the south is the main Boreal Forest which is the thick forest zone and is composed mainly of Black Spruce and Balsam Fir. Muskeg is common in the lowlands especially in the James Bay and Goose Bay areas.

Lastly, Rousseau has made the most recent contribution to this field; he divides the area into four biological zones, the Arctic, Hemiarctic, Sub-Arctic and Temperate. In comparison with other classifications, the Hemiarctic is an entirely new concept which he describes as a "mosaic zone" consisting of an emulsion of the Arctic and Sub-Arctic rather than simple a transition (see fig.7).

Table 8 shows a comparison of the classifications of Halliday, Hustich, Hare and Rousseau compared with the climatic provices of Koppen and Thornthwaite (after Blake (4)).

TABLE 8

Forest and Climatic Classification in Labrador-Ungava (after Blake 4)

Forest Regions (Halliday)	Forest Regions (Hustich)	Forest Regions (Hare)	Forest Types (Hare)	Forest Regions (Rousseau)	Dominant Habitats (Rousseau)	Climatic Classification: Koppen	Climatic Classification: Thornthwaite	Climatic Classification: Villeneuve
Tundra	Tundra	Tundra	Tundra	Arctique	Toundra	F Frost	D' Tundra	Toundra
Boreal Forest Tundra in new classification	Forest-Tundra Sub-Arctic	Forest-Tundra Ecotone	Tundra and Lichen-Woodland	Hemi-arctique	Toundra Forestiere			
	Taiga	Open Boreal Woodland	Lichen Woodland	Sub-arctique	Taiga ou parc Sub-arctique		C'1 Cool Micro-thermal	Taiga
	Southern Spruce Forest	Main Boreal Forest	Close Spruce-Fir Forest		Foret coni-ferienne temperee	D fc. Micro-thermal		
Boreal Forest	—	Boreal Mxd Forest Ecotone Southern Transition Zone	Close Forest with mxd Forest indicator species	Temperee	Foret de bois meles		C' 2 Warm Micro-thermal	Climat Temperee
Gt. Lakes-St. Lawrence Forest	—	Gt. Lakes-St. Lawrence Mxd Forest	Mixed Forest		Foret decidue ou foret feuille	D fb Micro-thermal		

Transition Zone; Sub-Arctic (Hare)

Fig. 5 FOREST REGIONS OF LABRADOR-UNGAVA
(Hustich)

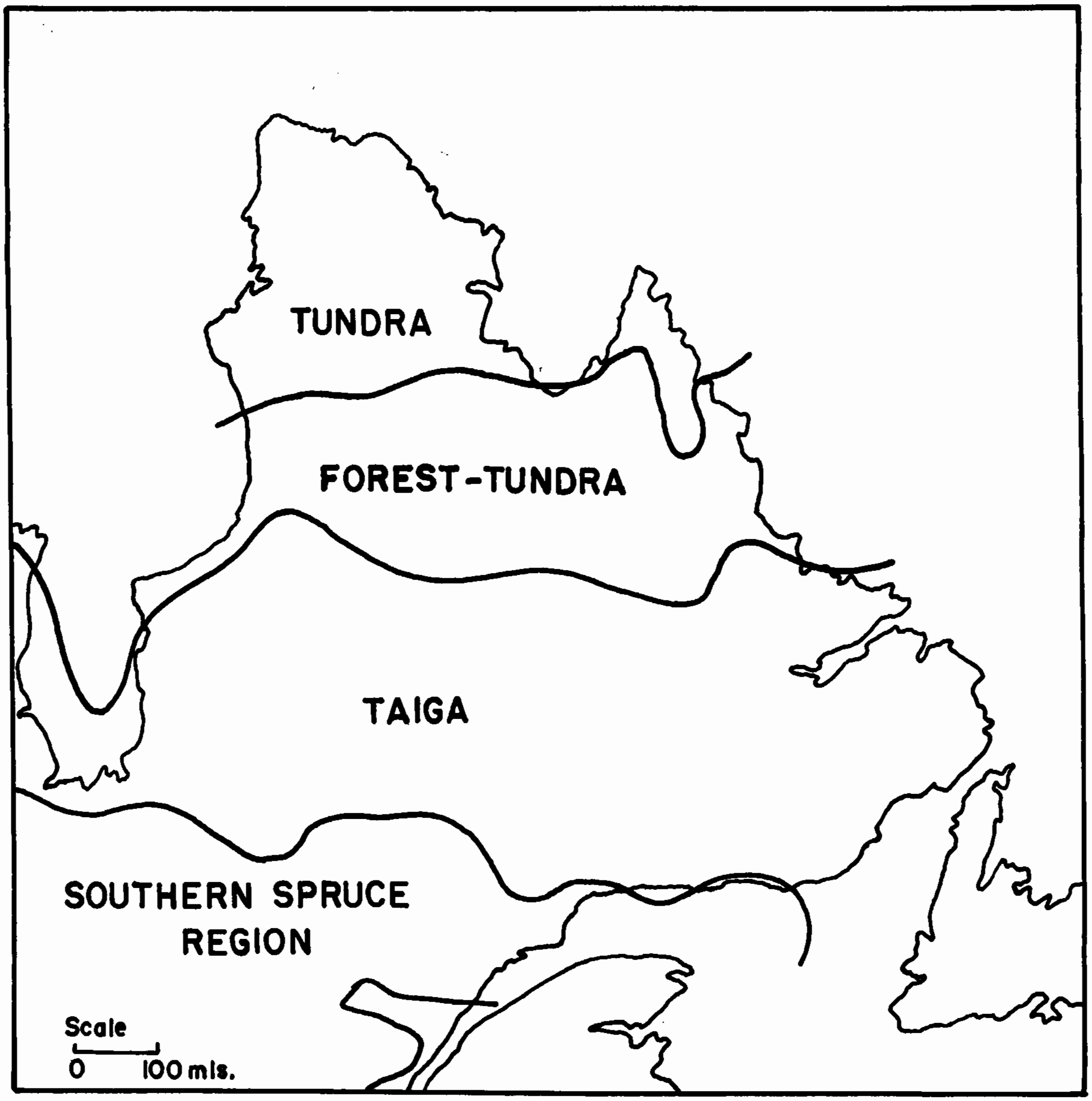


Fig. 6 FOREST REGIONS OF QUEBEC-LABRADOR. (Hare)

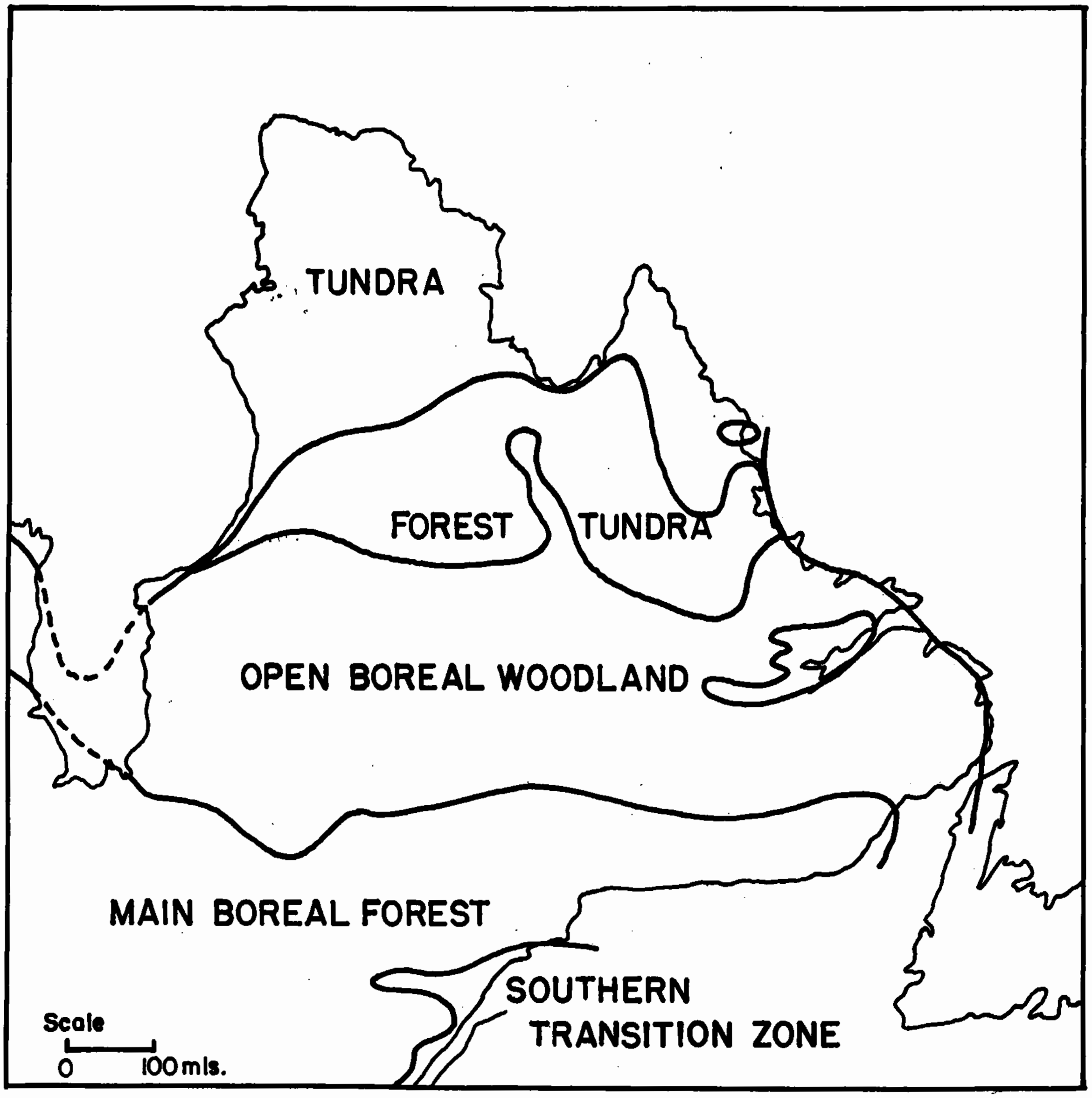
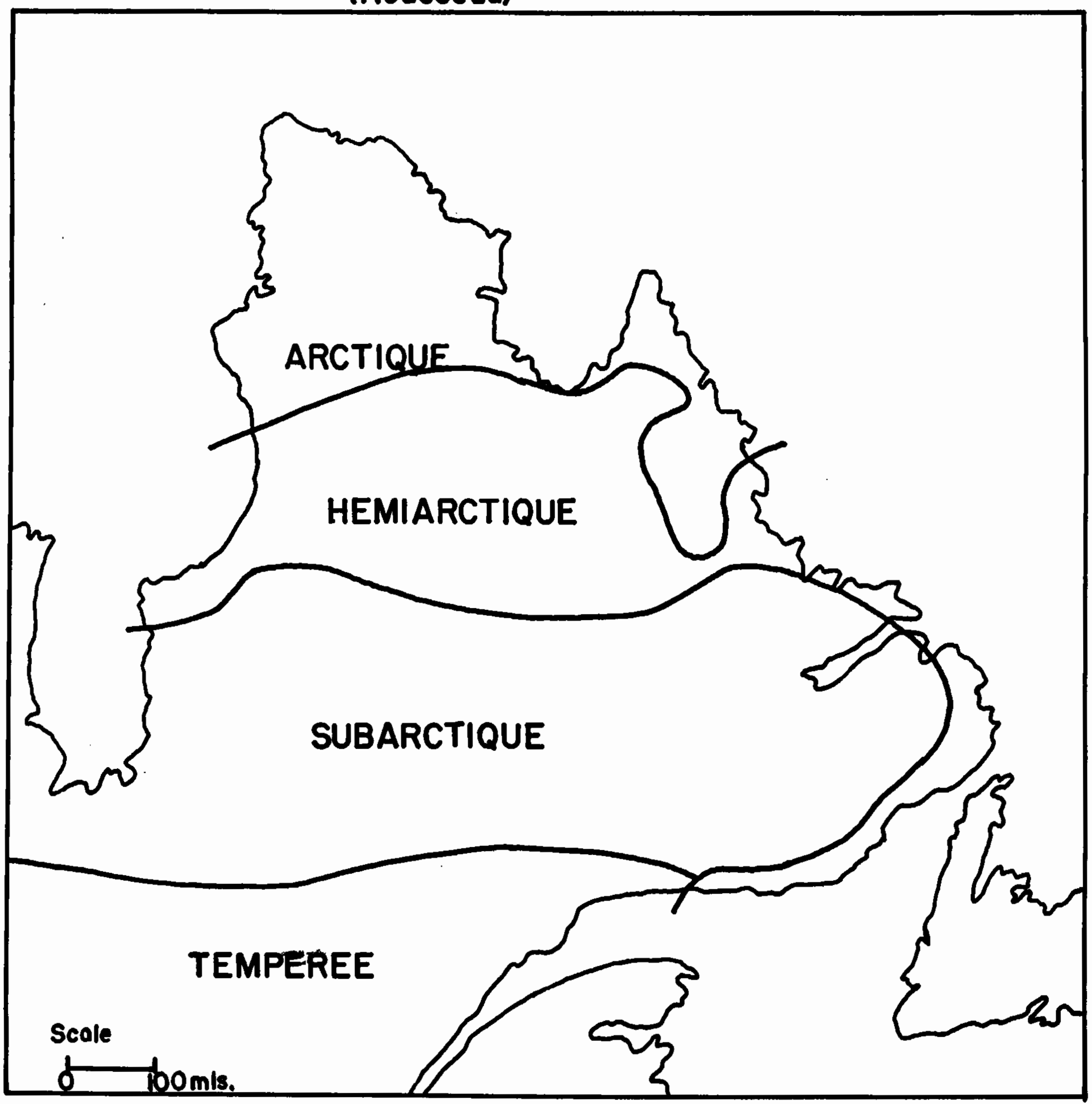


Fig. 7. BIOLOGICAL ZONES OF LABRADOR-UNGAVA.
(Rousseau)



Typical Tamarack swamp taken in late May during the melt season.

View looking northwards along Dolly Ridge, showing the treeless nature of the ridge vegetation as compared with that of the broad valley in the background.

The area under consideration is, then, essentially a mixture of vegetation types, owing to its transitional nature and the complex nature of the underlying physical conditions. Hustich thinks that the vegetation is richer and the tree growth more luxuriant here than in the granite-gneiss area, owing to the influence of the Precambrian sedimentary bedrock of the trough. He also considers the common Taiga Forest type - the black Spruce Muskeg - to be untypical here as stagnant terrain with acid soil is not he says, very common. It seems to be restricted in its best development, to the granite-gneiss. On the other hand, this area is peculiarly rich in Tamarack, due to the abundance of swamp on the less acid sedimentary rock. Another factor influencing the vegetation is the distribution of Glacial Drift. In this area is is mainly a uniform clay which is generally swathed on the sides of the ridges but is absent on the tops. The ridge tops, then, are usually treeless, frequently with large areas of bare shattered rock, but more usually with a covering of Lichen and low shrubs.

In the broad shallow valleys, the forest is often dense and progress can be very difficult. This is the Closed Crown Forest, which consists of both Black and White Spruce, the latter being the more common and indicative of less acid soil. Balsam Fir is also found. The undergrowth here consists of mosses and low herbs and shrubs. Dense stands of Black Spruce frequently border bogs.

The drier sites are dominated by the Lichen Woodland, the commonest forest type in the area, in which the trees are widely spaced and growing in a ground cover of Cladonia. This makes travelling both pleasant and

Typical Lichen Woodland, seen in May. The ground cover is not visible, but the photograph illustrates the general spacing and height of the trees. In the background is a mature stand, but the foreground shows regeneration on an old burnt-over area.

'Burn' on a ridge to the west of Knob Lake. Note the Beard Moss growing at the tops of the trees.

easy. One of the growth requirements of lichen is the absence of shade which accounts for the fact that the minimum distance measured between the trees is six or seven feet (Fraser) while they may be as much as four to five hundred feet apart.

Lastly, much of the area is covered by burn and according to Fraser seventy to eighty percent has been burned at some time, of which fifty percent has been burned in the last forty years. It is generally confined to the Lichen Forests because the lichen soon becomes very dry at the surface during a relatively short period of drought, in which time mosses and peat of the Closed Forest and Muskeg would remain saturated. Frequently the trees themselves are not burned, but are killed by the destruction of their roots. One of the peculiar properties of the Cladonia is the fact that when the top one or two inches are extremely dry, the lower layers at about four inches may remain saturated. Thus the basal layers tend to remain intact and protect the ground from erosion after a fire. The rate and nature of recovery after fire varies. If no tree seeds are immediately available, the area may become a lichen heath, but if trees do regenerate Fraser quotes a period of ninety to a hundred years for the recovery of the forest. Usually burns stop at the border of bogs, but if there has been a prolonged drought with drying of the upper layers of moss it is quite possible for fires to spread across them.

All these types of vegetation have been classified and described in detail in the Lashdrum classification (table 9) which is based on the series of Hustich and Hare. A study has been made of the Lichen Woodland in the Knob Lake area (Fraser, 5) but very little work has been done on the types of bog vegetation. Viereck (56) quotes the following figures for basal area of forest, in square feet per acre at Knob Lake: Muskeg 83, Lichen 89, White Spruce Forest 298. As the Muskeg is shown to be of almost equal importance to the Lichen Forest, and yet is only one of the types of bog vegetation in the area, the author feels it will be both of interest and value to study the bog as a separate entity.

TABLE 9

CLASSIFICATION OF COVER TYPES (LASHDRUM)

Hustich's Series	Hare's General Type	Cover Type
Moist	Close Forest	Mixed Moss Forest Coniferous Moss Forest Birch Woods
Dry	Lichen Woodland	Close Lichen Woodland Open Lichen Woodland Lichen Scrub
Wet	Muskeg	Fen Bog Encroachment Alder and Willow Thicket
Miscellaneous	-	Deep Water Bare Rock Burned-over areas

CHAPTER IV

CLASSIFICATION AND DESCRIPTION OF BOG VEGETATION

The main object of this study was to classify the bogs according to their physiographic characteristics rather than on an ecological basis, and therefore categories were established originally from the differing texture of the bogs as they appeared on the air-photographs. It was hoped that in this way these categories would be easily recognisable for use in further mapping. They did not pretend to be sophisticated divisions, but were based on the dominant forms of vegetation, and are being cited here as distinct groups without any implied relationship to one another. In such a study of vegetation, it is the dominant families and species rather than individuals that are most important and these should be recognised because of their indicator value. The custom of alluding to Sedge Meadow or Spruce Forest does not, however, imply that a certain species is dominant, but rather that there is an abundant growth of one type of vegetation. The terms used in the description of these types of bog vegetation are thus crudely physiognomic and without any further implication.

Previous work in this field has resulted in a variety of classifications (e.g. Radforth, 44; Cajander, 5; and von Post, 39) each bearing some relationship to that suggested by the present author, and as in the present work, they have been established with some limited purpose in mind. On the whole, other systems tend to be more complex, as more features are taken into consideration. In the present study we are merely concerned with the surface of the bog as it appears from the air. Other factors are taken into account, however, in an attempt to explain these surface forms. It is obviously necessary for any such classification that a field check should be made, and the observations from some of the individual bogs in the Knob Lake area are to be found in the Appendix. It is hoped that the categories suggested might be recognisable from air-photographs by students with or without field experience. Thus the categories could be mapped over a large area and some estimate made so that, for example, in a study of evapotranspiration the total area of a certain type of bog vegetation could quickly be established.

a. String Bog.

This appears on the air photographs as long festoons of apparently floating vegetation, assuming various patterns. On the ground, the fact that the festoons appeared to be floating was proved to be incorrect. The ridges of vegetation are composed of a dense growth of *Sphagnum* which is very firmly grounded i.e. superimposed on an accumulation of peat, and on which there may be a dense growth of *Ledum sp.*, *Vaccinium* and *Empetrum*. In some cases these bog ridges were seen formed entirely of a Sedge association, whereas in other cases, the shrubby undergrowth was interspersed with small *Larix sp.* and *Picea mariana*. The hollows between the ridges were filled with

STRING BOG: The upper photograph shows sinuous 'strings' composed predominantly of a sedge vegetation(see bog no. 10 in Appendix) The lower photograph shows 'strings' formed of mosses with a dense shrub layer and a scattered growth of mal-formed Larix sp.and Picea mariana.

stagnant water up to three feet deep, with a scattered growth of emerging sedges at the margin. The material underlying the hollows is a black substance, more liquid than solid, which is unconsolidated and yields the undecomposed remains of Sphagnum. It is mainly a black colloidal ooze containing decomposed carbonaceous matter. The material underlying the ridges is more consolidated, lighter in colour, and contains less decomposed material, so that when squeezed in the hand a light brown fluid runs off, and a mat of dead Sphagnum and Sedge is left. Where the ridge and hollow topography is found in a Sedge association, the difference in the subsurface material is not so marked. Radforth (46) has created categories for the differing forms of string bog, and although the writer does recognise distinctly differing forms of string bog within the group, she feels that as they are probably the result of the same physical process, it is unnecessary in the present study to make any further distinction.

The ridges appear to be a feature of sloping bogs, and assume in general three distinct patterns. They may be anastomosing, i.e. forming a network, but more frequently they are found in parallel 'waves', usually with an arcuate form. In some cases they may be seen on concentric arcs around a pond. The strings are usually narrow, from one to five yards across, and may be several hundred yards long stretching from one shore to another, across a bog. The bog hollows are usually wider than the ridges, although this may not be true at the lower end of the bogs where the ridges are more numerous. The strings run across the slope, acting as dams, so that the intervening hollows form terracettes.

b. Closed Strings.

On the air-photographs this group has a striped appearance, suggesting that the former strings have been succeeded by a drier vegetation and the open water between has disappeared. This pattern in the field appeared as alternating ridges and hollows, the vegetation of the ridges being identical to that of the string bog, but the hollows being occupied by sedge meadow. The latter is a dense growth of sedges, the recumbent stems and roots of which form a mat holding together an otherwise loose growth of *Sphagnum*. These are commonly referred to as "Strangmoor" in German and as "Aapasuo" in Finnish.

The patterns assumed by this type of vegetation are not unlike those of the string bog and it is difficult in many cases to know where to distinguish between them. The hollows (Flarke in German and Rimpi in Finnish) are underlain by a subsurface material which is the same as will be described for the Sedge Meadow in the following category.

c. Sedge Meadow.

In the first classification, which was made from air-photographs, this type was described as a smooth mat, and it was thought that it might represent a final stage in the infilling of String Bogs. The

CLOSED STRINGS: showing the alternate ridge and hollow topography with contrasting wet and drier vegetation.

SEDGE MEADOW: seen here during the spring melt season (see bog 3 in Appendix) author is now of the definite opinion that this is not the case, and that this is a completely different type of bog, i.e. an infilled lake basin. It often occupies large areas and the vegetation is much the same as that described in the bog hollows of the previous category. One distinguishing feature is the presence of the mat of sedges at the surface, which is generally about six inches thick and which is supported on a quaking bog of a very loosely compacted *Sphagnum* and sedge peat. The author would even hesitate to call this subsurface material peat, as it consists of an accumulation of dead organic remains in suspension. On drying in an oven this material decreases both in weight and volume by approximately twenty five percent.

The subsurface material was in all cases unconsolidated and unstratified, forming a quaking bog which could not hold the weight of a man once the surface mat had been broken through. Borings in these bogs revealed an average depth of twelve to fourteen feet, and frequently with a general pitch along the long axis. The base was composed of six inches of grey shaley clay succeeded by about a foot of very thick, plastic red clay. In one or two of the bogs tree remains were found immediately above the clay, in the peat, suggesting that the initial vegetation was of a more favourable climatic period.

d. Bog Forest.

This appears as a mottled grey surface on the air-photographs but it is possible to distinguish two sub-divisions, one having a much darker mottle than the other. It was suggested that the lighter tone might merely indicate the growth of young trees, but this was investigated in the field and was not the case, and therefore a sub-division of the category was justified.

First comes the Spruce Muskeg, described by Hustich (24) as the commonest type in the Taiga further south, occupying areas of poor drainage and acid soil. It is composed predominantly of closed crown stands of ill-formed black spruce growing in *Sphagnum*. The surface of the *Sphagnum* is generally hummocky with scattered pools and there is usually some shrubby undergrowth, such as *Ledum* and *Chamaedaphne*. The subsurface is usually fairly shallow - up to four feet, and the peat is composed of well-consolidated *Sphagnum* remains.

The other type is the Tamarack Forest which is particularly common in the Knob Lake area, and is rarely described from elsewhere. In it the trees are sparse and smaller than in the Spruce Muskeg, and are generally associated with a ground cover predominantly of sedges. The peat underlying the forest is less well consolidated than the above, being composed of a sedge and *Sphagnum* peat.

The categories described above are the five major types recognised by the texture on the photographs. It will be seen on the accompanying map, however, that seven groups have been plotted. In addition to the five basic groups, two others were recognised which were in fact a combination of two of the others. These are the String Bog with trees and the Closed Strings with tree growth. As the purpose of this study is to provide a base map for work involving the calculation of evapotranspiration the writer feels that a distinction should be made within the physical forms where there is a difference in cover type.

PERCENTAGE COVERAGE OF THE DIFFERENT BOG TYPES IN THE AREA OF THE ACCOMPANYING MAP OF THE KNOB LAKE AREA OF CENTRAL QUEBEC-LABRADOR

Only the five major categories are involved because although the other two types have been shown on the map, they only cover a very small percentage of the total area. Bog vegetation as a whole covers 7.5% of the map.

Percentage coverage of each bog type in relation to the total area of the map.

Sedge Meadow	2.4%
String Bog	1.9%
Closed Strings	0.1%
Spruce Muskeg	2.1%
Tamarack Forest	0.9%

Percentage coverage of each bog type in relation to the total area of bog vegetation.

Sedge Meadow	32.3%
String Bog	26.5%
Closed Strings	1.8%
Spruce Muskeg	27.7%
Tamarack Forest	11.7%

CHAPTER V

ORIGIN OF DIFFERENT BOG TYPES

The area which has been mapped is intended as a type area, and therefore any suggestions which are made, will be based on observations made within that area. It is important to remember, however, that the Knob Lake area is part of the Labrador Trough where the vegetation tends to be more luxuriant than elsewhere in Labrador-Ungava. We must assume that the physical conditions underlying the development of different bog types are the same here as elsewhere in the Sub-Arctic, and as the same types occur elsewhere, the author feels justified in considering Knob Lake as a type area, albeit the types occur in different proportions.

It is evident from the work of authors previously cited that bog vegetation is considered an integral part of the Sub-Arctic vegetation as a whole and it is estimated to cover 10-15% of the surface in some areas. Some attempt should be made therefore to try and explain these phenomena, because the higher percentage appears to lie in the zone between the Tundra and the Mixed Woodlands of the Great Lakes-St. Lawrence.

According to Swinnerton (51), the conditions necessary for the accumulation of peat are as follows:-

1. Adequate rainfall and surface water.
2. Growth of aquatic and moisture-loving plants.

3. A soil or sub-soil which will retain water at the surface.

4. A sufficiently humid atmosphere to prevent too rapid evaporation (low temperatures being equally effective).

5. Temperatures high enough to allow profuse growth of vegetation yet low enough to check too rapid decay.

We have seen from Chapter 2 that all of these climatic conditions are true for most of Labrador-Ungava. Precipitation is high, much of it falling in the summer as rain. The temperature, however, varies with latitude, and we shall see that there is a corresponding variation of bog type with latitude. In very general terms, however, the climate is similar throughout the Sub-Arctic of Eastern Canada and hence the second most important factor influencing bog distribution is the relief.

Dansereau and Segedas-Vianna (10) point out that recently glaciated areas are particularly favourable to bog formation because there will be found blocked drainage, cold climate and high humidity, all of which favour the accumulation of slowly decomposing organic matter. Following the natural order of plant succession, the drainage will be impeded until the tree growth with increased evaporation lowers the phreatic level, so that the bog tends to dry out. This process will only be possible, however, if the climate remains constant throughout.

The relief of the Knob Lake area has already been described and many of the features are in fact conditional factors for bog formation as listed above. The most important is the nature of the area as interior hub of the plateau; the abundance of glacial material having effectively disorganised the drainage to such an extent that it appears as a chaotic pattern of lakes and streams. The retention of this water at the surface is facilitated by the impervious nature of the stiff clay which is characteristic in the area, and provides an ideal habitat for the initiation of bogs. Glacial material has been reported from Alaska (Drury, 13) which sounds similar to that described by the author from the base of many bogs in the Knob Lake area. The other factor which is reported from Alaska as being contributary to bog formation is the presence of permafrost. Benninghoff (3) says that the presence of forest raises the permafrost level, as it shades the soil from a maximum penetration of heat and decreases air circulation. The raising of this level will cause a rise in the level of the ground water, and the surface soil will thus become a much wetter habitat encouraging the encroachment of mosses and Sphagnum. These have an even better insulating effect as they have such a low thermal conductivity, and it is common knowledge that the removal of a moss cover may hasten the disappearance of permafrost. The perennial argument as to whether or not permafrost causes bog formation or vice versa, seems to be a vicious circle because a thick vegetation cover also has the opposite effect. It prevents heat loss from the soil, and also retains a snow cover which in turn is an insulator and shields the ground from extreme minima in the winter. This would certainly seem to be true in the Knob Lake area. We have already noted that the maximum snowfall is in November, while freezing temperatures begin during September; yet, the bogs remain unfrozen until the end of December (personal correspondence with members of the McGill Laboratory). This, then, will possibly account for the fact that the few remaining permafrost patches in the area are found in the ridges which have very scant vegetation; being less sheltered than the valleys, these ridges are also more likely to be blown clear of snow by the prevailing north-westerly winds.

The author did not find permafrost under any of the bogs in the lowlands around Knob Lake. There is reason to believe that the bogs began to form very soon after the retreat of the Pleistocene ice, and therefore if the peat were going to raise the level of the permafrost, there would be some indication of this today. It has been argued that they may indicate the position of previous permafrost patches. Hanson (19) working on bogs in Western Canada, found no permafrost beneath them but claims that lenses were present at the time of inception. Many of the Knob Lake bogs have a depth of six feet or more, however, and surely this would have been sufficiently insulatory to maintain such patches had they been present.

It would seem then, that in this area permafrost cannot be correlated with the occurrence of bogs, but there is one feature which is of particular interest. The author did not visit any true palsa bogs, although small isolated ice mounds were seen in several bogs. Both Fraser (15) and Drummond (personal discussion) report palsa bogs in the area, although they are relatively rare. They were found overlying permafrost, and there would therefore seem to be some connection in this case.

Having suggested, then, that the occurrence of bog in Labrador-Ungava is governed by climate and the nature of the relief, it is desirable to attempt an explanation of the different forms. Although several categories have been described from Labrador-Ungava, bogs as a whole can be split into two major groups; the Sphagnum, and the Sedge communities. The Sedge Meadows and the Tamarack Forest belong in the former and the Spruce Muskeg in the latter. The String Bogs appear on the surface to be a mixture of both types, but opinion has generally been in favour of their having the same origin as the muskegs. This problem, however, will be discussed in the following chapter. The sub-surface features of these two broad groups would also suggest that their origin differs. The characteristic features of the Sedge Fen have already been described. The fact that they are frequently six feet or more in depth, and are underlain by an extremely liquid peat, would seem to suggest that they owe their origin to a former lake. Conversely, the shallower nature of the Sphagnum, and the fact that it forms a well consolidated peat, suggests that it has not been formed in water, but has accumulated on the ground with deterioation to a wetter habitat. That is, there are two fundamental processes in operation in the area; a building up from a wet to a drier habitat and the reverse process with the invasion of moisture-loving plants. The latter is a process in which there is an increase of soil moisture rather than inundation.

Much interest has been shown by botanists in these two groups of vegetation, and von Post (40) uses process as the basis for his classification of bog. He has three categories, Ombrogenous, Soligenous and Paludification bogs and in each the direction of movement of water in the peat is different. The Soligenous bogs are the basin bogs whose presence is determined by hollows in the topography, and arise from inundation. In these the process of accumulation is by the infilling of the water body, beginning with the presence of free floating aquatics and *Sphagnum*. Following this, aquatics become rooted and then (depending on the depth of the water) there may be a stage at which rooted plants have some aerial parts. Bog borings at Knob Lake reveal a depth of six feet or more suggesting that once a continuous cover is formed at the surface the growth of sedges will begin, and the accumulation of the organic matter will come from the base of the floating mat. Such a process would account for the presence in the Sedge Fen of a surface mat, underlain by the liquid peat. Dansereau and Segedas-Vianna (10) state that in this process of lake infilling it may be some time before the accumulation of material below the surface consolidates, so that at a relatively late stage the bog may still be floating. They also mention that decomposition is checked by immersion and this would account for the wood which was encountered intact at the base of some of these bogs. The important characteristic of these bogs is that they occur in depressions with sloping sides, and moisture is able to run down the rock slopes into the bog, and hence are found essentially in areas of high precipitation. The water running down the sides of the bogs will carry with it silt and other non-organic matter, and may cause an accumulation at the base of the peat. E. Derbyshire (private discussion) has suggested that this may be the cause of the occurence of thick clay at the base of so many of these Sedge Fens. In the description earlier, it will be noted that the plastic red clay overlies the grey shaley clay, which must have been formed <u>in situ</u>. The red clay is undoubtedly of glacial origin, but it is unlikely that it was deposited in its present form. This clay consists of fine red particles and it is more than likely that it has been washed out of the glacial till (which is plastered on the sides of the ridges in the area) and accumulated beneath the peat. Clay deposits such as this were not found beneath the spruce muskeg, so it is probable that the sloping sides of the von Post Soligenous mires are the cause of the sub-surface inorganic material in the Knob Lake area.

The Ombrogenous bogs are also features of a wet climate, but in addition they require warm temperatures, and none were recognised from air photographs in the lake plateau of central Labrador-Ungava. The characteristic form of these bogs is their convex profile with a 'lagg' or ditch at the margin. They are formed by the rapid

Typical case of normal lake infilling under humid conditions, seen on the north shore of the St. Lawrence Gulf near Seven Islands.

Raised or Ombrogenous Bog at Seven Islands. In contrast to the bogs of central Labrador-Ungava, note here the convex profile, the heath type of vegetation, and the 'lagg' or marginal ditch in the foreground.

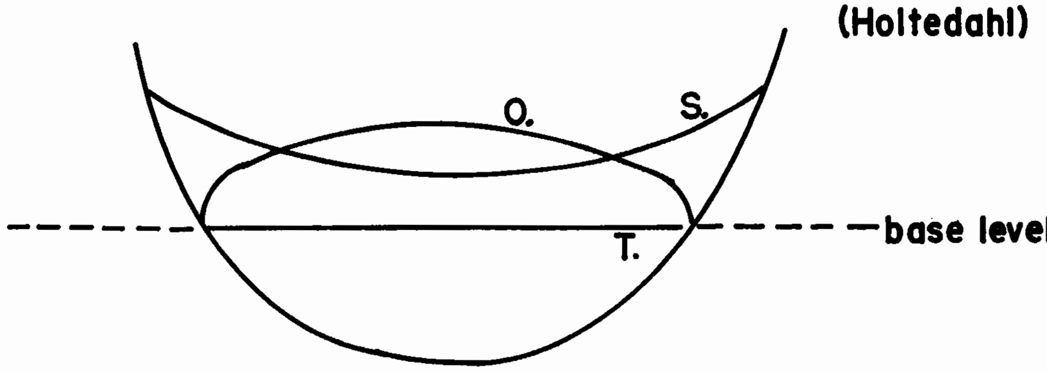
growth of mosses and Sphagnum causing a cushioning, and the source of the moisture is precipitation at the surface, which drains through the peat into the marginal lagg. Undoubtedly, the two months with mean temperatures of 50° F. at Knob Lake do not provide a sufficient period of time for any great accumulation of peat, nor are the temperatures high enough for the rapid growth of Sphagnum. They were seen by the author along the north shore of the St. Lawrence Gulf at Seven Islands and Shelter Bay. Here they were seen to have a heath type of vegetation having been colonised by ericads, birches and willow.

Holtehahl (23) describes a third type from Scandinavia, other than the Paludification bogs, known as Topogenous, being essentially related to the relief. He suggests that the layers of decomposing organic material build upwards in river valleys and hollows where stagnant ground water seeps up toward the surface. Many sedge meadows were seen in the Know Lake area, in which there was a distinct stream channel with depth of 4 or 5 feet. Probably these could be put into this category, the peat having built itself upward on either side of the stream, with the seepage of water.

The Paludification Swamps described by von Post (40) will be discussed in the following chapter. He considers them to be an extension of bog vegetation as a result of an increase in moisture. They belong to the second group, in which the process is one of retrogression to wetter conditions, and is dependent on a change in the amount of precipitation. It is probably that the spruce muskeg forest results from such an invasion of moisture-loving plants, as the lack of any significant inorganic material and the shallow and compact nature of the peat would suggest that it is not a result of inundation. That is, it has not accumulated in a depth of water as in the case of the basin bogs. Hustich (25) states that it is more characteristic of the plateau outside the Trough where soils are poorer and where shallow stagnant water may accumulate. In the area which was mapped around Knob Lake the Spruce Muskeg covered a greater area than the Sedge Fen, but the latter undoubtedly occurs in a higher proportion in the Trough than elsewhere.

FIG. 8. COMPARISON OF THE SURFACE RELIEF OF BOG TYPES.

(Holtedahl)



S. Soligenous O. Ombrogenous T. Topogenous.

The major difference between these two forms of bog is in the origin of the moisture, the sedge fen originating as a floating mat on a lake, while the organic matter accumulates from the top, whereas the *Sphagnum* bog builds itself upwards. Transeau (53) suggests that the reason behind the differing types is that the fens have some drainage, whereas the *Sphagnum* bogs are stagnant. Dansereau and Segedas-Vianna have constructed a table of comparison (see table 10) between the two types, but they do not suggest any reason for the differing vegetation.

TABLE 10

COMPARISON BETWEEN BOG AND FEN
(Dansereau and Segedas-Vianna)

	BOG	FEN
1.	Blocked drainage causes an indefinite accumulation of organic material. A small quantity of mineral soil is introduced by seepage, in-wash and atmospheric agents.	Drainage does not allow considerable accumulation of organic material. Shallow substratum and seepage permit a mixture of mineral and organic deposits.
2.	Drainage is congested by bog. Several small bogs may unite and modify drainage over a big area. Process reversed in a late stage when there is tree growth.	Drainage is gradually improved by growth and corresponding sedimentation.
3.	Open water invaded by floating mat and pools filled in from the top as well as from the base.	Open water filled in by non-floating vegetation. Filling in from the bottom upwards.
4.	Water table at the surface in Spring, and just below it for the rest of the year. Phreatic level just below the surface in the Spring, but much below it for the rest of the year.	Water table well above the surface in Spring, and a little below it for the rest of the year.

5.	Adjacent water brownish	Adjacent water dark greenish.
6.	Substratum cohesive - can hold man.	Substratum soft, and will absorb heavy objects.
7.	Substratum 100% organic; always peat.	Substratum with variable percentage of organic material, usually not peat.
8.	False bottom forms in open water due to the accumulation of colloids.	No false bottom.
9.	Presence of floating mat usually dominated by Ericoids.	Mat, when present, dominated by Graminoid plants.
10.	Physiognomic dominance of curvilinear contour; much branched shrubs, cushion-like tufts of herbs and mosses-curved surface of raised-bog.	Physiognomic dominance of rectilinear contour, Graminoid herbs, flat surface of the soil.
11.	On the whole the bog is a large cushion.	On the whole, a wet prairie.
12.	Dominance of Ericoids at pioneer stage.	Dominance of Graminoids at the pioneer stage.

13.	Dominance of needle-leaved types at sub-climax stage.	Dominance of the broad-leaved type.
14.	Vegetal cover continuous, uneven, forming cushion, eventually park-like.	Cover discontinuous, in tufts, eventually thicket-like.
15.	Mosses, mostly <u>Sphagnum</u>, forming lowest layer.	Mosses, especially <u>Sphagnum</u>, rare.

THE CONCEPT OF BOG AS A 'CLIMAX'

In a study of vegetation it is common to include a discussion on the possibility of a climax formation in the area. The former common concept of climax is the ultimate development of vegetation in any habitat, no further changes being possible under the climatic conditions which exist. The writer has been led to believe, however, that this concept is now completely discredited, present opinion being that there is no such thing as an equilibrium community.
As a Geographer, the author does not feel competant to judge whether or not such an ultimate form of vegetation does, in fact, exist, but would rather offer some comment on whether bog leads to, or follows forest in the Knob Lake area.

Zach (59) working on muskeg in Alaska, has reached the conclusion that it is the climax in that region and is invading the forest. Evidence of the forest being overcome by bog vegetation has been recorded from Labrador-Ungava, and was seen by the author in the Knob Lake area, but for reasons which will be given she would hesitate to use this as evidence of bogs being the climax. Zach quotes the following evidence for his theory.

1. Overabundance of rainfall, inhibiting decay of organic matter.
2. Cool temperatures and little sunshine, hindering decay.
3. Much cloud, hindering evaporation and transpiration.

4. The tendency for accumulating organic matter to clog unless on a steep enough slope.

5. Poor forest bordering the muskeg, suggesting throttling.

This concept may apply in Alaska, but it is important to remember that if the muskeg does increase, it will only do so to its altitudinal and gradient limit. It would be impossible to say whether the muskeg might be the climax in the Knob Lake area because the vegetation is so different in the valleys and on the interfluves. Drury (13), also from studies in Alaska, observes that Black Spruce has formerly occupied the lowland and the natural process today is toward the swamping of the forest, so that in this sense he might say that the muskeg is the climax. If, in the changing sequence of vegetation association, one type is more stable than the other, then it should occupy an increasingly large area with the passage of time. Thus Drury says that in Alaska where he was working the Sedge Meadows are as certainly the climax as the Spruce Muskeg. This obviously contradicts the consistent use of the climatic climax as formerly understood.

In the Knob Lake area, as in other Sub-Arctic regions, the vegetation is not only essentially very young, but it is influenced by the seasonal change of frost in the ground. Concepts of pioneer and climax vegetation cannot always be applicable where there is a constant change as a result of frost-heaving. All species must be adapted to pioneering and to disturbed conditions, and species composing the vegetation cannot develop a complex inter-relationship because they are not able to occupy the surface undisturbed. Thus according to Cowles (7) ..... "a condition of equilibrium is never approached as variable is approaching variable rather than a constant".

Thus, in the Knob Lake area, the writer does not think it true to say that the bog vegetation might be the climax, even though the present trend is toward wetter conditions. Not only are the bogs poor in species on account of the fact that they are hardy pioneering plants in a periglacial climate, but they have had to adapt themselves to changes in climate even over the past 100 years.

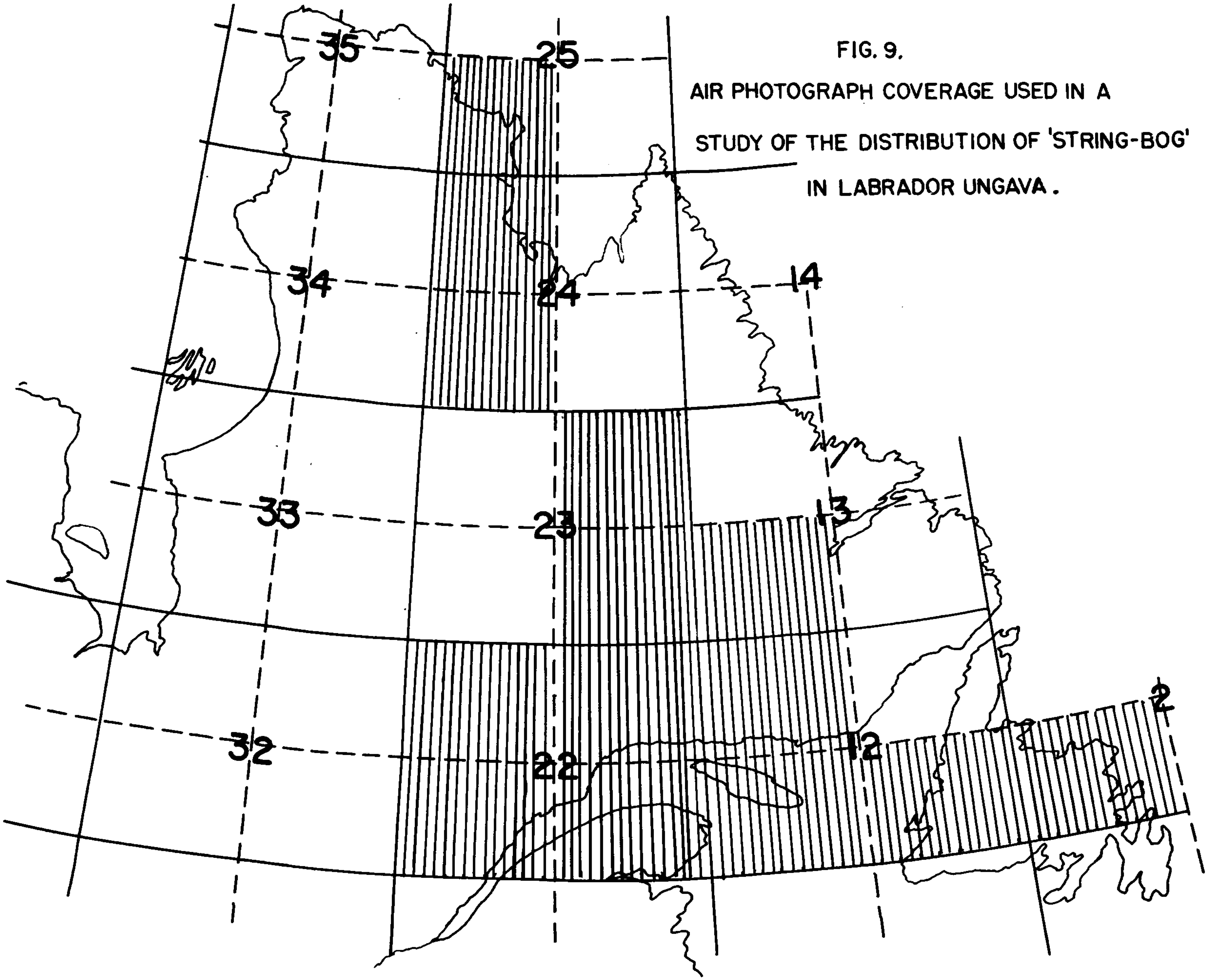


FIG. 9.

AIR PHOTOGRAPH COVERAGE USED IN A STUDY OF THE DISTRIBUTION OF 'STRING-BOG' IN LABRADOR UNGAVA.

NOTES ON THE DISTRIBUTION OF STRING BOG IN LABRADOR-UNGAVA

25 S.W. and 24 N.W.

No String Bogs in this area, but a marked development of Palsa Bogs.

24 S.W.

No spectacular String Bogs, but again an increase in the proportion of areas covered by Palsa Bog.

23 N.E. and S.E.

Area in which detailed mapping and field study was made. Good development of String Bog.

13 S.W.

Excellent large areas of String Bog, especially in the Goose Bay area.

22 N.W.

Very little String Bog, and only poorly developed.

22 S.W.

String Bog as far south as this, but very poor. There is a much higher percentage of Raised Bog - more rainfall and a higher rate of decomposition.

22 S.E.

Suggestions of String development, but much of the lowland has been cleared for cultivation.

12 N.W. and 22 N.E.

Very little String Bog, but probably the terrain is not suitable for the accumulation of decomposed material. This is the Laurentian scarp area and only small areas of bog are found in the hollows.

12 S.E.

Extensive String Bog but this seems to be the boundary of their development as there is an equal percentage of Raised Bog and Sedge Meadow.

12 S.W.

Anticosti Island: Magnificent large areas of String Bog and Sedge Fen.

2 S.W.

String Bogs present but not as well developed as further north. There is much Raised Bog here, particularly near to the coast - Atlantic influence.

CHAPTER VI

STRING BOGS AND THEIR FORMATION

In chapter 4, each type of bog as seen from air photographs was described, and it has been shown subsequently that in the Knob Lake area there are two main processes involved in the formation of these bogs. The object was to try and explain why the two different types of surface vegetation occur. With the category of String Bog, however, a completely different problem presents itself. Here we are concerned not with a distinctive type of vegetation, but with surface form associated with several different kinds of vegetation cover. The category corresponds to that described by Radforth (46) as Vermiculoid 2, but he is only interested in using the surface form as an indication of the condition of the sub-surface material.

In the Knob Lake area, these features were seen composed almost entirely of Sedges and grasses and concentric around the shores of open ponds (see bogs 7 and 8 in the Appendix). They were also found in the form of _Sphagnum_ ridges with a rich growth of shrubs and in some cases, lichens (see bog No. 3 in the Appendix). When the sedge ridges became more compact and offered a drier habitat, they were frequently colonised by _Larix laricina_ and _Betula sp._ (see bog No. 5), whereas in other cases the ridge and hollow topography of the bog surface appeared to be fairly stable, and the strings would have both Picea mariana and Larix laricina growing through a dense shrub layer (see bog No. 9 in Appendix). In all cases, the strings are formed across a slight slope, so that in effect each ridge constitutes a small dam behind which water becomes ponded. The actual slope of many String Bogs was measured and in all cases was found to be of the order of 1-3 degrees.

A study of vegetation throughout the peninsula of Labrador-Ungava shows that on the whole the distribution of String Bog is within the Boreal Woodland zone. To the north the predominant types of bog are Wet Meadow and Palsa Bog, both of which are almost certainly caused by the presence of permafrost. In the former case, sub-surface ice brings the water table close to the surface, thus creating a wet habitat in lowlying areas. The author believes that there may be some connection between the surface forms of Palsa and String Bogs. It was mentioned earlier (chapter 4) that the few Palsa bogs recorded in the Knob Lake area were found overlying permafrost patches, but even so no direct correlation can be assumed, because Drury (13) reports permafrost beneath the String Bogs in Alaska, which are completely ice free in the Knob Lake area. The author would rather suggest that these two forms of bog surface topography result from the activity of the surface layers, which Radforth calls the "Climafrost" (43). This is a term which he uses to describe the depth of the ground affected by freeze and thaw, whether it be the active layer of the permafrost, or in areas south of the continuous permafrost, the depth to which the ground freezes in winter. The surface of a Palsa bog is in effect the result of the formation of frost scars, and the retention of ice in the tussocks of grass. These will only form, however, where the depth of organic material is little more than 3 feet (Hopkins and Sigafoos, 22). Hence the intensity of frost heaving varies inversely with the depth of the peat cover, and surface features will be lacking where the peat is thicker than the depth of annual thaw. The nature of the Tundra climate is not, however, conducive to the accumulation of organic matter and Potzger and Courtemanche (41) claim that it is never more than 6 feet deep in the Tundra.

The author has reason to believe that the formation of String Bogs is dependent on several factors. One of these is the action of frost at the surface, and hence the similarity with the Palsa Bogs to the north. Another factor is the depth to which the peat is thawed out in the spring. Further conditions may add to the formation of String Bogs and will be discussed later in the chapter, but it is these two which the author believes govern the distribution of these bogs in Labrador-Ungava. There would seem to be a delicate balance between the depth and consistency of the peat, and the amount of frost activity at the surface. The actual process which the author believes to take place will be described in more detail, but the present discussion is an attempt to explain the distribution of the bogs. Northwards, the depth of the peat diminishes so that although frost heaving at the surface is extremely active the effectiveness of the sub-surface thaw is reduced. Southwards, bogs may be very deep, but with a longer thaw period, vegetation at the surface will colonise more rapidly and thus the ridges will not retain their form from year to year. It would seem, then, that there is a critical length of the freeze and thaw periods within which String Bogs are likely to develop. The author studied air photographs along a north to south transect through Labrador-Ungava, noting the areas where String Bogs were to be found (see fig. 9). If this is compared with the map showing the length of the freezing season (fig. 4), it would seem to show that the String Bogs are developed in areas with between 160 and 220 days when the temperature is below 32 degrees. i.e. the summer thaw beginning between April 20th and May 15th and ending between October 15th and November 5th (figs. 2 and 3).

It is generally agreed that these bogs with a ridge and hollow surface topography are characterised by an overall sloping surface, although opinions differ as to their origin. When seen from the air the patterns these bogs assume suggests a process analagous to solifluction. Hanson (19) says that the downhill movement of water below the surface, plus the weight of the saturated material on a slope, would cause horizontal cracking and movement downhill. Such downslope pressure is suggested by the lobed appearence of the ridges and the crowding together at the base of a slope. A converse process to this i.e. an uphill movement of the bogs, has also been suggested. This is the process described by von Post (40) as Paludification, and is dependent on an increase of moisture so that the moisture-loving bog plants (e.g. Sphagnum) invade the forest as the water table rises

Areas of Muskeg to the east of the Knob Lake Valley, showing
two types of surface relief.
N.B. the prevalence of lakes.

and the drainage becomes impeded. Wenner (58) considers that this process took place in Labrador-Ungava with the deterioration of climate after the climatic optimum. According to the von Post classification the feature is the reverse of a basin bog, in that it results from an increase of moisture at the surface of a formerly dry habitat. McKay (36) has described this process as the uphill creeping of ridges of Sphagnum, resulting in a terrace-like topography.

There would seem to be some confusion, however, in the use of the term Paludification, and the von Post original meaning has already been given. Subsequent authors have used the same expression in describing a drying-out process. Tanner (52) and Blake (4) use the terms 'aapa' or paludification with reference to bogs exhibiting ridges of Sphagnum and alternating stagnant pools yet it is precisely this type of surface which Tanner goes on to describe as being the result of a retrogressional development due to the drying up and freezing of the surface i.e. the decomposition of the surface by mechanical agents. Undoubtedly it may be true to say that in some areas the water table may be raised resulting in a local swamping of the forest. If the formation of String Bogs arose from the extension of this process over large areas, however, surely mature trees would be found growing on the strings, suggesting the remnants of a former forest. The author did not find any trees of sufficient age or stature on the String Bogs to suggest this mode of origin in the Knob Lake area. Admittedly one of the categories in the classification was String Bog with trees, but when these trees were examined in the field they were rarely found to be more than a hundred years old, and were more commonly about fifty to sixty years. The height of the trees was of the order of six to nine feet and they were commonly swathed in Beard Moss so that in general they presented a very grotesque appearance. These facts would rather suggest to the author that the trees had actually colonised the strings, but that under such conditions survival was a laborious process. If this is in fact the case, then it is desirable to explain the process of string development before their colonisation by a more xerophytic type of vegetation. The fact that this form of surface topography in the bogs was seen with various types of vegetation on the strings would suggest that they might form originally under wetter conditions when the sub-surface material is more fluid, and that the type of vegetation cover would change as surface became drier. This, however, presupposes a continuous cover of bog vegetation before the development of ridges and hollows.

Drury (13) suggests that basin bogs are the initial type before the development of a String Bog, and certainly the author frequently observed this development at the downslope end of a Sedge Meadow. Another factor contributing to this theory was the presence of the grey and red plastic clays which were always found beneath the Sedge Meadows and also at the base of more extensive String Bogs, whereas the bog forest was underlain only by the grey shaley material. Lewis and Dowding (31) also report a similar stiff plastic clay underlying the same types of bog in Alberta.

The theory of the downhill movement of organic material in a manner analogous to solifluction, has already been mentioned, and the author thinks that this process is most likely in the Knob Lake area. It would be more satisfactory if a longer field season could be spent in the area in order to measure any such downhill movement, but comparison of the features exhibited in this area, with those described by Auer (1) and Drury (13) have led the author to believe that similar processes are in operation. Hansen (19) ascribes the formation of half-moon shaped ridges on bog surfaces to the seepage of water and the weight of water saturated peat causing sufficient pressure to force the whole mass downhill. Drury, describing a similar process in Alaska, thinks that the process operates in the spring when the abundance of melt water will carry organic material across a frozen substrate. The extremely liquid nature of the sub-surface organic material of both the Sedge Meadows and the String Bogs in the Knob Lake area, would suggest that the movement of seeping melt water might cause such slumping of the bog surface. Drury states that in Alaska such slumping takes place across a frozen substrate, but we have seen that in Labrador-Ungava, no permafrost is found beneath these bogs. Is it not possible then that the characteristic plastic red clay at the base of the bogs might provide an excellent lubricant surface on which such saturated material would slide ?

Given that such a process might initiate the ridge and hollow topography at the surface of a bog, however slight, other factors will contribute to their maintenance. The most important of these is undoubtedly the nature of the climate and length of the thaw season, which has already been discussed earlier in the chapter. Auer (1) is of the opinion that in the fall the water in the hollows will freeze first and the edges of the ice will exercise pressure on the sides of the ridges, thus a squeezing will occur in the peat. Conversely, in the spring, the ice will persist longer in the strings and Troll (55) considers that this will result in additional doming, although the ice rarely remains throughout the summer. According to this theory, however, movement of the underlying material and distortion of the bog ridges will be more effective in the autumn when the ridges are not still anchored. In the spring, the thaw is fairly rapid at the surface, but evaporation is low, hence the melt water may have great force. In this way plant remains and slush may be washed against the ridges. This, according to Auer, contributes to the local dryness as a tide-like collection which encourages colonisation by less hydrophitic mosses.

It is suggested then that once differences in level have been established the process of string formation is in a sense self-perpetuating, but the process is probably not entirely mechanical. The botanical aspect must also be taken into consideration. The iniation of ridges on a bog surface results in the raising of these parts of the surface above the water level, thus encouraging more mesophitic species. On the other hand, the dam action of the ridges leads to the persistent swamping of the intervening hollows which thus further exaggerates the difference between the two habitats. Once more the importance of the delicate balance of the contributing factors must be stressed. If the climate became any drier, such that the hollows were not in a state of continued inundation, then they would develop a mat of vegetation and there would be a tendency toward a smoothing out of the bog topography. Another factor which should be taken into consideration is the length of the growing season. To the south of the Boreal Forest, temperatures and rainfall are such that the growth of Sphagnum during any one season would probably compensate the formation of bog ridges, so that they would not retain their form. In the Knob Lake area the growing season has a mean length of 101 days (see table 4) based on a mean daily temperature above 43 degrees. Some arctic Botanists have shown that plant growth starts at temperatures below this figure, but in the bogs of the Knob Lake area there were few signs of plant activity before June, which is the first month with a mean above this figure. The most probable reason for this lack of plant activity until the summer, is that, as was noted earlier, the bogs are still frozen in this area up to the end of June, and hence the subaerial parts of the bog plants will be affected by the proximity of the ice surface.

It would seem probable, then, that the unusual patterns which are found on the surface of bogs in the Boreal Forest zone, result from a combination of the general process of frost action and the normal tendencies of plant colonisation.

CHAPTER VII

SUMMARY AND CONSLUSIONS

This thesis is primarily concerned with the subdivision of bog vegetation, as seen from air photographs, into categories which could easily be recognised by students unfamiliar with their characteristics in the field. The classification is simple, but the author believes that in attempting to explain their formation the fundamental processes of bog formation in the Sub-Arctic have been covered. One of the most striking bog types included in the classification was that of String Bog. This was not so much a distinct vegetation type, but a phenomenal pattern assumed by the surface vegetation. Again an explanation of the development of this extraordinary form of micro-topography has been attempted, but it is apparent that much more field work is necessary before any more definite conclusions can be drawn for the Knob Lake area.

It can be shown that the shales of the Labrador Trough provide a less acid habitat than the granite-gneiss area and thus favour the formation of Sedge Meadow and Tamarack bog. In addition to this factor, the nature of the underlying topography has been conducive to lake infilling, thus accounting for the abundance of the so called 'basin bogs'. As it has also been suggested that the String Bogs originate from these basin bogs, this probably accounts for their development being more extensive in the trough than in the nearby granite-gneiss country.

The problem of String Bog formation is of particular interest, and by comparison with similar work elsewhere, the author suggests that it is essentially a frozen ground pattern, but without the underlying permafrost. According to Auer (1) "the hypothesis for Strangmoor is a strong expression of winter ground frost and summer thaw". The present thesis, however, proposes a combination of both mechanical and botanical factors in their development. On the other hand, the initial establishment of a ridge pattern on the surface of the bogs is still not explained and a considerable amount of research remains to be done and continued measurements made of movement in the peat, before any more definite conclusions might be reached. The Knob Lake area does not exhibit String Bog formation at its best, but was chosen for study by the writer on account of its accessibility.

SELECTED BIBLIOGRAPHY

(1) Auer, V. "Uber die Entstehung der Strang auf den Torfmooren". Acta Forestalia Fennica 12: 1920. pp. 23-145.

(2) Auer, V. "Peat bogs of S. E. Canada". Hanebb. d. Moorkunda VII. Berlin 1933. Also Memoir 162, Geol. Survey of Canada p. 5. 1930.

(3) Benninghoff, W. S. "The Interaction of Vegetation and Soil Frost Phenomena". Arctic Vol. 5. No. 1. 1952. pp. 34-43.

(4) Blake, W. Vegetation and Physiography of the Goose Bay area, Labrador. Unpub. M.Sc. thesis. McGill Univ. 1953.

(5) Cajander A. K. "Studien uber die Moore Fennlands". Acta Forestalia Fennica No. 2. 1913.

(6) Coombs, D. B. The Hudson Bay Lowland: A Geographical Study. Unpub. M.A. thesis. McGill Univ. 1952.

(7) Cowles, H. C. "The causes of Vegetation Cycles". Bot. Gaz. 51, 1911. pp. 161-183.

(8) Dachnowski, A. P. "Peat Deposits in the United States". Soil Science Vol. 10. No. 6. 1920, pp. 453-465.

(9) Dansereau, Pierre. "Sur les differences de structure entre diverses tourbieres". Ann. de l'ACFAC 15, 1949. pp. 128-130.

(10) Dansereau, Pierre, and F. Segedas-Vianna. "Ecological study of the peat bogs of E. North America. 1. Structure and evolution of vegetation". Can. J. of Bot. 30, 1952, pp. 490-520.

(11) Douglas, Mary, and R. N. Drummond. "Map of the Physiographic Regions of Labrador-Ungava". Canadian Geographer No. 5. 1955. pp. 9-16.

(12) Drummond, R. N. A Traverse of the Romaine River to establish Ground Control for the Interpretation of Air-Photographs. Unpub. M.Sc. thesis McGill Univ. 1950. 173 pp.

(13) Drury, W. H. "Bog Flats and Physiographic Process in the Upper Kuskokwim River Region of Alaska". Contry. Gray Herb., Harvard Univ. 178, 1956.

(14) Flint, R. F. Glacial Geology and the Pleistocene Epoch. New York, John Wiley, 1947.

(15) Fraser, E. Morton. Some aspects of the Ecology of the Lichen Woodland in the Knob Lake area. Being an extract from a report in preparation on the Forest Ecology of the area. Unpub. typescript, Oct, 1956.

(16) Gustafson, J. K. and A. E. Moss. "The role of the Geologist in the development of the Labrador-Quebec Iron Ore deposits". Trans. Assoc. in Eng. 196. 1953, pp. 593-602.

(17) Halliday, W. E. D. "A Forest Classification for Canada". Dom. For. Ser. Bull. 89. Dep. Mines and Resources. Ottawa. 1937.

(18) Hamelin, Louis-Edmund. "Les Tourbieres Reticules du Quebec-Labrador Subarctique: Interpretation Morpho-Climatique". Cahiers de Geog. de Quebec. October 1957.

(19) Hanson, Herbert, G. "Vegetation and Soil Profiles in some solifluction and mound areas in Alaska". Ecology 31. pp. 606-630. 1950.

(20) Hare, F. K. The Climate of the Eastern Canadian Arctic and Sub-Arctic and its influence in Accessibility. Unpub. Dr. es Arts. thesis. Univ. of Montreal. Two volumes. 1950. 440 pp.

(21) Hare, F. K. "Climate and Zonal divisions of the Boreal Forest Formations in Eastern Canada". Geog. Review 40. 1950. pp. 615-635.

(22) Hopkins D. M. and R. S. Sigafoos. "Frost Action and Vegetation Patterns on the Seward Peninsula, Alaska". U. S. Geol. Survey Bull. 974-c. 1951. pp. 51-100.

(23) Holtedahl, O. Norges Geologi. Vol.2. Oslo 1953. pp. 867-887.

(24) Hustich, Ilmari. "Forest Geography of the Labrador Peninsula". Acta Geogr. 10, No. 2. 1949. pp.1-63.

(25) Hustich, Ilmari. "Phytogeographical regions of Labrador". Arctic Vol. 2. 1949. pp. 36-42.

(26) Hustich, Ilmari. "Notes on the Coniferous Forest and the Tree Limit on the East Coast of Newfoundland-Labrador". Acta Geogr. Vol.7 No.1. 1939, pp.1-70.

(27) Hustich, Ilmari. "On Forests and Tree Growth in the Knob Lake area, Quebec-Labrador Peninsula". Acta Geogr. 13. No.1. 1954. p.6.

(28) Hustich, Ilmari. On the Phytogeography of the Subarctic Hudson Bay Lowland., Unpub. report submitted to the Arctic Institute of North America. Feb. 1957.

(29) Katz, N. J. "Sphagnum Bogs of Central Russia: Phytosociology, Ecology and Succession". J. of Ecol. Vol.14. 1926 pp. 177-202.

(30) Lajoie, Paul G. Exploratory Soil Survey of the Fort Chimo District (Ungava Bay, Quebec) Canada, Dept. of Agric., Experimental Farm Service. Unpub. Typescript. 1954.

(31) Lewis, F. J. and E. S. Dowding. "The Vegetation and Retrogressive changes of Peat Areas (Muskeg) in central Alberta". J. of Ecol. Vol.14. 1926. pp. 317-341.

(32) Lotz, J. R. Soils and Agricultural Possibilities in the Knob Lake area, P.Q. Unpub. M.Sc. thesis McGill Univ. 1957.

(33) Lougee, R. New Concept of Ice Age History. Unpub. preliminary typescript of a paper presented to the Ass. Am. Geog. Dec. 1958.

(34) MacFarlane. I. C. Guide to a Field Description of Muskeg. Canada, National Research Council, Assoc. Comm. on Soil and Snow Mech. Tech. Mem. 44. Jan. 1957.

(35) Marie-Victorin, Fr. "Phytogeographical problems of Eastern Canada". Contr. Lab. Univ. Montreal 30 1938.

(36) McKay, I. A. Forest types of the Kenemie-Kenemich drainage basin, Labrador: an interpretation of cover types from an aerial-photograph mosiac. Unpub. M.Sc. thesis, McGill Univ. 1956.

(37) Moss, E. H. "Marsh and Bog Vegetation in N.W. Alberta". Can. J. of Bot. 31. 1953. p. 448.

(38) Nebiker, W. Evaporation/Transpiration studies at Knob Lake, Quebec. June-Sept. 1956. Unpub. typescript, McGill Univ. 1956. 10 pp.

(39) von Post, Lennart. "Einige Aufgaben der regionalen Moorforschung". Sveriges Geologiska Undersökning. Ser. 6 No. 337. Stockholm 1926.

(40) von Post, Lennart. "The Geographical Survey of Irish Bogs". Irish Naturalists Jour. Vol.6. No.9. 1937.

(41) Potzger J. E. and Albert Courtemanche. "Permafrost and some characteristics of bogs and vegetation in northern Quebec". Rev. Canadienne de Geog. 9. (2-3) 1955. pp. 107-114.

(42) Potzger J. E. and Albert Courtemanche. "A Series of bogs across Quebec from the St. Lawrence to James Bay". Can. J. of Bot. 34. 1956. pp. 473-500.

(43) Radforth, N. W. Organic Terrain Organisation from the Air (less than 1000 ft.) Handbook No. 1. Canada, Defence Research Board, Department of National Defence. Ottawa, 1955.

(44) Radforth, N. W. Suggested Classification of Muskeg for the Engineer. Canada, National Research Council, Assoc. Comm. on Soil and Snow Mech. Tech. Mem. 24. Ottawa, May, 1952.

(45) Radforth, N. W. Proceedings of the Western Muskeg Research Meeting. Canada, National Research Council, Assoc. Comm. on Soil and Snow Mech. Tech. Mem. 38, Ottawa, Sept. 1955.

(46) Radforth N. W. Organic Terrain Organisation from the Air (altitudes 1000-5000 ft.) Handbook No.2. Canada, Defence Research Board, Department of National Defence, Ottawa, 1956.

(47) Rigg. G. B. "The Development of Sphagnum Bogs in North America". Bot. Rev. 6. 1940 pp. 666-693.

(48) Rigg. G. B. "Some Raised Bogs of S.E. Alaska with notes on flat bogs and muskegs". Am. J. of Bot. Vol.24 1937. p.194.

(49) Sigafoos, R. S. "Soil Instability and Tundra Vegetation". Ohio. J. of Science Vol.51. Nov. 1951. pp.281-298.

(50) Sjörs, H. "Bogs and Fens in the Hudson Bay Lowlands". Arctic Vol.12. No.1. 1959. p.3.

(51) Swinnerton, A. A. "Peat in Canada". Can. Geog. Jour. Vol.31. No. 1. 1945. p.18.

(52) Tanner, V. "Outlines of Geography, Life and Customs of Newfoundland-Labrador". Acta Geog. Vol.8. No.1. 1944. 400 pp.

(53) Transeau, E. N. "On the Geographic Distribution and Ecological relations of the Bog Plant Societies of northern N. America". Bot. Gaz. 36, 1903 pp. 401-420.

(54) Tedrow, J. C. Pedological Study of the Soil Forming Processes of the Arctic Coastal Plain of Alaska in the vicinity of Point Barrow, Alaska. Progress report prepared for the Arctic Institute of North America. D. N. R. No.175. Rutgers Univ. Oct. 1956.

(55) Troll, C. "Strukturboden, Solifluktion, Frostklimat der Erde". Geol. Rundschau 34. 1944, pp. 545-695.

(56) Vierick, L. A Preliminary Survey of the Cover Types of Knob Lake, P.Q. Unpub. typescript, McGill Univ. Subarctic Research Lab. Knob Lake, Que. May 1955. 15 pp.

(57) Villeneuve, G. Oscar. Climatic Conditions of the Province of Quebec and their Relationship to the Forests. Ph.D. thesis, Yale Univ. Also in Prov. of Quebec, Dept. of Lands and Forests, Bull No.6. 1946.

(58) Wenner, C. "Pollen Diagrams from Labrador". Geogr. Annaler 29. 1947. pp. 137-374.

(59) Zach, Lawrence W. A. "Northern Climax, Forest or Muskeg ?" Ecology Vol.31. 1950. pp. 304-306.

APPENDIX

NOTES ON SOME OF THE INDIVIDUAL BOGS STUDIED

Notes were made according to the booking system for the surface investigations of muskeg suggested by MacFarlane, and outlined below

1. Site.
2. Date of field inspection.
3. Detailed location a) map
   b) air-photograph.
4. Approximate area of the terrain.
5. Surface elevation.
6. Physiographic features.
7. Water conditions a) evidence of drainage pattern.
   b) depth of water table.
   c) colour of the water.
8. Description a) surface coverage.
   b) topography.
9. Classification on preliminary mapping.
10. Notes on climatic conditions.
11. Photographs (number and description).
12. General remarks.

Bog No. 1. In the upper photograph, dead tree boles are seen submerged in Sedge Fen. The lower photograph shows the southern end of the bog, and in the middle distance three raised ice-mounds with more xerophitic vegetation.

Bog No. 1. The margin of the bog in its northern section. The lower photograph shows the difference in level between the northern and southern sections of the bog. The student in the middle distance is standing just below the level of the southern bog which is four to five feet higher than the northen part.

BOG 1

1. 200 yards west of the north end of the airstrip.

2. 27th May, 1957.

3. a) 23 J/15(W) - Canada 1:50,000 (Knob Lake).

   b) R.C.A.F. A 13866/57.

4. Approximately 1750 x 400 yards.

5. 1650 ft.

6. Situated on a flat at the bottom of the Knob Lake valley near to Pearce Lake.

7. a) Northern part seems to be draining away to the north. On the west is a filled-in pond with no outlet. Southern end seems to be stagnant open water between the strings.

   b) Melt water at the surface. Frozen at 3".

   c) Clear - no colour.

8. a) Dominant Sedge and *Sphagnum*, with *Cladonia*, *Ledum groenlandicum*, and *Larix laricina*. In some places almost entirely Sedges.

   b) Where all Sedge, usually completely flat, with Sedges growing in tussocks. On the main bog, strings seem to be filling-in with Sedge vegetation. Some apparently Xerophitic mounds which may be in process of inundation by the bog. Also much open water.

9. String bog in centre, Sedge to the south. Tamarack bog to the N.W.

10. Seen after much rain but in fine weather conditions. Thaw not well advanced.

11. B & W Kodak Pan X deep yellow filter 1/30 at f.5.6

    20. Sedge, moss ridges - much open water.

    19. Open Sedge Meadow.

    18. Dead tree boles with bases submerged in Sedge Fen.

    17. Xerophitic mound rising out of Sedges.

    16. Distant view of above.

    15. Ditto.

    14. Difference in level between north and south ends of the bog.

    12. Bog at N.W. end.

    11. Ditto.

12. Drainage may be due to season - extraordinary ponding in some places where drainage would seem natural.

BOG 2

1. 300 yards S.E. of airstrip.

2. May 27th, 1957.

3. 23 J/15 W., Canada 1/50,000, (Knob Lake).

4. 200 x 200 yards.

5. 1,650 ft.

6. Hollow at base of a scarp which is covered by close Lichen Woodland and from which there is probably much run-off.

7. a) Stream at base of scarp flowing into bog. Some minor drainage south but may only be excess due to snow melt.

   b) Some snow at surface. Sphagnum very wet and spongey - ice visible sometimes at 4-5" but frequent deep pools 9 ins. to 1 ft.

   c) Mainly clear but sometimes brownish in pools.

8. a) Definite string with dominant Sphagnum and some sedge growth. Abundant dead Tamarack with some attempt at regeneration but rather feeble. A few Black Spruce.

   b) Strings short and joined - possibly closing in.

   c) Fairly obvious that bog has submerged forest here fairly recently as some trees are still dying. Certainly not a burn as the secondary shoots are still intact.

9. Classed on map as Tamarack forest.

10. Same as bog one.

11. B & W Kodak Pan-X deep yellow filter 1/30 at f.5.6

    8. Tamaracks on Sphagnum strings with ice in open pools.

<u>Bog No. 3</u>. The northern section of the bog, where the open pool is surrounded with Sedge Fen which is underlain by a fairly well-consolidated peat. The pond drains out to the north and in some places at this end of the pond, the peat has been eroded into small but distinct vertical banks. The lower photograph shows the southern end of the bog where sinuous strings were formed of *Sphagnum* and Ledum *groenlandicum*

BOG 3

1. 100 yards east of airstrip and parallel to it, crossed by embanked road used before construction of present airstrip.

2. May 28th, 1957.

3. a) 23 J/15 W, Canada, 1:50,000, (Knob Lake).

   b) R.C.A.F. A 13866/57.

4. Approx. 600 x 100 yds.

5. 1,650 ft.

6. Situated on a flat between John Lake and Knob Lake at the bottom of the Knob Lake valley.

7. a) At present drainage between the northern and southern sections northwards via drain under road and at north end of bog via artificially cut channel.

   b) Melt-water at surface - frozen at 4-6 inches.

   c) Water clear, sometimes brownish.

   d) pH 4.6 - 4.8

8. a) Dominant Sedge Meadow with some peat formation. (Depth to be investigated after thaw). In the southern section some Sphagnum strings with Ledum groenlandicum. Margins of the bog show a zonation from Sphagnum with Ledum and dwarf Betula where the Sphagnum becomes drier. Behind this, dead Tamaracks mixed with young trees of the same species, apparently regenerating satisfactorily, although scattered. Behind these again, a slightly elevated bog forest, about two feet above the bog level with dominant Black Spruce and some Tamarack.

8. b) At present the bog shows two distinct levels with about two feet difference on either side of the road which crosses it, the higher being to the south. The northern section forms a sedge fen with a small amount of peat accumulation surrounding an open pond. In the south, a stretch of open water with some emergent sedges is being dammed up by the road. Behind this there are several Sphagnum strings with abundant Ledum groenlandicum growing on them. These strings seem to be holding up one or two small patches of open water which merge into flat sedge fen.

9. Complete cover of flat Sedge Fen - (this is obviously not so). Southern section correctly marked as string bog.

10. Seen after much rain in dull showery weather. Thaw not well advanced.

11. B & W Kodak Pan - X 1/30 at f.4 deep yellow filter.

    5. Lake in the north surrounded by sedge fen with Bog Forest at margin.

    4. Apparent 'strings' of sedge probably due to inundation caused by the damming effect of the road.

    3. Margin of southern section showing dead trees and young Tamaracks.

    2. Strings in southern section of Sphagnum and Ledum sp.

12. Before the road was built, this bog was obviously continuous but with two types of bog formation. Now, however, the road has modified this with the effect that the southern bog seems to have built itself up to the level of the road, thus being much wetter than formerly. From the nature of the margins of this southern section it seems that before the road was built the normal succession was taking place and that Larix was regenerating on to the margin of the bog. Since then the level of the bog has risen thus killing the Spruces which were intermingled with the Tamarack, the latter being more tolerant of wetter conditions (Marie-Victorin p.142).

Bog No. 4. Above, the margin of the bog, showing the abrupt change from the Tamarack swamp in the foreground to the Spruce muskeg behind.

The author standing on one of the concentric strings at the southern end of the bog. These curve round to the right of the photograph. They are formed of both sedges and *Sphagnum* on which there is a dense growth of *Ledum groenlandicum* and *Betula sp.*

BOG 4

1. 600 yards of the S.W. end of the old air strip.

2. 29th May, 1957.

3. a) 23 J/15 East, Canada, 1:50,000, (Knob Lake).

   b) R.C.A.F. A13866/77.

4. Approx. half a mile long by 150-200 yards wide.

5. 1,600 ft.

6. Situated in a very shallow depression between two areas of Lichen Woodland.

7. a) No apparent drainage though according to the map it joins with a river draining northward to Peter Lake.

   b) Frozen at 2 inches, meltwater on top.

   c) Water clear.

8. a) Ground flora of Sphagnum and sedge mixed with some grasses; also dwarf birches and labrador tea on drier parts. On the bog surface many Tamaracks with scattered black and white Spruce. At the margins there is a quick transition to dominant Spruce of the bog-forest.

   b) Only the southern end of the bog was visited on account of lack of time, but here there appeared to be an old string formation between which the sedge had 'filled in' and become dominant. One or two strings in the form of concentric areas were seen but on the whole the strings have a chaotic appearance. Otherwise there is no change in the level of the bog except at the margins where it rises abruptly by about one or two feet to the bog-forest.

9. Sedge fen with some bog-forest at the northern end but small patches of string in the south. The latter was seen to be correct although there was tree growth on the strings.

10. Seen after two or three days with temperatures above freezing and fairly dry weather, thus the thaw was quite well advanced.

11. B & W Kodak Pan-X 1/30 at f.8. Deep yellow filter.

20. General view of the bog.

Bog No. 5. Above, the marginal Tamarack bog. Below, string development in the central part of the bog where the Sphagnum supports a dense shrubby growth with occasional young Tamaracks.

BOG 5

1. 66° 50' W. 54° 50' N., near southwest of shore of Squaw Lake.

2. 30th May, 1957.

3. a) 23 J/15 West, Canada, 1:50,000, (Knob Lake).

   b) R.C.A.F. A13866/71.

4. 700 x 250 yards.

5. 1,650 feet.

6. Situated on a flat between low ridges at the southwest of Squaw Lake.

7. a) According to the map there is drainage to the southeast but there is no apparent drainage on the bog.

   b) Meltwater - frozen at 4-6 inches.

   c) Water clear, but often muddy at base.

   d) pH 5.0.

8. a) Dominant sedge, with distinct Sphagnum ridges. Young Tamaracks colonising the strings, together with Ledum, young dwarf birches and willows and a species of blueberry. In the water between the strings, less dense growth of sedge, with Potomageton. Margin distinct with a zone of Tamarack bog about 40 yards wide giving way to Spruce. Note:- burnt tree boles found in the middle of the wettest string bog.

   b) In the centre of the bog was a fairly extensive area of open water with string development on the eastern side. Across the middle of the bog a string has built up into a ridge which has become colonised by Tamaracks. Where the Sedge is completely dominant and the standing water is not more than one inch deep, there is typical niggerhead development. Strings have possibly formed at right-angles to the direction of flow.

9. Originally mapped as string with peripheral areas of Sedge Fen and Bog Forest. This proved wrong in distribution rather than in type; there was more Bog Forest of Tamaracks along the margins than was apparent from the air photograph.

10. Seen in dull showery weather after a period of 3-4 days thaw.

11. B & W Kodak Pan-X, deep yellow filter, 1/30 at f.5.6.

    15 & 16. Both views of string bog.

12. It is a problem whether the *Sphagnum* or the sedge mat is the first to form in the open water because the strings are composed of both *Sphagnum* and sedge while there is considerable sedge growth in the open water between.

BOG 6

1. 54° 49' 30" N., 66° 50' W. About ½ mile due south of bog 5.

2. 30th May, 1957.

3. a) 23 J/15 West, Canada, 1:50,000, (Knob Lake).

   b) R.C.A.F. A13866/71.

4. 250 x 50 yards.

5. 1,650 feet.

6. Infilling a narrow and shallow river valley draining to the southeast.

7. a) According to the map this is draining to the south into Maryjo Lake. However, it is in an area of indeterminate drainage and on observation seemed to be flowing into the area of open water to the northwest.

   b) Meltwater - frozen at 5-6 inches but a distinct channel of about 2-2½ feet wandering through the bog suggesting that there is permanent flow through the bog.

   c) Water clear, often muddy at base except in the channel.

8. a) Dominant sedge, with one or two marked transverse Sphagnum strings. Abrupt margin; there is a narrow belt of Tamarack bog at the foot of a small ridge covered by Lichen Woodland vegetation.

   b) Apart from the transverse Sphagnum strings, the sedge had formed distinct short strings parallel to the direction of the current. The bog as a whole was almost completely flat but with small pools of open water.

9. Correctly mapped as string bog.

10. Same as bog 5.

11. No photographs were taken as there was no sufficiently elevated position from which photographs of the strings could be taken.

12. Why are strings parallel to the direction of the current as opposed to those we have seen previously which tend to form across a valley ?

Bog No. 7. Concentric sedge strings, parallel to the shore of the bog pond. This photograph was taken at the end of May, when the mean daily temperature had been above 32 degrees for almost a week, and there was considerable ponding of meltwater at the surface.

Bog No. 10. Sedge and *Sphagnum* strings damming up the water between so that the surface of the bog has a terraced appearance.

BOG 7

1. 54° 45' 50" N, 66° 49' 50" W. Due south of bog 6 across a small ridge.

2. 30th May, 1957.

3. a) 23 J/15, Canada, 1:50,000, (Knob Lake).

   b) R.C.A.F. A13866/71.

4. 800 x 800 yards.

5. 1,650 feet.

6. On gently sloping ground, situated within an area of generally indeterminate drainage.

7. a) No apparent drainage !

   b) Frozen at 5-6 inches with snow 4-6 inches deep amongst the trees.

8. a) Mainly Tamarack and Sedge with humps of Sphagnum on the sloping ground. In the northeast and centre of the bog areas of open water surrounded by Sedge Fen.

   b) The sloping bog was found between two areas of open water with a difference of approximately six feet downwards towards the southwest. It is possible that this had formed over a shallow rock ridge as there were promontories of this on either side. There was no drainage between the upper and lower levels of the bog. In this sloping part there were abundant Tamaracks - on the average between 3½ and 5 feet apart, with occasional Spruces, the latter being much younger. The ground flora mainly consisted of Sphagnum mounds which had probably formed from frost-heaving around and on which there was dense Sedge growth. At the bottom of this ridge, on the margins of the larger patch of open water there were concentric sedge strings parallel to the shore.

9. Mapped as bog with trees on the margins and strings to the south. Only the northern part of the bog was visited and here the interpretation was seen to be correct.

10. Same as bogs 5 and 6.

11. B & W Kodak Pan-X, deep yellow filter, 1/30 at f.5.6.

    14. Tamarack and sedge on sloping hillside.

    13. Sedge strings parallel to the open water.

12. The fact that the strings were both parallel to the edge of the water and to the slope suggests that the bog may have built itself up over this slope to the area where there is some open water to the northeast.

Bog No. 8. The upper photograph shows the margin of one of the areas of open water where the sedge shows a tendency to grow in lines parallel to the shore. Below, the open water in the left background is ponded up by the 'flight' of strings coming down to the lower right of the photograph.

BOG 8

1. 54° 51' N, 65° 42' W.

2. 31st May, 1957.

3. a) 23 J/15 East, Canada, 1:50,000, (Knob Lake).

   b) R.C.A.F. A13866/189.

4. 350 x 40 yards.

5. 1,550 feet.

6. Shallow narrow depression between two ridges with Lichen Woodland vegetation.

7. a) No apparent drainage.

   b) Frozen at 4 inches.

8. a) Dominant Sedge with Lycopodium and Potomogeton in the water. Very narrow margin. No Tamarack bog but spruce bog at edges. Around margins Ledum, dwarf Betula and some spruce regeneration, but this last obviously fairly recent as the trees were not more than 12-18 inches high.

   b) In the southwestern half of the bog were two areas of open water separated by a transverse Sphagnum string. In the north-east the depression is crossed by a series of Sphagnum strings, between which the water has become almost filled in with sedge growth. Along the margins of the open water on the western side where the slope into the depression was more gradual, sedge strings have formed parallel to the shore.

9. Originally mapped as string bog, continuing southeastwards as spruce muskeg. The former was seen to be correct, butthe area to the south was not visited.

10. Excellent fine weather conditions, after about a week of thaw.

11. B & W Kodak Pan-X, deep yellow filter, 1/30 at 5.8.

    11. Sedge strings parallel to the shore.

    10. Transverse *Sphagnum* strings.

12. N.B. Formation of both transverse and longitudinal strings in the same area of bog.

Bog No. 9. The central part of the bog where the Sedge Fen was drained by a wide river channel. This can be seen in the middle distance, with areas of bare peat at the margin. Below, the northern end of the bog where the long strings with a dense woody growth were found. The spruce trees growing on these strings were mal-formed, and on them there was often a thick growth of Beard Moss.

BOG 9

1. $\frac{1}{4}$ mile northeast from bog 8.

2. 31st May, 1957.

3. a) 23 J/15 East, Canada, 1:50,000, (Knob Lake).

   b) R.C.A.F. A13866/189.

4. 600 x 200 yards.

5. 1,550 ft.

6. Situated on flat at the southwest end of large lake to east of Peter Lake.

7. a) Drained by a river channel about 4 feet deep and 10-12 feet wide with about a 2 m.p.h. current and draining to lake in (6).

   b) Frozen at about 6-7 inches. Among the strings the thaw had penetrated deeper, so that the Sphagnum had become very spongey.

8. a) Three zones of vegetation. In the south Sedge and *Sphagnum* fen in which there was Tamarack growth. Many of these trees were dead but there was a wide margin of live Tamarack extending northwards. In the centre of the bog there was an area of open water surrounded by sedge fen under which there was a considerable accumulation of peat, visible at the edges of the channel to a depth of 4 feet, but possibly extending beneath that. Across the northern end of the open water was a $2\frac{1}{2}$ ft. high ridge composed of *Sphagnum*, on which there was a dense growth of *Ledum* with occasional dwarf *Betula*. On the aerial

photograph there is an area of open water to the north of this, but examination in the field showed that in the five years since the photograph was taken this has become completely filled in with a dense sedge mat. To the north of this again the bog was composed of continuous long transverse strings. These were formed of Sphagnum on which there was a dense woody growth of dwarf Birch and young Spruce trees. There were occasional Tamaracks but these were very stunted.

9. Originally mapped correctly with strings in north and sedge mat in south.

10. Weather same as Bog 8.

11. B & W Kodak Pan-X, deep yellow filter, 1/30 at f.8.

 9 & 8. Views of the spectacular string formation at the northern end of the bog.

 One Kodachrome No.8 on reel. Excellent of strings at north end.

12. Marked difference between vegetation of the string section and that to the south through which there was a drainage channel. Worth detailed study.

BOG 10

1. 54° 51' 50" No., 66° 42' 0" W. Entering eastern side of large lake east of Peter Lake.

2. 3rd June, 1957.

3. a) 23 J/15 East, Canada, 1:50,000, (Knob Lake)

   b) R.C.A.F. A13866/189.

4. Crescent-shaped, 500 x 150-200 yards.

5. 1,550 feet.

6. Situated on an area of land sloping towards the lake.

7. a) Drainage insignificant.

   b) Frozen in strings at about 4-5 inches. In the water between the strings, at 1 ft.

8. a) The entire bog was dominated by a Sedge mat. There were three zones. In the lower part of the bog the _Sphagnum_ formed large strings parallel to the strike of the slope. The Sedge was often growing in a _Sphagnum_ base of the strings but in the water between was associated with _Potomageton_ and a dense growth of _Lycopodium_. About 120 yards from the edge of the lake there was a belt of trees extending across the bog on slightly raised ground and consisting of young Spruce, rooted in _Sphagnum_, with an undergrowth of _Ledum_ and _Vaccinium_. Above this again there was a remarkable development of parallel strings, again parallel to the strike. These were never more than a foot across but the width of the open water between was usually 3-4 feet. The vegetation here was the same as was seen lower, but

the strings were not formed of such a dense vegetative growth. At the distal end of the bog there were two areas of open water, separated by strings somewhat thicker than already described. In the water, there was a moderately dense Sedge growth, with one or two elongated Sphagnum mounds showing above the water, again parallel to the direction of the strike. In this upper part of the bog the sedge mat surrounding the open water supported some young Tamaracks (although only 4-5 feet high, when cut across these exhibited approximately 35 annual growth rings). The bog as a whole showed no distinct margin of Tamarack sedge bog, the Spruce-Sphagnum association coming down to the edge of the sedge mat.

9. Mapped correctly as string bog.

10. Seen after several days of quick thaw, but in cool temperatures with snow showers.

11. B & W Kodak Pan-X, deep yellow filter, 1/30 at f.5.6.

    7-2. All views of string bog.

12. From the vegetation in the open water of this bog it would seem that the theory of build-up rather than of breakdown of strings is more valid.

BOG 11

1. About 600 yards south of the road to the old airstrip and parallel to the northern part of Lake Hannas.

2. 7th June, 1957.

3. a) 23 J/15 East, Canada, 1:50,000, (Knob Lake).

   b) R.C.A.F. A13866/77.

4. 150 x 350 to 500 yards along its longest section, but curving round in the south to form a circular area approximately 300 yards in diameter.

5. 1,550 feet.

6. Situated on a flat bordering a small stream flowing towards Lake Hannas.

7. a) One or two small streams breaking out at the edges from beneath a peat layer about two feet thick.

   b) Generally frozen at 5-6 inches where vegetation present, although deep in open water occasionally.

   c) Water cloudy and dark brown, often thick with accumulated matter at the bottom.

   d) pH 4.8-5.0

8. a) At first sight the bog appears as a flat sedge mat, but on closer inspection is found to consist of several divisions depententent on the bog form. In the northern section the aerial photograph shows an area of open water, to the east of which there is string formation. Now, however, although the strings are still present, the open water has become almost completely

filled with Sedge and grass. Where the lake is closing in there is a quaking sedge mat with black ooze underneath and in some places a suggestion of palsa form. The strings in this section are composed of Sedge and Sphagnum with some woody growth. In the northwest there is a belt about 20 feet wide of Tamarack bog, with trees about 5-6 feet high.

To the south, across the centre of the bog there is a large raised dry mound composed of moss, reindeer moss, Labrador Tea, Spruce and occasional herbaceous species. Underneath this the ice came within 2-3 inches of the surface. Nearby there is a series of concentric strings damming up a small lake behind the mound. These strings were about 2-3 inches above the water but the water between was about 6-9 inches deep, at the bottom of which there was 3-4 inches of decomposed Sphagnum and sedge remains. The strings themselves were composed predominantly of Sedge and there did not seem to be any building up in process. The pool which was being held up had similar rotting matter at the bottom, but was about 15 inches deep. Growing out of the decomposed material to about 4-6 inches above the surface of the water was a species of Juncus, with distribution of approximately 1 per square foot.

Between this pool and the upper circular portion of the bog there are longitudinal ridges of Sphagnum with Sedge, blueberry and small Tamaracks, again only about 4-5 ft. high. Between the ridges there was open water up to a foot in depth, and again Sedge remains in the water but the extent of decomposition was not as far advanced as that seem previously.

The upper circular portion is about 5 ft. higher than the rest of the bog and with a little drainage off at its margins. It is a flat area of Sedge growth in hummocks with blueberry, dwarf willow and Sweet Gale. There is evidently an accumulation of peat here as seen where the drainage channels have cut into it at the margins. This association has a fairly abrupt margin where the spruce and <u>Sphagnum</u> mounds meet it.

9. Originally mapped as sedge with areas of string but the Tamarack margin in the north was missed.

10. Seen after two days of cold weather with snow showers, on a cool cloudy day.

11. Kodachrome, UV filter, 1/60 at f.5.6.

    20. View of the string near to the mound.

12. Worth more intensive study when there has been more thaw as the string development seems to be fairly stable.

BOG 12

1. Southeastern portion of a relatively long lake (which shows white on the air photograph). Approximately 600 yards from the northwestern end of the old airstrip and in a line continuing its general direction.

2. 9th June, 1957.

3. a) 23 J/15 East, Canada, 1:50,000, (Knob Lake).

   b) R.C.A.F. A13866/189.

4. 200 x 250 yards.

5. 1,550 feet.

6. The bog and associated lake form a small depression following the general alignment of the country on a Lichen Woodland ridge.

7. a) No apparent drainage but as there is wet ground downslope to the west, there is possibly some seepage in that direction.

   b) Frozen at 8 inches where the vegetation came above the water level, but at about one foot below the open water.

   c) Water clear.

8. An almost circular pond in the middle of which there was a large island of bog vegetation. Surrounding the pond there was a Spruce-*Sphagnum* association except in the west where the Lichen Woodland comes down to the water. The *Sphagnum* grew in distinct ridges and mounds on which there was often a dense growth of birch and/or willow together with blueberry and Labrador Tea. The margin between the open water and the bog forest was distinct.

The depth of the water was generally about 3 or 4 inches but near the island the depth increased probably to 12-18 inches. Growing under the water in the shallow part there was a continuous spongy mat of Sphagnum in which there was some sedge growth; the latter became more dense in the northwest.

The island appeared to be composed of Sphagnum ridges. Some of these had evidently become quite dry as the tops of them were covered with a Cladonia mat. There was an abundant woody growth in the form of blueberry, Labrador Tea and probably birch and willow. There was also spruce growth, the younger members being fairly dense but the more sparse taller trees are now dead.

9. The bog was not noticed in the original mapping. This was an error, as it is identifiable as bog from the photograph.

10. Seen on a warm sunny day after approximately two weeks of thaw. N.B. First mosquitoes.

11. No record of photographs taken on this day.

12. The existence of the island with a fairly dry form of bog vegetation is interesting and might possibly be due to the presence of an underlying rock knoll. We have no proof of this but the fact that the Lichen Woodland comes down to the edge of the water nearby suggests this.

BOG 13

1. About one mile to the northwest of the old airstrip in the same general direction as the alignment of the airstrip and in a direct line with it.

2. 9th June, 1957.

3. a) 23 J/15 East, Canada, 1:50,000, (Knob Lake).

   b) R.C.A.F. A13866/189.

4. About 500 x 250 yards.

5. 1,550 feet.

6. Situated, as bog 12, in a slight depression on the same Lichen Woodland ridge.

7. a) No apparent drainage.

   b) Probably frozen, but not near to the surface.

   c) Water brown, but not opaque, often with floating, decomposing organic material.

8. The bog was surrounded by spruce bog forest, although this was only traversed on one side of the bog. The central area was composed of a series of transverse strings. These reached a height of up to a foot above the surface of the water and were about three feet wide. The water between was usually 4-5 ft. across and between one and two feet in depth. The strings were composed of *Sphagnum* which was probably building up fairly rapidly and on which there was a layer of woody growth consisting of *Ledum*, *Vaccinium* and some birch and willow. There were occasional black spruces, but although these had a feathery

appearance and did not seem to be in a healthy condition, there was a fairly dense regeneration by adventitious roots along the strings. Sample cross-sections of these trees were cut and it was seen that one of the larger trees of diameter one inch about 18 inches from the ground showed 57 annual growth rings. During this period there seemed to have been two periods of retarded growth; one during the past 12 years (1945 - 1957 ?) and the other, a period of 15 years, ending 32 years ago (1910 - 1925 ?). A sample of the younger trees, formed from an adventitious propagation from the above tree showed a diameter of ½ inch with 27 annual growth rings with no perceptible variation in growth.

In the water between the strings there was no apparent live vegetation. There were thick mats of floating organic remains, probably mainly Sphagnum. These mats were probably formed as a result of frost heaving. There was no Sedge or Sphagnum growth in these pools.

9. Correctly mapped as string bog.
10. Seen under same conditions as bog 12.
11. Kodachrome exposures of the floating dead remains in the pools, two general views of the strings, and a close up of the brightly coloured Sphagnum forming the strings.
12. The apparent luxuriant growth on the strings and the lack of any living matter in the pools between would seem to suggest

that these strings have been in existence for some time and may in fact be a climax form? To be revisited.

BOG 14

1. Situated parallel to bog 13 and approximately 500 yards to the northwest of it.

2. 9th June, 1957.

3. a) 23 J/15 East, Canada, 1:50,000, (Knob Lake).

   b) R.C.A.F. A13866/189.

4. About 600 yards long and ten wide.

5. 1,550 feet.

6. Situated in a shallow and narrow groove following the alignment of a rocky ridge and almost certainly structurally determined.

7. a) No apparent drainage.

   b) Frozen at about eight inches.

   c) Very little water present. What there was - clear - probably seasonal melt.

8. The vegetation is arranged in a series of ridges which seem to have been strings but they were diagonally across the bog. It was mainly composed of Sphagnum with birch and blueberry on these "ridges", and there was some spruce growth but the trees were generally more than six feet high and there did not seem to be very much regeneration. In the depressions between these ridges there was some sedge growth but the sedges had become flattened linearly along the surface as if the snow melt had drained off towards the south. There was very little open water at the time. If this was string it was definitely closing in and the Sphagnum on and between the ridges seemed to be

building up. One of the spruce trees was cut across. It had a diameter of 2¼ inches and showed 60 annual growth rings which were fairly even. The thicker trunk seemed to suggest that the conditions were more favourable than in Bog 13 in that there was very little open water and the Sphagnum was probably drier.

9. Not originally mapped because its unusual shape makes it easily mistaken for a narrow belt of trees.

10. Seen under same conditions as Bog 12.

BOG 15

1. In the northwestern corner of the air photograph are two long lakes nearly meeting in a V at their southern ends. Bog 15 is situated at the southwest corner of the western one.

2. 9th June, 1957.

3. a) 23 J/15 East, Canada, 1:50,000, (Knob Lake).

   b) R.C.A.F. A13866/189.

4. Roughly triangular in shape, about 200 yards along the median from the southern angle.

5. 1,600 feet.

6. Situated on the flat ground as an extension of the lake.

7. a) No apparent drainage but probably a stream flows in here via the bog. The bog resembles a large delta.

   b) Ice at indeterminate depth, probably about 1 ft.

   c) Water between strings dark and almost opaque.

8. The lake was bordered to the extreme south by a flat Sedge mat which was rooted in thick black mud. Adjacent to this in the southeast the bog was composed of a series of parallel strings probably transverse to the direction of an inflowing stream but following the line of the lakeshore. The strings were about 10 inches to 1 foot in height and were composed of *Sphagnum* with dense shrubby growth and some black spruce. In places where there was no woody growth the *Sphagnum* formed a quaking cover over viscous black mud. The strings and the water which is being held between them, seem to form a series of terraces as

they were damming up the lake so that its water level is about 2 feet above the general level of the base of the bog.

9. Incorrectly mapped as bog forest. This was true only in so far as the strings had shrub growth on them.

10. Seen under same conditions as Bog 12.

11. -

12. Obviously if there is such a stream as that postulated in 7a it cannot enter the lake. It would seem possible that the bog and consequently the strings were formed as a result of this stream entering the lake but that the stream now becomes lost in the lower part of the bog.

BOG 16

1.. Situated slightly below the summit of Dolly ridge to the north east of the road where it turns away from the summit.

2. 18th June, 1957.

3. a) 23 J/15 West, Canada, 1:50,000, (Knob Lake).

   b) R.C.A.F. A13866/75.

4. About 400 yards long, mostly being filled by a fairly deep lake, but bordered on the east by an upstanding shore of peat and to the south by bog vegetation.

5. 1,850 feet.

6. Situated in a structural hollow between two ridges of steeply dipping rock.

7. a) Drainage into the northern end by a fast flowing but small stream. This enters the lake, but there is no obvious drainage out at the southern end. There must be seepage out through the Sphagnum into the generally wet ground to the south. At the present there is some water finding its way out over the Sphagnum but this is probably only a result of the higher water level in the lake owing to the melting ice.

   b) Ice generally found at about 10" to a foot beneath the vegetation and at a rather shallower depth, beneath the organic remains in the bottom of the lake.

   c. Water very clear.

8. The lake was about 4 feet deep in some places, the water being quite clear, but there was an accumulation of black organic

material at the bottom. This seemed to be about 18" to 2 ft. thick, and seemed to be composed of mainly Sphagnum remains. To the east the shore had a bank about 4-5" high of upstanding peat and the bog vegetation there was mainly of a sedge mat with a little woody growth, such as Ledum, Kalmia, dwarf birch and some willow. Under this in some places there was a Sphagnum cover. To the south the lake was being dammed up by a Sphagnum string which had grown to about 6" above the level of the water. There was a dense woody growth on this string and the willows were growing out over the water. To the south this string merged with a sedge growth which seemed to have filled in the water which may have been left after the lake had been dammed off. There also seemed to be vestages of some Sphagnum strings in this mat. There were also one or two small pools of open water with sedge growth.

9. Originally mapped as sedge bog surrounding a lake. It does appear as such on the photograph, because the Sphagnum is only visible on closer inspection, beneath the sedge.

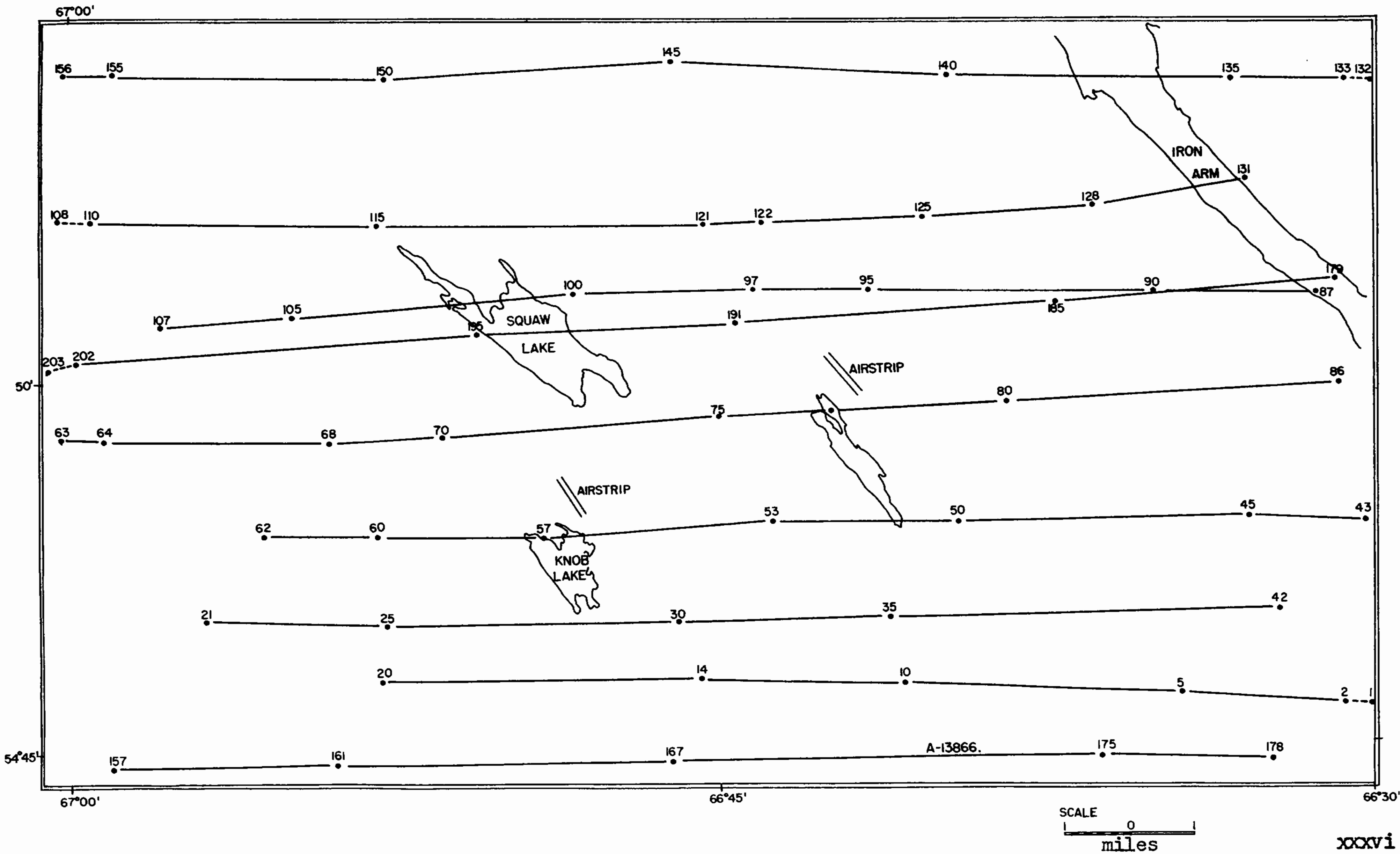
10. Seen on a cloudless day after several weeks of thaw.

11. -

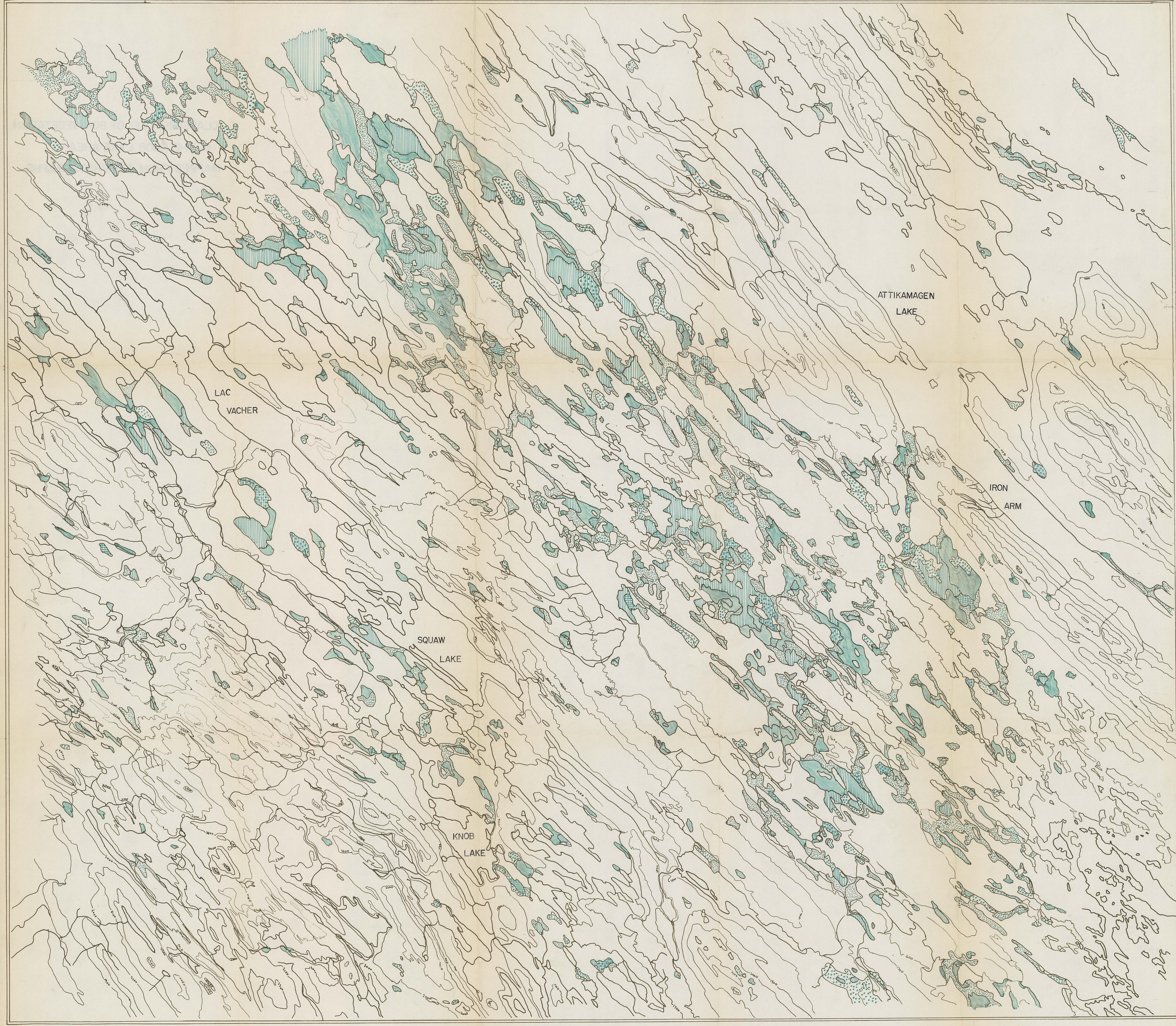
12. Here we had an undoubted case of a string damming up a lake, and the fact that the string was grounded was proved by taking a boring through the string. Borings were also put down in the lake itself and through the peat on the east side of the lake.

There was found to be a lens of ice at no great depth below the surface and borings could only be made where this became thin and the ice could be penetrated.

FLIGHT-LINE SERIES A-13866 FOR VERTICAL AIR PHOTOGRAPHS (from 9,500') OVER THE KNOB LAKE AREA



CLASSIFICATION OF BOG VEGETATION
IN THE KNOB LAKE AREA,
MAPPED FROM AIR-PHOTOGRAPHS.



KNOB LAKE.

scale 1.42,220 (approx)

LEGEND

String Bog
" " with trees
Closed in Strings
" " " with trees
Sedge Meadow
Spruce Muskeg
Tamarack Forest