OBSERVATIONS ON THE VEGETATION OF AN AVALON BOG POND

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by

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ABSTRACT

Observations are made on the vegetation of a bog pond on the Avalon Peninsula of Newfoundland. A general description is given of the pond and surrounding district, as well as the results of a line transect across the encroaching mat. Some consideration is given to the relationship between the Avalon vegetation and that of the mainland.

A record of Utricularia purpurea Walt. is reported for Newfoundland.

A list is included of vascular plants and bryophytes collected from the margin, the mat, the bottom, and the open water.

ACKNOWLEDGMENTS

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Thanks are extended to Dr. R.K. Lee of the National Museum of Canada for the suggestion of the subject, and for the map of Island Pond, Figure 3 in this thesis.

Dr. Ernest Rouleau of l'Institut Botanique de l'Université de Montréal kindly identified most of the vascular plants collected. Identification of bryophyte specimens is due to Dr. A.W.H. Damman of the University of Connecticut, and Dr. R.R. Ireland of the National Museum of Canada.

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CHAPTER I

INTRODUCTION

Newfoundland has about 2,500,000 hectares of bogland. This landscape is shared with other once-glaciated regions where a cool moist climate has enabled peat to develop on poorly-drained terrain.

Bogs have been extensively studied from many points of view. They have a potential economic value for the production of peat moss or when drained as agricultural land. They have an intrinsic interest as a specialized complex of plants, animals, and physical environment which progresses through well-defined stages. They may be valuable as reservoirs of water and refuges for wildlife. Study of plant remains in bogs throws light on past climatic conditions.

The present study focusses on a 30 hectare area in Newfoundland's peatlands -- a pond in the region of blanket bogs which lies between Colinet and Whitbourne, Avalon Peninsula. It was suggested as a subject by Dr. R.K. Lee, then (1966) of the Department of Biology of Memorial University, and was one of the sites studied by him during the summer of 1965 in connection with the snipe research programme of the Canadian Wildlife Service (Lee, 1966).

Considerable plant collecting has been done in the general region. Robinson and Shrenk (1896) seem to have been the first to make extensive collections in the neighbourhood of Whitbourne and Salmonier, as well as at Placentia. M.L. Fernald, the enthusiastic writer on the flora of Newfoundland, was in Whitbourne in 1911 and 1924 (Fernald, 1911, 1926). More recently, Dr. Ernest Rouleau of l'Institut Botanique de l'Université de Montréal whose check list of the vascular plants of Newfoundland (1956) is a standard reference, has contributed to the knowledge of the flora. The Agnes Ayre collection, which forms the basis of the Herbarium[1] of Memorial University's Dept. of Biology, contains plants from the district.

The vegetation of Avalon bogs has been studied in connection with the evaluation of peatlands by Pollett (1967) and others. There is an experimental station south of Colinet where drained bog land is being used as community pasture.

The pond in question and the land just around it do not seem to have been given special attention. It is hoped by taking a close look at this small typical example of Avalon vegetation to add to the knowledge of the region, to provide a useful record for future observers, and to

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[1] Agnes Marion Ayre Herbarium (NFLD.)

note any features which might distinguish it from comparable regions outside Newfoundland.

We should note here what is meant by "a typical bog pond". Welch (1952) has defined a bog lake as "an area of open water, commonly surrounded, either wholly or in part, by true bog margins, possessing peat deposits about the margins, or the bottom, or both; usually with a false bottom composed largely of very finely divided, flocculent, vegetable matter; containing considerable amounts of colloidal materials; and so constituted genetically that in time it may become completely occupied by bog vegetation."

The course of this development follows a well-known sequence, starting with invasion of open water by plants whose stems or roots advance horizontally from the edge. These plants form a framework where sediment accumulates and where other plants may be supported. The floating mat formed by the pioneers eventually becomes thick and heavy enough to rest on the bottom; shrubs replace the pioneer plants on the mat, to be followed in their turn by trees, larch being usually the first tree to grow on the open surface. The final stage of the sere is considered to be coniferous forest -- in the boreal regions spruce and fir; farther to the south white cedar (_Thuja occidentalis_ L.) may be dominant (Dansereau and Segadas-Viama, 1952; Conway, 1949).

CHAPTER II

MATERIALS AND METHODS

The area studied included the pond itself and the margin up to the surrounding barrier of trees. Vascular plants and bryophytes were collected during the summers of 1965 and 1966, and on subsequent visits which were made from time to time up to the spring of 1970. The pressed specimens have been deposited in the Herbarium of Memorial University. Permanent slides were made of many of the bryophyte specimens.

Nomenclature of vascular plants follows the usage of Gray's Manual of Botany, 8th edition, 1950. Nomenclature of the mosses follows that of the "List of mosses of North America", Crum, Steere, and Anderson in Bryologist, 68; pp. 377-434, 1965, except as noted in Appendix C. Nomenclature of the liverworts is taken from Conard, "How to know the mosses and liverworts", 1956. Correct authorities for plant names are given in Appendix B for the vascular plants and Appendix C for the bryophytes.

On June 30 and July 6, 7, and 9, 1966 a line transect was carried out from a marked stump at the margin across the mat to the island at the centre of the pond. It was chosen so as to cross all the concentric zones, and ran from the base mark in a direction N 51° E. (magnetic) to touch the eastern edge of the island. All vascular plants touching the line were enumerated for the first 80 metres. Moss cover was estimated, and bryophyte specimens on the line collected. From 80 metres, which was the limit for wading, the line was continued by boat in less detail as far as the island (328 metres).

Distances along the line from 0 to 80 metres were measured with a tape. From 80 metres to the island the distances were calculated by triangulation, reference marks being the base mark, a stake at 35 metres along the line, and another stake set up well to the east of the transect line. The method of calculating these distances is shown in Appendix A.

The thickness of the mat was sounded at intervals with a long rake handle marked in decimetres.

Samples were taken from the unsubmerged and submerged surface of the mat, and 31 samples were obtained from below the surface with a Swedish peat corer. All samples were examined for general appearance. Oven-dried fractions of the subsurface samples were incinerated at 400° C. overnight to determine weight loss on ignition. This figure was taken as an indication of their organic content.

The pH values of all surface and subsurface samples were measured with a Beckman pH meter. Some measurements were made with the electrodes inserted directly in the sample, some after mixing the sample with distilled water, as will be noted in the section on observations.

Samples of soil were taken from two places on the bottom where the mat had not encroached, and were examined for appearance, texture, pH, and loss of weight on ignition.

CHAPTER III

GENERAL DESCRIPTION OF DISTRICT

The pond, known as "Island Pond", lies about halfway between the valleys of the Rocky and Colinet Rivers, in the southern part of the wide valley connecting St. Mary's and Trinity Bays. More exactly, it is 4.8 km. north of Colinet and about 400 metres east of Route 32 at approximately 47° 15' N., 53° 32' W., and at an elevation lying between 30.5 and 45.7 metres above sea level. It is shown on the National Topographic map of the Argentia district (Sheet 1N/5 east half).

The region is underlain by what Fernald called "the hopelessly sterile, siliceous Avalonian rock" (Fernald, 1926), from which the thin soil of the Avalon is formed. This underlying rock is pre-Cambrian in age, and consists of red arkose and slate, green arkose and siltstone, and apple-green slate (McCartney, 1956).

The surface covering, soil and vegetation, has been developing only since the last withdrawal of the Pleistocene ice. Radiocarbon measurements on peat from the base of the Bay Bulls bog, 56 km. slightly north of east from Island Pond, give an age of 7,400 $\pm$ 150 years (Olsen and Broecker, 1959). This date would fix the minimum possible age of deglaciation, but further considerations indicate a longer period.

A sample of lake sediment from a site in Richmond County, Cape Breton, about 185 km. south of the latitude of Bay Bulls, was dated at 10,340 ± 220 years before the present (Livingstone and Livingstone, 1958). The sample was extracted at a depth of about 4 metres in a boring of total depth 6.6 metres, and the pollen collected at this level indicated a boreal forest vegetation.

Present opinion of local geographers places the edge of the retreating ice on the Avalon nearing its last stand at about 13,000 years ago (Rogerson, personal communication).

One of the subsidiary ice caps retreated to a centre near the upper end of St. Mary's Bay. The contour lines in the neighbourhood of Island Pond are the edges of moraines which mark succeeding positions of this receding ice mass. Melt-water channels can be recognized which drained water from the edge of the ice or from underneath it.

The region is covered by blanket bog. The surface is partly open, covered with Sphagnum and such typical bog plants as Scirpus cespitosus, Sarracenia purpurea, Kalmia polifolia, and Andromeda glaucophylla; partly shrub- or tree-covered. The trees are mostly spruce or larch, but there is a certain amount of fir. The district is sprinkled with small ponds.

The trees appear somewhat stunted, whether because of the poor and water-logged substrate, or because the best trees have been removed by lumbering. The region between the Colinet and Rocky Rivers has been extensively cut over in the past. Alexander Murray, in the report on the Geological Survey of Newfoundland for 1872 spoke of "many stout sticks of spruce, etc." near the forks of the Rocky main brook, but added, "the best of which, however, wherever easily accessible, have been already culled out and driven down the river to the settlements in St. Mary's Bay."

Figures 1 and 2, a stereoscopic pair, give an aerial view of the district immediately surrounding the pond, which can be seen towards the upper right. (Photo, Canada Dept. Mines and Resources; scale 1/4 mile to the inch, or 0.158 km. per cm.) Part of the Colinet River can be seen on Figure 1, and the Rocky River on Figure 2. The road shows up clearly, and the scattered alternation of trees and open bog can be seen.

CHAPTER IV

CLIMATE

The climate has added its influence to the conditions of substrate and topography to determine the vegetation of the region.

Presumably there have been climatic fluctuations in the past corresponding to the amelioration of conditions after the ice age, the postglacial optimum, and the subsequent worsening of climate. However, no direct evidence from sediments or peat seems to have been collected in Newfoundland.

The present-day climate in the neighbourhood of Island Pond is typical of the Avalon Peninsula. The climate of Newfoundland is influenced by both continental and marine factors. On the Avalon, where no point is more than 24 kilometres from the sea, marine influence is strong.

The cold Labrador current sweeps around the shore, in the spring bringing with it ice from the far north. The result is cool weather throughout the spring months and a late start to the growing season. The summers are cool and the winter temperatures not excessively cold. At Colinet, 4.8 kilometres from Island Pond, where there is a weather station, the mean daily maximum and minimum for the warmest month (August) are 19.4° C. and 11.3° C.; for the coldest month (February) the values are 0.4° C. and -7.9° C. Owing to the cold late spring the growing season begins about two weeks later than in Cape Breton, and a month later than in Montreal. Even after the daytime temperatures are well above freezing, there is a probability of frost well into the month of June.

The seasonal variation between the mean temperatures of the warmest and coldest months is 19.1°C. In a completely oceanic environment one might expect less fluctuation between mean summer and winter temperatures -- in the British Isles, for instance, the range is around 11° C. or less. However, it is small compared to the differences found at points inland on the continent. At Montreal the difference between the mean temperatures of January and July is nearly 33° C.; at Winnipeg it is 39° C.

The prevailing winds are westerly. In summer south-westerly winds warmed from passage over the continent lose moisture as they approach Newfoundland over the cold ocean water, and rain and fog are frequent. Cyclonic storms, caused by the meeting of the prevailing westerlies and the subpolar easterlies sweep across from west to east, especially in winter, when the colder air masses move south. The frequent strong winds are a deterrent to plant growth, especially to trees.

Colinet lies in a region of high precipitation, the mean annual value being 147 cm. This is distributed throughout the year, being slightly greater during the winter, but there is a water surplus all the year round. The mean annual snowfall is 269 cm. As the temperature rises above freezing from time to time during the winter, there is a certain amount of melting, and the snow cover is not as thick as might be expected from the total fall.

The climate as recorded at Colinet can be summarized by the Thornthwaite classification as $AC_2'rb_2'$, that is, it is perhumid, warm microthermal, with no seasonal water deficiency, and a temperature regime equal to the second mesothermal. This last term indicates that the climate tends to be oceanic rather than continental.

The climate of Island Pond, then, offers to the growing plant a relatively short growing season, a surplus of moisture, high winds, a cool to moderately warm summer, and a not very severe winter.

Information on the climate was obtained from the following references: Canada Dept. of Transport, Meteorological Branch, 1964 and 1967; Hare, 1952; Koeppe and De Long, 1958; Summers and Summers, 1965; Thornthwaite, 1948.

CHAPTER V

DESCRIPTION OF POND

The cool, humid climate, the acidity of the substrate, and the obstruction to drainage caused by the topography of the residual drift have combined to produce the boggy landscape of the region.

Island Pond, with its tangle of aquatic plants and encroaching mat, is a small representative part of this development. It lies roughly north and south, about 660 metres in length and 440 metres in width. Its outline and the position of the small wooded island can be seen from the map, Figure 3, and from Figure 4, an enlargement of part of Figure 1.

A conspicuous feature is a large beaver house near the north end. Another smaller beaver house lies about the middle of the eastern shore.

The principal inlet is a large stream entering at the north end, formed by the confluence of several small streams rising in the wet boggy area two or three miles to the north-east. A smaller stream enters at the south-east corner and a still smaller one part way along the eastern shore. These seem to be following old meltwater channels from the higher land to the south-east, which rises to about

76.2 metres, and can be seen in Figures 1 and 4. Several trickles of water enter from the wooded banks of the west shore. A low beaver dam stretches across the mouth of the outlet stream at the south end, and the current becomes swift as it swirls over the dam. The outlet stream continues in a general south-westerly direction for about 3 kilometres to empty into the Rocky River.

The pond is not deep, probably not much more than two metres at its deepest. The bottom is partly covered by a mossy and sedgy layer, partly it is firm and rocky. This rocky bottom is probably boulder till; it is thinly covered by flocculent, oozy material. The rocky rim of the depression forms a bank which marks the edge of the zone of trees which surrounds the pond.

The open part is a "soup" of aquatic plants, floating or submerged. At the north and south ends of the pond wide expanses of mat show well-marked zones, and mat vegetation is developing along the west side. The east side shows an abrupt transition from shallow water to dry shore. Most of this shore is wooded to the edge, but near the smaller stream there is a grassy stretch between the pond and the woods.

The zonation of the mat is shown on Figure 3. The zones extend irregularly around the pond except for a large part of the eastern shore, and a part of the western shore. The most shoreward zone consists of *Myrica Gale* mixed with ericaceous plants. Next comes a zone of sedge dominated by the large yellow-green Carex rostrata. This zone gives way abruptly to a wide zone of the horsetail Equisetum fluviatile, with a noticeable band of Menyanthes trifoliata at the junction and many Iris in the outer part of the Carex zone. Outside the horsetails lies open water, with conspicuous floating leaves of several aquatic species.

Below and between the vascular plants of the mat the surface is largely covered with moss, chiefly Sphagnum species. The mossy cover extends on for some distance under water, and moss covers a good deal of the bottom of the pond. The rocky, muddy areas of the bottom are carpeted with small submerged plants, and here, too, are rooted many plants with floating leaves.

To-day Island Pond lies relatively undisturbed, except for the casual fisherman, but it bears traces of human activity. The remains of the foundations of a dam can be seen in the outlet stream below the present beaver dam. Thirty or forty years ago, according to local residents, the pond was dammed while logs were collected from neighbouring woods operations to be floated down the outlet river to Rocky River and St. Mary's Bay. Here and there along the banks logs, larger than most of the trees which now surround the pond, lie buried in the soft wet ground. To-day the beavers maintain the water level with their dam, and freshly gnawed stumps show that they have been at work.

Figures 5 to 12 show some of the features described.

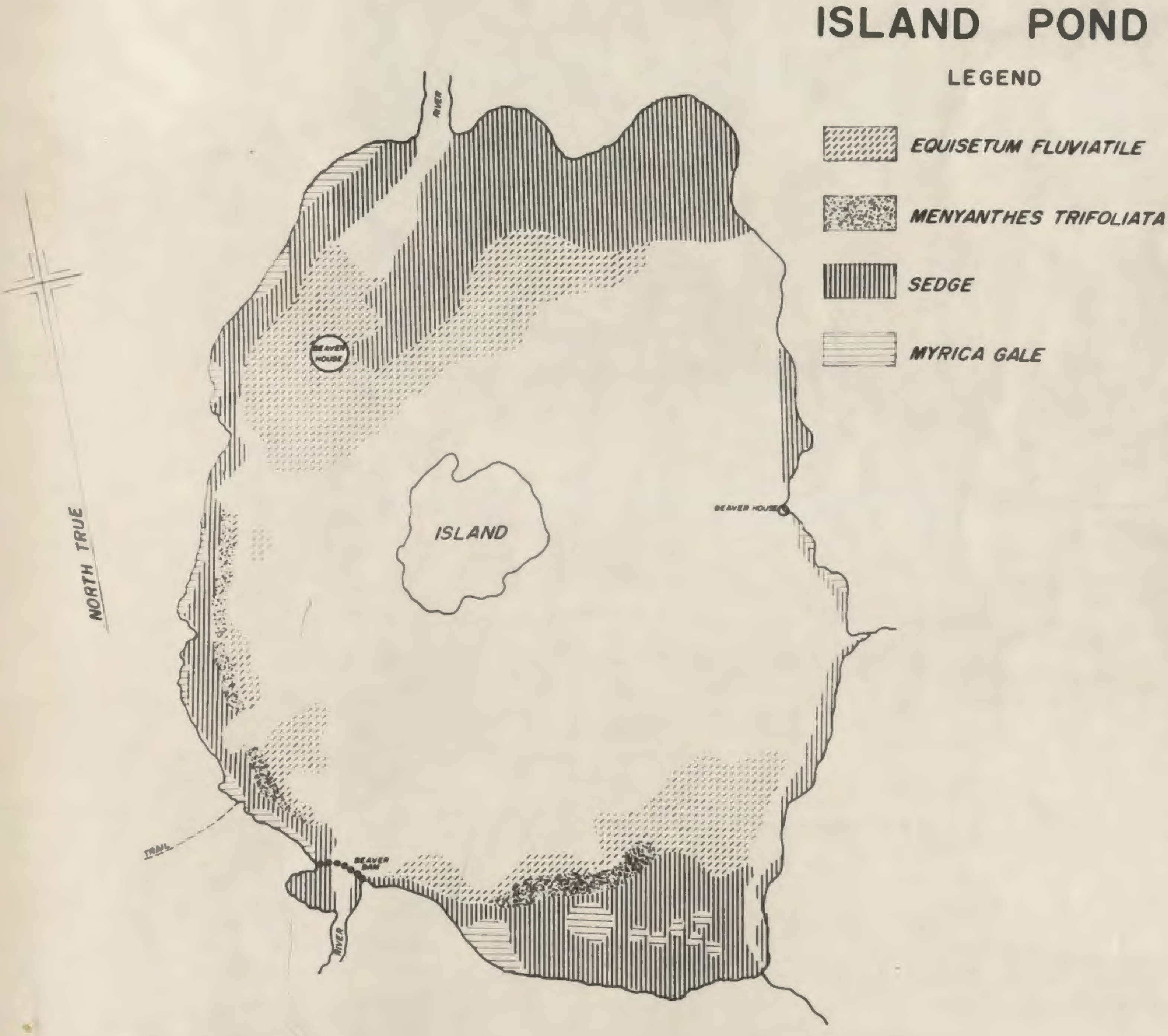

ISLAND POND
LEGEND
EQUISETUM FLUVIATILE
MENYANTHES TRIFOLIATA
SEDGE
MYRICA GALE
RIVER
BEAVER HOUSE
ISLAND
NORTH TRUE
BEAVER HOUSE
TRAIL
BEAVER DAM
RIVER

Figure 3.

Fig. 5 Large beaver house. Looking towards inlet from west shore. May 11, 1966.

Fig. 6 Smaller beaver house, east shore, showing abrupt transition from water to rocky shore.

Fig. 7 Beaver dam, looking from below dam towards island. July 6, 1966.

Fig. 8 Beaver dam, looking north-west towards west shore. September.

Fig. 9 Grassy west shore opposite island, September. Note Calamagrostis canadensis and Aster nemoralis.

Fig. 10 Looking north across mat from south end -- Carex, line of Iris, Equisetum beyond.

Fig. 11 Mat vegetation, south-west shore, May 11, 1966.

Fig. 12 Same, July 6, 1966. Myrica, Carex, Equisetum.

CHAPTER VI

OBSERVATIONS

Transect:

Figure 13 summarizes conditions along the transect line, which will be described under the headings Vascular Plants, Bryophytes, and Substrate.

(1) Vascular Plants

Four zones were apparent to the eye in early July;

(a) From the base mark to 12 metres from shore, *Myrica Gale* dominated.

(b) From 12 to 46 metres, *Carex rostrata* dominated.

(c) Where *Carex* gave way to Equisetum, a narrow band of *Menyanthes trifoliata* was apparent.

(d) From 50 metres out to open water, *Equisetum* dominated.

On closer inspection, other plants became apparent. In zone (a) among the *Myrica* were *Carex rostrata*, *Ledum groenlandicum*, and *Chamaedaphne calyculata*, as well as some unidentified grass. (Later in the season *Aster nemoralis* was plentiful in this zone.) The substrate throughout was only slightly damp, and felt solid underfoot.

Zone (b) contained abundant shrubs of Myrica Gale out to about 38 metres. Beyond 40 metres no Myrica Gale was seen, and in this outer part of the Carex zone, Iris versicolor grew. Thus the Myrica and Carex zones were not as sharply divided as they seemed at first glance. Cover of Myrica along the line from 0 to 12 metres was estimated to be 40%. From 12 to 40 metres the plants were smaller and mostly overtopped by Carex, but the extent of coverage along the line was 26%, indicating an encroachment outward of Myrica.

The transition from Carex to Equisetum was sharp. (Figures 13, part 1, 14) The ground surface became submerged, the character of the Sphagnum cover changed (Table I below), and Carex was rapidly replaced by the first individuals of the wide Equisetum zone which stretched from 47 metres to open water at 100 metres. Other plants noted in the Equisetum zone included Carex limosa, Carex canescens, Potentilla palustris, and some submerged aquatics, as Utricularia.

The continuity of the zonal succession was interrupted at about 35 metres by a shallow muddy puddle. Here Carex rostrata was replaced by Menyanthes trifoliata and the small sedges Carex limosa and Carex canescens.

The deeper muddy depression at the beginning of the Equisetum zone (see Figures 13, part 1, 15) was not typical of the mat in general. It represented an arm of deeper water extending towards the more open region around the beaver dam. The mat to the east of the transect line had a more level surface. This was not immediately apparent, but on a visit to the pond on May 26, 1967, when the water level was lower, the channel could be plainly seen. It petered out a few metres to the east of the transect line.

From 80 metres, where wading became impossible, the line was continued by boat. (Figure 13, part 2). Fewer samples were taken in this region. The pondward edge of the Equisetum zone was reached at 100 metres. Beyond this point the water was relatively open, with many Nuphar plants. The mossy mat surface continued under the water, though here it was not firm enough to sustain weight. Two very shallow portions were encountered at 145-155 metres and at 245-285 metres. On these shallow places grew Carex spp., Potentilla palustris, and some unidentified grass. At the time of lower water level, May 26, 1967, it could be seen that these two shallows represented two arms of mat vegetation jutting out from the south-east side of the pond, and crossing the transect line. See Figure 16.

Beyond 290 metres open water continued out to the island, which was calculated to be about 330 metres from the base mark. A sounding in the open region showed a mat surface 85 cm. below the water surface and hard bottom deeper than 180 cm. Near the island the bottom appeared to be hard and rocky with no covering moss growth. A band of

Carex rostrata surrounded the island, with some Carex canescens and Eleocharis palustris. There was no Equisetum here.

(2) Bryophytes

The bryophyte cover along the transect showed two distinct regions.

(a) From the base mark to the beginning of the Equisetum zone the moss cover was discontinuous, interspersed with patches of surface mud with decaying Carex and other plant debris. Table I shows the extent of moss cover. Even where no moss grew on the surface, however, sub-surface samples nearly all showed moss remains. Moss grew partly as a flat cover and partly in "cushions" up to 25 cm. in diameter.

The moss of this region was almost entirely Sphagnum, predominantly S. papillosum, except around the puddle at 35 metres. Mixed with the Sphagnum of the cushions were other species of mosses and liverworts. Here and there on the damp ground among the Carex and Sphagnum grew the thalloid liverwort Pellia epiphylla. See Table II for Sphagnum along the transect and Table III for other bryophytes.

(b) At the junction of the Equisetum and Carex zones the moss cover changed abruptly to a mixture of S. subsecundum var. inundatum and Drepanocladus exannulatus with a small admixture of S. cuspidatum at the point of change. From this point on, the submerged surface of the mat was covered with the mixture of Sphagnum and Drepanocladus, their relative proportions changing as the surface extended farther from shore. At the landward edge of the Equisetum zone the proportion of Sphagnum strands to Drepanocladus strands in the surface samples was about 3:1. This ratio decreased along the line so that at 80 metres the ratio of Sphagnum strands to Drepanocladus strands was 1:2 and at 130 metres in deeper water it was only 1:4. As the Drepanocladus strands were consistently longer than the Sphagnum, the relative percentage of plant material of the two species was not the same as the ratio of the numbers of strands of each. The relative percentage of plant material is estimated in Table IV.

(3) Substrate

The variation in substrate can be followed from Figures 13, parts 1&2 and 14. It was firm and only slightly moist at the edge, becoming progressively damper pondwards. The Carex rostrata in the pondward part of its zone was rooted in very wet muddy ground. The Equisetum, after the few metres of soft mud mentioned above, grew on a submerged mossy surface which quaked underfoot, though it was firm enough to sustain a person's weight. At 80 metres increasing depth of water and decreasing firmness of mat made wading impossible. The mossy surface continued under water more or less continuously. The outer edge of the mat was not distinguished. However, soundings close to the island showed a hard bottom with small rocks and apparently with no moss cover.

Table V describes surface conditions at various distances along the transect. Samples marked "surface sample" were scraped or dredged off the mat surface and stored in plastic bags. The specimens marked as "Bottles" were taken from the immediate subsurface at the time of obtaining the cores described below.

In the case of the "surface samples" pH values were taken by immersing the electrodes directly in the moist sample, or in water squeezed from the sample.

The specimens in the bottles had been air-dried. They were mixed with distilled water in the proportions noted before the pH measurement was made. As these measurements were not made until the specimens had been stored for some days, they probably do not reflect actual conditions in the field. They may serve for comparison among the samples. Their values may be followed from Table V. It will be noted that the most acid region was among the shrubs (pH 4.4 - 4.7). Values were higher in general farther out on the mat, though several samples dredged from deeper water had low values.

Table VI describes the samples taken with the peat corer in July, 1966, as well as a few cores taken on May 26, 1967.

All cores from the base mark to 40 metres were brown and more or less wet, with no discernible profile. The organic content of all specimens from 0 metres to 30 metres was high, loss on ignition being up to 95% just below the surface, and not less than 54% except for the core at 2 metres. Here the lowest 10 cm. (sample 5) was gray and clay-like. On exposure to air the specimen quickly dried to hard gray lumps, obviously much denser than the overlying material. Its weight loss on ignition was only 2.35%. Microscopic examination showed no diatoms or plant remains, which were present in all the other subsurface specimens. Its pH was 5.45, compared with pH values of 5.0 higher in the core, and 4.7 at the surface. When some of the cores were repeated in May, 1967 this layer could not be found again, though five or six attempts were made at 2 metres and in the immediate neighbourhood.

The cores at 34 metres and 40 metres had a lower organic content, loss on ignition ranging from 32% to 62%. This change in organic content may reflect the decreasing number of Myrica and ericaceous plants at this distance.

Beyond 50 metres it was noted that resistance to the rake handle used in sounding became suddenly less at a depth of 125 to 130 cm. This was taken as an indication of the lower surface of the mat.

From this point, too, the lowest layer of the cores (at 50, 60, 70, 75 metres) was gray, with a blue layer above at 70 and 75 metres. Two cores at 60 metres, one taken in July, 1966 and the other in May, 1967, showed a definite watery region above the gray lowest layer.

No cores were taken from the mat at a greater distance, so it is not known how far this gray lowest region extends.

The gray specimens from 70 and 75 metres dried to a whitish gray with loss on ignition of 8%. The lowest specimens from 50 metres and 60 metres dried to a yellower colour, with losses of 20% and 15%. All blue specimens dried to a yellowish brown. The two which were incinerated showed weight losses of 17.7% and 13.5%.

Two other cores examined on May 26, 1967 may be mentioned. They were taken east of the transect line beyond the point where the "ditch" crossing the line at 46-56 metres ends. A fairly sharp line of demarcation separated the dark mossy surface with young _Equisetum_ sprouts from the zone of _Carex_ and scattered _Iris_. Cores were taken from each side of this line at the nearest point where the zones were definite, about a metre and a half apart. The core from the _Carex_ side was a uniform brown. The core from the _Equisetum_ side had a gray lowest layer.

Particulars of the cores are recorded in Table VI. See also Figure 13. The essential information may be condensed as follows:

From 0 to 30 metres, i.e. from the edge to beyond the *Myrica* and *Chamaedaphne*, the cores were brown, with obvious plant remains, possibly more decomposed at the bottom; pH values at all levels ranged between 4.4 and 4.8. The exception was a core at 2 m. 45 cm. deep, with a gray layer of mineral material, pH 5.45 at the lowest 10 cm. From 50 m. to 79 m., i.e. from about the start of the horsetail zone, all cores showed a gray clay-like layer of about 15 cm. on the bottom. Above the gray at 70 m. and 75 m. was a band of blue, and above this the cores were brown, mossy and wet. These cores were less acid than the cores nearer the outer edge, most samples having a pH between 5.3 and 5.9. The blue samples were 6.3 and 6.1.

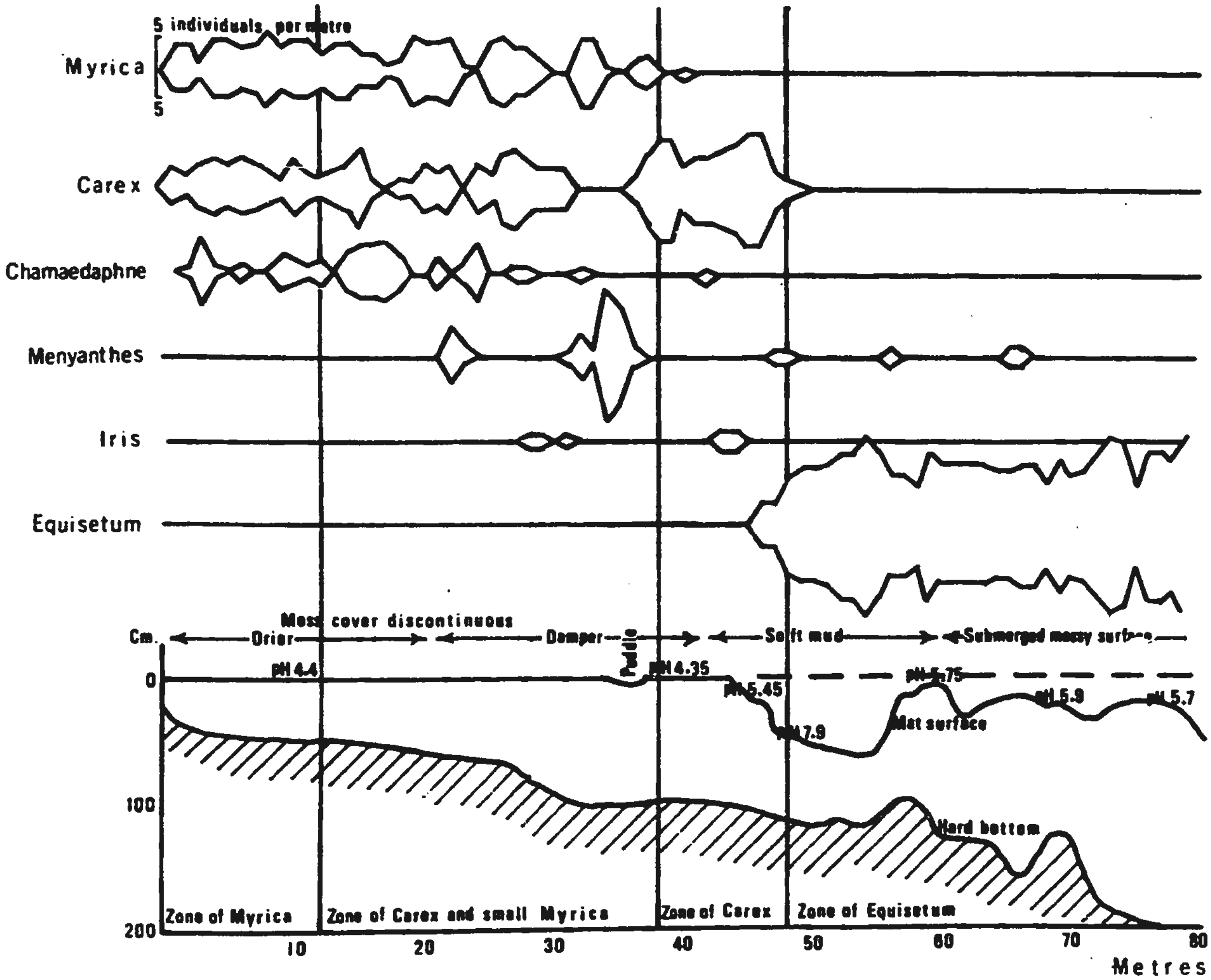


Figure 13, part 1. Transect from 0 to 80 metres.

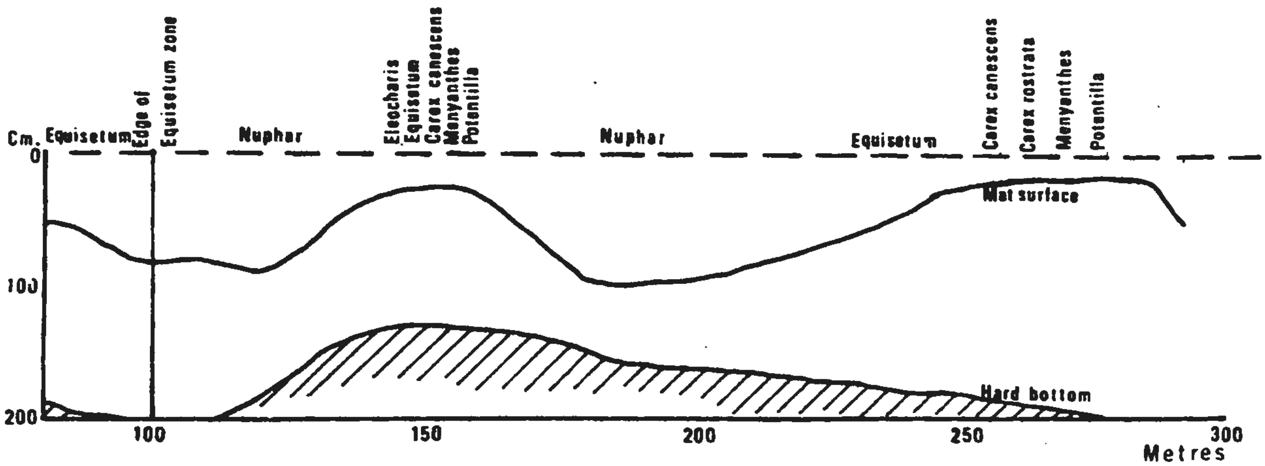


Figure 13, part 2. Transect from 80 to 300 metres.

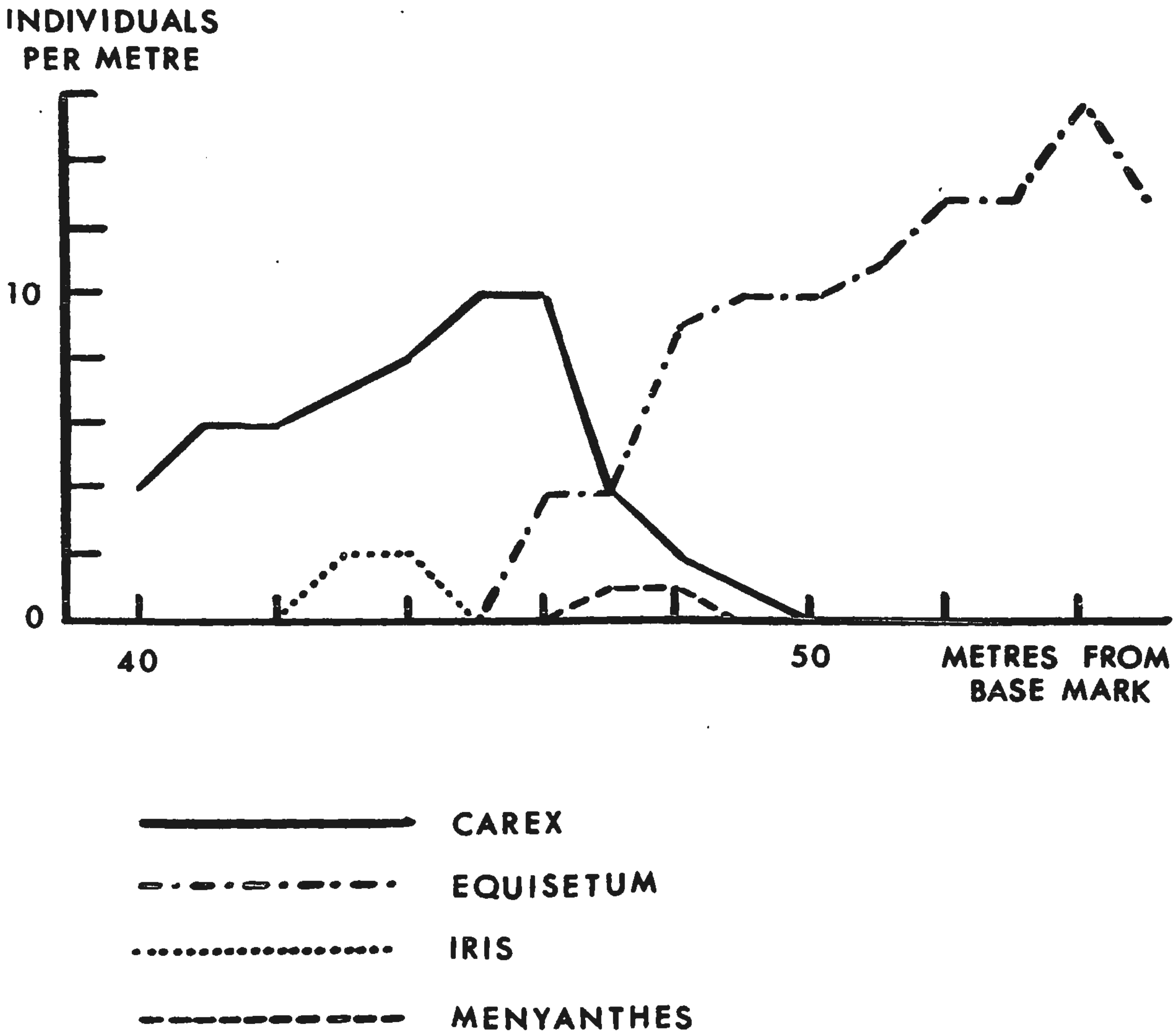


Figure 14. Transition from *Carex* to *Equisetum* zone.

Fig. 15 Using corer on transect line
Muddy depression at 50 m.

Fig. 16 Shallows exposed at low water level.
May 27, 1967. To east of transect line.

Table I

Extent of Moss cover along transect

Metres from base mark	
1 - 4	Sphagnum 70%
5 - 8	leaf mould
9	moss 30% (cushion)
10 - 12	leaf mould
12	2 cushions, 25 cm. and 10 cm.
13	Sphagnum 5%
14	leaf mould
15	Sphagnum 10%
16	Sphagnum 2%
17	leaf mould
18 - 25	mostly Sphagnum
26	mostly leaf mould
27 - 33	moss continuous
34 - 35	muddy puddle, Sphagnum around edge
36	mud and Sphagnum
37 - 38	mud, 1 clump Sphagnum
39	a little moss
40 - 44	mud, 20% Sphagnum, water over surface
45	some Sphagnum

Table I (Continued)

Metres from base mark	
46 - 55	muddy
57 - 80	mossy surface, submerged

Samples off submerged surface at following distances showed

91 m.	scanty moss
103 m.	soft flocculent debris
107 m.	as at 103 m.
131 m.	moss
175 m.	moss
285 m.	moss

Table II

Sphagnum on Transect

Coll. No.	Metres	Species	Habitat, etc.	Date
414	2 - 3	*S. tenellum*	on moist ground	Apr. 13/68
415	3	*S. papillosum*	on damp ground	Apr. 13/68
surface samp.	9	*S. papillosum*	cushion on damp ground	June 30/66
399	12	*S. papillosum*	cushion with others	June 30/66
411	12	*S. papillosum*	damp ground	Apr. 13/68
--	12 - 18	*S. papillosum*		
416	18	*S. papillosum*	mixed in clump	Apr. 13/68
417	18	*S. subsecundum*		
surface samp.	34	*S. imbricatum*	mixed at puddle edge	June 30/66
	34	*S. pulchrum*		
418	34	*S. pulchrum*	in clump at puddle edge	Apr. 13/68
422	38	*S. imbricatum*	clump	Apr. 13/68
surface samp.	40	*S. subsecundum* var. *inundatum*		July 6/66
" "	45	*S. subsecundum* var. *inundatum*		July 6/66

Table II (Continued)

Coll. No.	Metres	Species	Habitat, etc.	Date
419	46	S. subsecundum var. inundatum	edge of horsetails very wet	Apr. 13/68
420	46	S. cuspidatum	mixed with 419	Apr. 13/68

Submerged samples from metres 50, 60, 70, 80, 130, 175, 285, all resemble # 419.

Table III

Bryophytes other than *Sphagnum* along Transect

Coll. No.	Species	Habitat, etc.	Date
Surface samp.	*Rhytidiadelphus loreus*	9 m., among *Sphagnum*	June 30/66
400	*Rhytidiadelphus loreus*	12 m., in clump with *Sphagnum* # 399	
401	*Lophozia ventricosa*		
402	*Polytrichum juniperinum*	12 m., one group	June 30/66
403	*Scapania undulata*		
404	*Drepanocladus uncinatus*		
405	*Sharpiella turfacea*		
406	*Plagiothecium denticulatum*		
407	*Dicranum scoparium*		
409	*Pleurozium schreberi*	12 m., one group	Apr. 13/68
410	*Rhytidiadelphus loreus*		
412	*Dicranum scoparium*		
413	*Drepanocladus uncinatus*		
	small amount *Lophozia ventricosa*		
surface samp.	*Drepanocladus exannulatus*	34 m., at puddle edge	June 30/66
396	*Pellia epiphylla*	40 m., on wet ground among *Sphagnum* & *Carex*	
421	*Drepanocladus exannulatus*	46 m., damp to submerged among *Sphagnum* at edge of horsetails	Apr. 13/68
surface samp.	*Drepanocladus exannulatus*	from samples of submerged surface at metres 60, 70 80, 130, 175, 285	July 7/66 & July 9/66

Table IV

Approximate ratio of *Drepanocladus exannulatus* (D) to *Sphagnum sp.* (S) on submerged mat surface

Metres from base mark	% D.	% S.
45	0	100
46	12	88
60	25	75
70	45	55
80	67	33
130	85	15

Table V

Substrate along Transect

Date	Metres on line	Specimen	Description	pH	How measured
6/7/66	2	Bottle 4	Dark brown crumbly mixture of decaying sedge, *Sphagnum* leaves and stems	4.7	1 gm. air-dried plus 4 ml. dist. water
7/7/66	3	Bottle 7	Dark brown undecayed and partly decayed sedge and *Sphagnum*	4.6	"
30/6/66	11	Surface sample	Muddy paste with sedge remains, *Myrica* leaves, plant fibres	4.4	Electrodes in sample
6/7/66	34	Bottle 15	Dark brown, moist, very decayed but recognizable *Sphagnum*	5.3	0.66 gms: 4 ml. water
6/7/66	40	Surface sample	Decaying plants --- sedge, *Sphagnum*, *Myrica*, Ericaceae	4.35	Water squeezed from sedgy mixture
6/7/66	40	Bottle 19	Mud from surface water	6.4	0.24 gms. : 4 ml. water
6/7/66	45	Surface sample	Almost no muddy material, approx. equal sedge & *Sphagnum*	5.45	Water squeezed from specimen
				Surface submerged from this point	
6/7/66	50	" "	Amorphous muddy mass some sedgy fibres	7.9 8.3	Electrodes in specimen 2 readings
7/7/66	60	" "	Mostly wet *Sphagnum* Some sedge & *Equisetum* stems	5.75 5.75	Electrodes in moss " " squeezed out water

Table V (Continued)

Date	Metres on line	Specimen	Description	pH	How measured
7/7/66	70	Surface sample	Mostly moss, Sphagnum and Drepanocladus. Sedge remains visible	5.90 6.11	Electrodes in moss " " squeezed out water
7/7/66	79	" "	Mostly moss -- Sphagnum and Drepanocladus. Few fibrous sedgy remains, piece of Equisetum	5.69 5.79	In moss In water
9/7/66	91	St. 3	Decomposed material-sedge leaves and culms, scanty moss	5.25	Muddy water squeezed from sample
9/7/66	103	St. 4	Soft fine flocculent material. No moss; mud squeezes out	4.80	Wet mud squeezed from sample
9/7/66	107	St. 5	As above. Mass wet and plastic; no water will squeeze out	4.85	Electrodes dipped in paste
9/7/66	144	St. 7	Fibrous, scarcely decomposed sedge and Sphagnum	6.0	Muddy water squeezed from sample
9/7/66	176	St. 10	Mostly Sphagnum with some sedge remains. Coated with flocculent red brown material	4.90	"
9/7/66	285	St. 12	Mostly moss	4.60	"

Table VI

Cores

Date	Metres on line	Depth to hard bottom	Sample and depth	% Weight loss on ignition	Description
7/7/66	0	20 cm.	1. 11 cm. (bottom of chamber)	69.18	Dark brown, moist, evident sedge remains. White particles ab. 0.3 mm., some diatoms, some *Sphagnum*. Brown water squeezes out
7/7/66	1	40 cm.	2. 5 cm. 3. 22 - 30 cm. (bottom)	88.33 88.43	Core all brown, damp, very soft. Recognizable plant remains, mostly sedge, some *Sphagnum*. Brown water squeezes out.
6/7/66	2		4. surface 5. 26 - 36 cm. (bottom) 6. 15 - 25 cm.	93.91 2.35 75.15	Upper part of core dark brown with decaying sedge and *Sphagnum*, algal or fungal threads, brown water squeezes out. Lowest 10 cm. gray and clay-like, quickly drying to hard gray lumps. No diatoms, hardly any plant remains - these prob. cont. from upper core. Seems completely mineral, dense. pH 5.45 cfd. with pH 4.7 in upper core.
7/7/66	3	45 cm.	7. surface - 5 cm. 8. bottom	89.94 69.74	Core all dark brown, reddish tinge. Much sedge and *Sphagnum* recognizable throughout. Brown water squeezes out.

Date	Metres on line	Depth to hard bottom	Sample and depth	% Weight loss on ignition	Description
6/7/66	10	50 cm.	9. Bottom	90.48	Dark brown with reddish tinge, *Sphagnum* and fibrous sedge remains. Brown water squeezes out.
6/7/66	20	60 cm.	10. upper 11. bottom	90.46 83.58	Dark brown, reddish tinge. *Sphagnum*, sedge, other plant remains. Brown water squeezes out.
6/7/66	30	95 cm.	12. upper 13. bottom 14. ?	54.06 95.81 36.48	Dark brown, poss. sl. lighter at bottom. Brown water squeezes out.
26/5/67	2 10 20 30	 45 cm. 50 cm. 75 cm.	cores rechecked, samples not kept.		Cores mossy brown nearly to bottom. A little brown mud at bottom. No profile distinguishable. Could not find gray region of sample 5, though several trials made.
6/7/66	34	75	15. Surface under puddle	37.85	Mud puddle on surface. Core all brown Surface sample very dark brown, sticky, some mud squeezes out. Plant content very decayed, some clearly *Sphagnum*.
26/5/67	35	65	9 - 67. Lower, under puddle		Surface very wet mud. Core wet brown. Top half almost empty.
6/7/66	40	95	17. bottom 18. upper 19. surface water & residue	31.88 44.44 61.59	Core dark brown, sedge, *Sphagnum*, other moss. Slight amount mud squeezed out.

Table VI (Continued)

Date	Metres on line	Depth to hard bottom	Sample and depth	% Weight loss on ignition	Description
26/5/67	40	70	no sample		Core all wet brown. Surface shows alternate patches of moss and muddy sedge.
7/7/66	50	120	20. bottom (gray) 21. brown sect.	20.34 28.82	Mat not firm. One tends to sink through. Sample 20 is gray, not enough material to squeeze. Sample 21 is dark brown, contains sedge, *Sphagnum*, other moss; very wet, muddy water squeezes out.
26/5/67	50		no sample		Very wet, one sinks through. No sample obtained
7/7/66	60	132	22. bottom 23. mid-chamber 24. upper	15.55 17.72 34.59	Bottom 15 cm. gray, above this an empty space, changes to brown at 30 cm. above bottom. Muddy water squeezed out from upper sample. Considerable plant material at top, very little at bottom, with increased number of diatoms.
26/5/67	60	110	7 - 67 from lower gray 8 - 67 from wet space		surface soggy, wet, mossy
7/7/66	70	134	25. gray, lowest 26. blue, mid 27. brown, upper	8.714 13.46 24.41	Lowest 15 cm. gray, next 20 cm. blue, then brown. Top sample med. brown, fine peaty appearance, friable; mid. sample pasty; bottom dried to hard gray lumps. Some moss at top, no plant debris at bottom.

Table VI (Continued)

Date	Metres on line	Depth to hard bottom	Sample and depth	% Weight loss or ignition	Description
26/5/67	70	130	no sample		Bottom 20 cm. gray with blue streaks, solid, resembles 2 - 67 below. Above, too wet and soggy to collect, obviously mossy.
7/7/66	75	185	29. gray, lowest 30. blue	7.891 14.99	Lowest 15 cm. gray, above bluish. No plants at bottom, some *Sphagnum* higher. Pasty consistency.
26/5/67	75	170	4 - 67 bottom 5 - 67, 60 to 100 cm. from surface 6 - 67		Core extremely wet, contains much moss. Clay brought up on point of sampler
7/7/66	79	200	31. 150 to 200 cm. below surface	14.00	Scanty *Sphagnum*, clay-like texture
26/5/67	79	200	1 - 67 ab. 60 cm. below surface 2 - 67 as low as possible 3 - 67		Surface is very wet moss, submerged ab. 1 ft. Sample 2 - 67 is gray with blue streaks. Difficult to get, and poss. cont. from higher portion. 3 - 67 is a lump of pure blue from lowest sample.

26/5/67 Two cores were taken east of the transect line beyond the point where the "ditch" of 46 - 56 m. ends. They were about 5 feet apart, on either side of the fairly sharp line between the dark mossy surface with very young *Equisetum* and the *Carex* zone with scattered *Iris*. The core on the *Carex* side (hard bottom 120 cm.) was all brown. The core on the *Equisetum* side had gray at the bottom.

Plants and Substrates of Open Water and Bottom:

In the parts of the pond not yet encroached on by mat vegetation (along the east and part of the west shores, around the island, and south towards the outlet) aquatic plants were abundant. Over the deeper parts floated leaves of *Nuphar*, *Nymphoides*, and *Glyceria*, and at the edges *Eleocharis palustris* and *Eriocaulon septentrionale* emerged. Large plants of *Utricularia vulgaris* floated below the surface throughout the pond, and for a brief period in August their scapes carrying conspicuous yellow flowers stood up above the surface.

The only area devoid of vegetation was the region around the beaver house on the east shore. For some metres around here there was no floating vegetation and the bottom was covered with a soft flocculent ooze, owing probably to the activities of the beavers, which feed on water lily rhizomes and other aquatics.

Elsewhere, beyond the edge of the *Sphagnum* mat growth, the bottom was carpeted with small submerged plants. *Isoetes* was plentiful, mixed with *Utricularia intermedia* and other plants. One typical area yielded a mixture of *Isoetes tuckermani*, *Subularia aquatica*, *Eleocharis acicularis*, and *Ranunculus reptans*. Two areas of *Nitella flexilis* were observed mixed with other small plants.

Aquatic mosses were plentiful on the mud bottom, mostly Drepanocladus exannulatus, whose decaying remains added to the tangle of plants and must be contributing to the buildup of material on the pond bottom. Three species of Fontinalis were found among plants on the bottom or attached to stones.

Of the vascular plants in this region of the pond, the water lilies were also found on the submerged mat surface; the rest were confined to the non-sphagnous bottom, as were the Fontinalis species. Drepanocladus exannulatus was found everywhere -- on the non-sphagnous bottom and mixed in varying proportions with Sphagnum, as noted above in the description of the mat bryophytes.

A moss-covered tussock about 50 cm. across, emerging not far from the edge of the mat at the south-west corner, was found to be floating. It had probably broken off from the edge of the stream entering near by, as there was no Sphagnum on it. It was covered with a mixture of Mnium cinclidioides and Philonotis fontana, both common mosses of stream banks, as well as Drepanocladus exannulatus.

A sample of soil was collected from between the stones of the hard bottom about half-way along the western shore. It was pinkish brown in colour; under 30x magnification some particles were distinctly red, a few were greenish.

An air-dried fraction mixed with an equal amount of distilled water gave a pH of 5.67.

On incineration at 400° C. overnight of oven-dried material the weight loss was 2.01%.

Sieving of the incinerated sample showed the following percentages of particle size:

Diameter of particles	Percentage
over 4 mm.	15.94
2.0 - 4	9.87
1.0 - 2.0	5.18
0.5 - 1.0	4.54
0.25 - 0.5	5.83
0.125 - 0.25	18.41
0.063 - 0.125	19.58
0.032 - 0.063	7.41
Less than 0.032 mm.	13.24

See Figure 17.

The fraction with particles of diameter between 0.25 mm. and 0.5 mm. had a speckled white appearance which proved to be caused by numerous macrospore coats of _Isoetes tuckermani_ and _I. muricata_. Some broken spores appeared as well in the next smaller fraction. Macrospores of _Isoetes_ have an outer siliceous coating, evidently resistant to the heating of the sample.

Some of the very soft material from around the east shore beaver house was also collected. It was stored in the refrigerator and frozen. When unfrozen and brought up to room temperature it had the appearance of very wet dark brown mud.

pH measurements were as follows:

Sample alone (2 determinations)	Sample plus equal amount by volume of distilled water (2 determinations)	Water filtered off sample
5.15	5.33	6.0
5.18	5.30	

Loss of weight of an oven-dried fraction after incineration was 33.6%.

Sieving of air-dried material was unsatisfactory, owing to the large amount of organic debris. The incinerated material gave the following fractions:

Diameter of particles	Percentage
over 1 mm.	trace
0.5 - 1	"
0.25 - 0.5	"
0.125 - 0.25	1.9 -- many broken *Isoetes* spores
0.063 - 0.125	8.3 -- many large pennate diatoms
0.032 - 0.063	15.4
less than 0.032 mm.	70.0

See Figure 18.

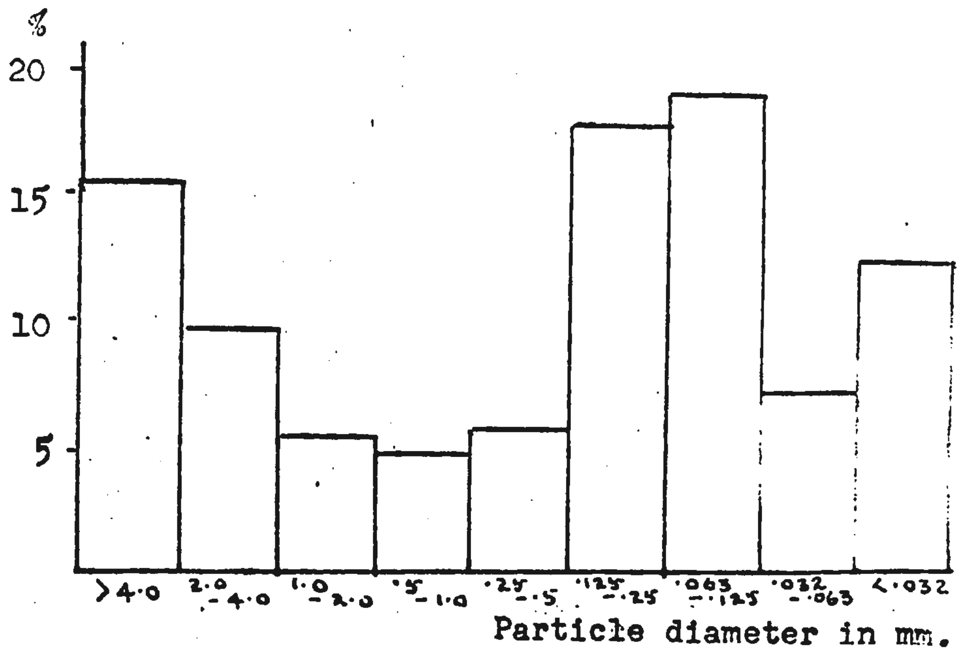


Figure 17. Earth from hard bo..om.

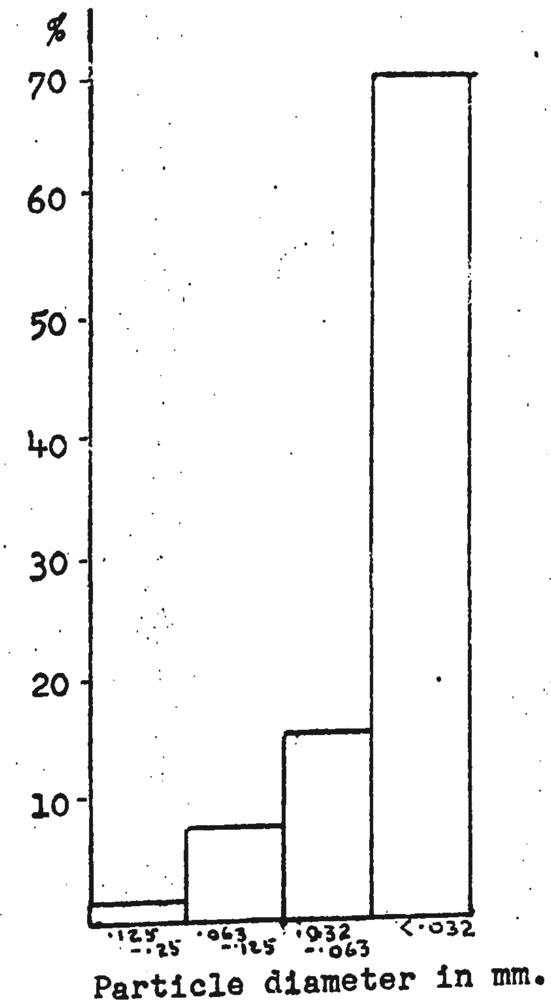


Figure 18.

Ooze from east shore.

Plants of the Margin:

Along the west shore where there was no mat vegetation, the soft margin between the water and the trees contained grass and large sedges typical of damp meadows and swamps -- Calamagrostis canadensis, Glyceria canadensis, Juncus effusus, var. Pylaei, Scirpus atrocinctus. Drosera intermedia was found growing on the muddy edge. Figure 9 shows the transition from shore to pond here, with the Aster nemoralis which grew conspicuously here as well as among the Chamaedaphne and Myrica of the mat.

On the east shore the transition was even sharper, the trees coming to the rocky edge, except for one or two grassy clearings. See Figure 6 showing beaver house and east shore.

Bryophytes Beyond the Study Area:

Although the open bog surface was not part of the area studied, it was felt that a comparison would be interesting between the bryophytes of the pond and mat and those of the bog lying outside the tree zone which encircled the pond. This surface was largely covered by Sphagnum accompanied by the usual bog plants -- Scirpus cespitosus, Sarracenia purpurea, Kalmia polifolia, Andromeda glaucophylla, Vaccinium Oxycoccos, and others. Drier parts of the surface were covered by a tightly-growing yellow-green to brownish Sphagnum. Wetter parts had a growth of finer, pinkish-red Sphagnum, of which some of the more robust heads were brown.

The first species proved to be *S. imbricatum*, some of which had also been found on the *Carex* mat. This is a plant of ombrotrophic or acid minerotrophic open peatland, forming high cushions in the drier parts of bogs (Sjörs, Duncan, 1962). The second *Sphagnum* belonged to the section Acutifolia; it is probably *S. plumulosum*, a species of open, acid, and fairly wet peatland. Mixed among both species of *Sphagnum* were two liverworts, one a species of *Odontoschisma*, the other of *Microlepidozia*, probably *M. setacea*. *Odontoschisma* is said to be common on damp peaty soils. *M. setacea* is only found with *Sphagnum*, usually on elevated tussocks, associated with bog ericads (Conard 1956, Schuster 1969).

The bryophyte cover changed abruptly at the edge of the woods. The *Sphagnum* under the trees was *S. girgensohnii*, a characteristic *Sphagnum* of coniferous forest, accompanied by *Hylocomium splendens* and *Pleurozium schreberi*, with the liverworts *Bazzania trilobata*, *Barbilophozia barbata*, and *Ptilidium pulcherrimum*. The lichen *Cladonia gracilis* was also present here.

For a complete list of vascular plants and bryophytes see Appendices B and C.

CHAPTER VII

DISCUSSION

Comments on Observations

The pond region from open water to treed edge is a good example of a bog sere. Aquatic, pioneering, and consolidating stages, up to a beginning of the *Picea* - *Abies* climax can be recognized, as described by Dansereau and Segadas-Viama (1952). The aquatic associations of the open pond, the *Equisetum* zone, and outer *Carex* zone are not typical only of bog vegetation. The succession towards the bog stages is determined by the drainage conditions of the surrounding terrain.

The pond does not have the false bottom often found in bog lakes (Dansereau & Segadas-Viama, 1952; Jewell & Brown, 1929). This is unconsolidated oozy material largely composed of finely-divided plant detritus, too tenuous to support submerged plants, which builds up over the bottom. Its level may fluctuate. It contributes to the filling-in of a pond, and may become organic mud capable of supporting plant growth if it builds up sufficiently, or if the water level falls.

In the case of Island Pond, the established carpet of small plants growing among the stones on the bottom may consolidate some of the ooze. It may be noted that around the beaver house where there was no vegetation a large amount of flocculent ooze with a loss on ignition of 33.6% was collected, while the soil from the carpeted bottom had a coarser texture and a loss of ignition of only 2%. See Figures 17 and 18. Possibly the relatively large in-coming and out-going streams provide enough drainage to carry off a certain amount of unconsolidated material. The drainage of the pond during logging operations may also have interrupted the build-up of a false bottom.

The mineral soil from among the stones of the hard bottom was typical of soil formed from till. Its texture was not at all uniform, containing particles of all sizes from pebbles down to fine silt. It had resulted from the grinding down of the underlying parent material mentioned on p. 7 and contrasted sharply with the largely organic material of the mat.

There seemed to be a gray pasty layer of sediment accumulated under the floating part of the mat. The blue samples immediately above this layer became a yellowish brown when aerated, and probably represented a gleyed water-logged layer at the base of the floating mat material. The number of samples was too small to draw definite conclusions. It would be interesting to investigate this region further, with an adequate number of samples and tests for chemical composition.

It will be convenient to comment on some of the vascular plants first, and then the bryophytes, although the separation is very artificial, as both divisions are intimately associated and interact with one another. In fact, the whole life of the pond, plant and animal, is so intermingled that one regrets having to pass over the sponges, the rotifers, the insect larvae, the minute crustaceans, and many other animal inhabitants.

An interesting group among the aquatics was formed by the bladderworts, of which four species were found. (A fifth, *Utricularia cornuta*, grows on the open bog just beyond the region studied in this paper.)

The bladderworts supplement their photosynthetic activity by trapping small insects or crustaceans in minute bladders which secrete a digestive enzyme. The bladders have a trapdoor mechanism, tripped when sensitive hairs on the outside are touched. When the prey has been sucked in and digested water is extracted and a negative pressure restored inside the bladder. One specimen collected was observed to have a small ostracod, about 1 mm. in length, actively moving about in a bladder whose dimensions were about 2 mm. by 1.5 mm. (coll. no. 485).

The most plentiful species was *Utricularia vulgaris*, whose thick lengths floated below the surface almost throughout the pond. *U. intermedia* and *U. minor* were found on the bottom. An interesting discovery was *U. purpurea*, found on the mud bottom or tangled together with the two first species. *U. purpurea* had not previously been recorded in Newfoundland (Smith, 1966). It differs from other species in its uniquely whorled leaves and its more globular bladders.

Equisetum fluviatile (the river horsetail) formed a prominent part of the vegetation from early June to late autumn. The stems of the new season's growth come up from the perennial rhizomes which with their wiry roots form a compact network encroaching outwards. From the open water it was striking to see straight lines of *Equisetum* stems "marching out" towards the centre of the pond. Strobili were borne early in the season; later the stem tips were sterile. The stems were at first unbranched; later in the season, particularly in the deeper water, whorls of slender branches appeared. The branched and unbranched forms have been separated as *E. fluviatile* (typical) and *E. fluviatile* forma *Linnaeanum*, but seem to be simply seasonal states (Fernald, 1921, Gray's Manual, 1950). As winter approaches the aerial stems die and snap off, probably by ice action. In early spring swathes of blackened horsetail stems lie around the shoreward edge of the zone.

The submerged surface in which the horsetail rhizomes were embedded was a mixture of live or decaying aquatic moss, sedge remains, and accumulating sediment. This formed a thick layer over the hard bottom. On the shallower parts small sedges emerged, and *Potentilla palustris* was common. At the shoreward edge of the *Equisetum* zone *Menyanthes trifoliata* appeared. Both *P. palustris* and *M. trifoliata* are mat-builders, having underwater stems which support moss growth and accumulate deposits in which other plants can take root. Immediately next to the narrow band of *Menyanthes* came the zone of large sedge, *Carex rostrata*. There was no intermingling of *C. rostrata* and *E. fluviatile*, and the delineation of these two zones appeared sharp.

The mat became progressively more solid across the *Carex* zone. At its pondward edge the surface was soft and 20 cm. under water. *Iris* was plentiful here. At the landward edge the surface was above water, and shrubs and sedge intermingled. The transition to the shrub zone was not sharp. *Myrica* and *Chamaedaphne* grew out among the sedge, and a certain amount of sedge remained among the bushes at the edge.

The tree margin followed the rocky rim of the pond, the edge of a band of climax vegetation dominated by spruce and fir. The only trees advancing into the open area were some young larch up to five or six feet high on the drier region of the sedge mat at the extreme south end. Whitened larch skeletons a little farther out on the mat showed that previous invaders had not been successful. A slight increase in water level would probably have a severe effect on young trees invading this zone.

The bryophytes showed a gradation from those typical of aquatic and marshy conditions to the peat-building Sphagnum of the outer mat.

Of the aquatic mosses, the three Fontinalis species were found only in the open part of the pond or in the stream below the beaver dam, on the mud bottom or attached to stones.

Dr. R.R. Ireland, who identified the Fontinalis specimens, remarked that Fontinalis flaccida is not recorded from Newfoundland in Welch's definitive monograph on the Fontinalaceae. Most probably this reflects the fact that aquatic mosses have not been extensively collected here, and further dipping into ponds and streams might show it to be fairly common.

The other aquatic moss, Drepanocladus exannulatus, was ubiquitous in all submerged areas. On the underwater part of the mat, it became mixed with an increasing proportion of Sphagnum subsecundum var. inundatum as it reached the shallower and emergent surface. At the shoreward edge of the horsetail zone a second Sphagnum -- S. cuspidatum var torreyanum -- joined the mixture, and beyond this point Drepanocladus disappeared. Table IV gives the relative proportions of Drepanocladus and Sphagnum on the submerged mat surface.

In the Carex zone the dominant Sphagnum was S. papillosum, the most acidophilous of the species collected. It is a hummock-builder and peat-former, and formed the greater part of the moss cushions among the Chamaedaphne and Myrica. The surface samples here had pH values of 4.3 to 4.7.

The succession from edge to centre of the pond corresponds to a series described in a lecture given at Memorial University in 1968 by Dr. Leo Heikurainen. He was speaking on the classification of peatlands according to productivity. Plant communities, arranged according to percentage cover of constituents, can be placed in a continuum indicating conditions from poor to favorable. His sample series ran from Sphagnum papillosum, indicating oligotrophic condition, through several moss and Carex species, including C. rostrata, with Drepanocladus at the eutrophic end of the scale.

Rate of Filling In

It is difficult to say how fast the mat vegetation is encroaching on the pond. The subjective impression after four years of intermittent observation is that the emergent vegetation is becoming more prominent.

Four years is a short time for any significant change to appear, although the filling-in process is said to proceed very rapidly once a certain stage of build-up is reached. Auer (1930) mentions a bog lake at Alfred, Ontario, observed in 1914. Within twelve years the floating mat had completely covered it with a surface solid enough to walk on. Deevey (1943) speaks of a small pond "about three yards across" in a bog in southern Connecticut, where sailing had been enjoyed less than a century before.

However, mat growth may remain in essentially the same condition for many years. Buell et al (1968) reporting on a pond which had been observed for a period of over thirty years, found the floating mat margin in the same position in 1967 as it had occupied in 1934, although the relative widths of the concentric zones had changed. Edge erosion had balanced mat growth. They agree with Conway (1949) that bog lake development does not always proceed at an unbroken pace, but may go through periods of fast change, followed by apparent standstill, depending on local or climatic conditions.

In the case of Island Pond, the dead larch on the south mat (p. 57 above) may indicate that conditions have fluctuated during the last few years.

Changes in the level of the mat do occur. As mentioned above, (Table VI) depths to hard bottom measured on May 26, 1967 were up to 25 cm. less than those of early July, 1966. Conditions near the edge were then noticeably drier.

At the time of writing (July, 1970) the water level is the highest yet observed. A depth check at 40 metres from the base mark gives a depth to hard bottom of 107 cm., compared with 95 cm. in July, 1966 and 70 cm. in May, 1967. Conditions are soggy up to the rocky rim of the pond, and the surface is submerged except for the Sphagnum hummocks in the outer zone. This rise in level coincides with a noticeable increase in height of the beaver dam. The difference between the levels of 1966 and 1967 may also have been due to the height of the beaver dam, although no definite difference in it was noted at the time. It seems not to have been caused by a difference in precipitation, because there was actually a greater precipitation in early 1967 than in 1966. Precipitation at Colinet for the six months prior to the July, 1966 measurements was 63.6 cm., and for the six months prior to the May, 1967 measurements was 91.4 cm.

Activities of the beavers thus may interfere with what would otherwise be the natural course of events.

Figure 4, taken September 28, 1966 from an altitude of 2620 metres above sea level may be compared with Figure 19, taken fifteen years earlier on September 21, 1951 from an altitude of 2590 metres. Both views were taken at the end of the growing season, and records show no killing frost in September of either year to affect the appearance of the vegetation.

At first glance Figure 4 seems to show an increase in filling-in of the pond. The photographs, however, are not identical in contrast. Careful inspection shows outlines in the 1951 picture which correspond to the outlines of the underwater mat growth in 1966, although the area is much darker on the earlier print. Water level may have been slightly lower in 1966. The average runoff from the Rocky River, which drains the district, was 9.74 cu. m./sec. between Oct. 1, 1965 and Sept. 30, 1966, compared with 10.45 cu. m./sec. between Oct. 1, 1950 and Sept. 30, 1951. This may have had some effect on the appearance of the two pictures. It is possible that the difference in contrast between the two is caused by a difference in light conditions or in photographic equipment.

It does seem safe to say that between 1951 and 1966 the *Carex* mat at the north end has advanced slightly, and at the south end has become more consolidated. Other conclusions will have to await future observations.

Relation to Mainland Vegetation

Fernald early pointed out that the Newfoundland flora contained an element with arctic affinities and also an element with pronounced southern affinities. (Fernald 1911, 1918 a, 1918 b). The arctic species are mostly to be found on the calcareous soil and rocks of the western region of the island. The Avalon, with its generally acid and thin soil, contains a mixture of common North American plants of like latitudes, with an element of southern affinities, including many plants typical of the Atlantic coastal plain. It also contains some species which are confined to the extreme eastern part of North America and are also found in Atlantic Europe. Many species which grow in the same latitude on the mainland or in Cape Breton are missing from Newfoundland.

The plants of Island Pond fall mostly into the category of common North American species. Its water lilies, pondweed, horsetails, and aquatic grasses are repeated in shallow lakes and streams across the continent. The mat-builders *Menyanthes trifoliata* and *Potentilla palustris* are found from New England to the Pacific coast. The *Carex* mat with its interlacing rhizomes and the *Chamaedaphne* and *Myrica* of the consolidated mat are common components of North American bog ponds. Two species representing the coastal plain element are *Nymphoides cordata* and *Utricularia purpurea*, both of which extend as far south as Florida and Louisiana.

The four species of *Utricularia* furnish a certain contrast in their geographic distribution typical of elements in the Newfoundland flora, as well as in their ecology. *U. vulgaris*, *U. intermedia*, and *U. minor* are circumboreal in distribution. On the North American continent

<u>U. vulgaris</u> is found in the north from Labrador to Alaska, south through the New England States, New York, the Great Lakes region, the Rocky Mountains and the Pacific coast. In some localities it extends as far south as Florida, Texas, and Southern California. The other two circumboreal species are found in areas more or less glaciated during the Wisconsin period. <u>U. purpurea</u>, on the other hand, has more southerly affinities. It is found in Nova Scotia, New Brunswick, south along the Atlantic coast to Florida, Mississippi, Louisiana, Cuba, and Central America. Curiously, in Quebec it is known only from stations in the Laurentians forty to a hundred miles north of Montreal. (Marie-Victorin 1940; Dr. E. Rouleau, personal communication). This is a disruption of range. One might expect that a coastal plain plant would reach Quebec via the Hudson-Champlain-Richelieu route. Marie-Victorin suggested it might have reached its Laurentian stations through the Ottawa geographic system.

Of the four, <u>U. vulgaris</u> tolerates the widest range of conditions, growing in acidic or basic water, usually free-floating below the surface. <u>U. intermedia</u> is mostly found in acidic water, but there are exceptions. It grows on muddy bottoms or edges of ponds, sometimes floating. <u>U. minor</u> is generally considered to grow best in water overlying a calcareaous substrate, but it, too, shows exceptions. Rossbach (1939), from whom this information was taken, speaks of finding <u>U. minor</u> at the bottom of a spring-fed pool in a deep bog, not far from Sphagnum and Chamaedaphne, "in close company with Nitella". It is interesting that the U. minor collected from Island Pond was found in the same two spots where Nitella flexilis was growing. U. purpurea, a typical coastal plain type, is a plant of acid and boggy habitats.

To complete the record of the genus in the region, it may be added that the non-aquatic U. cornuta of the nearby bog is here in the northerly part of its range, and extends southwards on peaty or sandy soil to Florida and Texas.

The only plant not common to many regions on the continent was Juncus bulbosus, a rush with flaccid, filiform leaves and stems. found submerged in the stream below the beaver dam. This is a plant of amphi-Atlantic distribution, found in North America only in south-east Newfoundland, St. Pierre and Miquelon, Sable Island and Nova Scotia.

Island Pond thus furnishes a typical example of the classical bog pond described in many texts.

In actual fact, this type of pond, with clearly marked zones of vegetation and extensive mat formation does not seem common on the Avalon Peninsula. Newfoundland bogs differ from many bogs described from other parts of North America (Gates, 1942; Conway, 1949; Rigg, 1938, 1940) in having no sedimentary peat. According to Pollett (1967), the characteristic material at their base consists of remains of mesotrophic fen and bog plants. Their peat is made up of more or less decomposed sedge or Sphagnum, with no lake sediment and no tree remains. Evidently the filling in of open water has not been an extensive process here. It is likely that the continual strong winds and the wave action caused by them are the chief factors in inhibiting or delaying widespread growth of mats on many ponds where they would otherwise form. One may speculate that this development, besides being hampered by the relatively short growing season and the prevalence of strong winds, has been going on for a shorter time than in comparable regions on the mainland owing to the complications of re-establishing vegetation on an island.

There has been much discussion as to routes and chronology of the revegetation of Newfoundland at the close of the last ice age. To explain his observations on the distribution of the Newfoundland flora, Fernald first postulated that the island was revegetated by two routes. Arctic plants and boreal plants which reached south Labrador were able to migrate across the Straits of Belle Isle. A southern element migrated north and east along the then largely uncovered continental shelf which furnished a sandy more or less continuous stretch connecting Newfoundland with the rest of the coastal plain, which nowadays hardly extends north of Cape Cod. Probably shallow channels crossed it here and there, and there would be many ponds. Some deep water channels would cross it also, notably the Gulf of Maine and the Laurentian Channel. Plants which migrated along this route would be inhabitants of acid siliceous soil, not forest trees nor plants of richer soils.

Fernald claimed that animal distribution followed the same pattern (Fernald, 1911). Most of Newfoundland's native fauna, such as the caribou, marten, arctic hare, and ptarmigan are akin to Labrador species, while the Newfoundland vole and Newfoundland muskrat are closely akin to New England species. Squirrel, porcupine, deer, and other Canadian woodland animals are not found in Newfoundland.

Later, Fernald set back the time of supposed migration along the continental shelf in view of the contention that parts of Newfoundland had escaped glaciation, at least during the Wisconsin period, and possibly even during earlier Pleistocene glaciations (Coleman, 1926; Fernald, 1933 Pt. II). Plants would have survived on elevated non-glaciated parts of the island, from which refuges they would spread as conditions ameliorated.

This latter hypothesis has been demolished by the findings of later geologists, among them MacClintock and Twenhofel (1940), who established that the whole island had been completely glaciated. However, sea level was certainly much lowered during glacial and early postglacial periods, and the possibility of a migration route along an emergent continental shelf is not necessarily ruled out.

E.S. Deevey, who has written extensively on Pleistocene biogeography, feels that a route from New England across Georges' and Brown's Banks to Nova Scotia may have been open as late as Boreal time, and notes the disjunct ranges of certain plants in New England, Nova Scotia, and Newfoundland. He comments, "Material probably exists in the literature of special groups, such as mammals, for an interesting investigation of this island [Newfoundland], but so far no one appears to have tried to see what bearing it may have on glacial and postglacial changes of land and sea in eastern North America." (Deevey, 1949).

Such a discussion was supplied by Cameron (1958). He concluded from a study of the mammals of the islands of the Gulf of St. Lawrence that no land bridge had existed post-glacially by which they might have reached Newfoundland, Anticosti, or the Magdalens. He considered that the paucity of native mammalian species, as well as the absence of reptiles and amphibia, was evidence against a land bridge. He noted that the unpropitious and turbulent currents about the island would make chance entry of animals by means of ice rafts or floating debris very rare, and considered that the high degree of subspeciation shown in the native fauna indicated few and early arrivals.

Daly postulated a marginal bulge about the glaciated zone, and that the outer edge of the forced-up continental shelf formed a row of islands from New Jersey to Newfoundland which permitted the spread of many species of plants. (Daly, 1934)

Investigations off the north-eastern coast of the United States indicate a broad coastal plain with vegetation extending unbroken out from shore. Finds of mammoth and mastodon teeth show that these animals were roaming this peaty plain at least as late as 11,000 years ago, and presumably they were finding suitable forage. At that time sea level was 70 metres lower than it is to-day, and great areas of the now submerged banks would be exposed. Before that date, the sea level was of course even lower, the lowest point being - 123 metres about 19,000 years ago (Whitmore et al., 1967; Emory & Garrison, 1967; Emory et al., 1967).

Here we might note the dictum of S. A. Cain, who discounted long distance dispersal of plants by birds or currents, that "the migration of plants is intimately linked with a continuity of suitable habitats." (Cain, 1944)

All these considerations make the existence of a postglacial continuous route for plant migration along the continental shelf to Newfoundland sound plausible. However, it remains to be established whether by the time the surface of Newfoundland was sufficiently ice-free and its climate sufficiently ameliorated to support the temperate plants of the coastal plain, the ocean level was still low enough for their continuous dispersal. MacClintock and Twenhofel state that immediately after slight deglaciation had resulted in the recession of the ice border to within the present shore line, with deposition of drift, sea level was high enough to allow deposition of marine sediments over the lower glacial suite (MacClintock & Twenhofel, 1940). These deposits are not seen on the Avalon, but if the Avalon is sinking, as described by Jeness, the evidence of such happenings along the coast may be submerged. Jeness states that the age of glacial material on the Avalon relative to deposits farther west on the island is not known, and that studies on carbonaceous bog materials would be illuminating. (Jeness, 1960).

Perhaps the comment of Godwin (1949) is still pertinent. In discussing the land connections of the British Isles with the continent, and the presence of peat and forest remains on the floor of the North Sea, he says, "It must be recognized that the same climatic amelioration which rendered the land available for recolonization by plants and animals also restored the sea barriers which presently impede migration, and that we do not know the precise relationship of these two processes."

Damman (1965), who is well acquainted with the Newfoundland vegetation, thinks that glacial history is often unnecessarily invoked to account for present-day distribution, which may just as readily be explained by climatic and edaphic factors. Southerly species could have moved northwards in the postglacial climatic optimum, and their restriction now to certain areas is due to present-day conditions. For example, the "coastal plain" species do not tolerate very low winter temperatures, hence are found largely in the south-east of Newfoundland and along the south coast -- some only in the Avalon and Burin Peninsulas. Certain temperate or boreal plants found in Cape Breton are not found in Newfoundland simply because of unsuitable habitat and a too-short growing season, not because their entry was blocked by physical barriers.

That climatic conditions were once more favorable is well attested. Fernald speaks of finding crumbling stumps, some a foot or more in diameter, on the tableland east of Blanc Sablon, which he considered to indicate an ancient forest of considerable size. He could not estimate its age, but he quotes Jacques Cartier's well known description of that shore in 1534 as a land of rocks and moss and stunted woods -- "the land that God gave to Cain." (Fernald, 1911, Pt. I)

Deevey mentions pollen profiles from Labrador in which Bowman found hemlock pollen (Deevey, 1951). Hemlock is now found in the maritime provinces, but not in the Gaspé, in Newfoundland, or north of the Gulf of St. Lawrence.

The Straits of Belle Isle would not be a formidable barrier to the passage of seeds or plant parts, which could be wind-borne, or travel on floating ice or driftwood, or be attached to animals which made the crossing.

Even Cabot Strait may not have been as impassable as envisaged by Fernald and others. Air-borne spores of fungi and bacteria are known to travel hundreds of kilometres in upper air currents. The prevailing westerly winds might blow some of the lighter seeds, especially those equipped with floating devices, across the hundred kilometres of the Strait. Cyclonic storms, with winds of a hundred miles an hour or more, would surely suck up small particles and distribute them for great distances. Small amounts of earth or mud may be carried on the feet or feathers of birds, and propagules of algae and other plants undoubtedly migrate this way. Though birds are reputed to "travel empty", it might be that a bird, perhaps blown off course, could transport seeds in its digestive tract. Any plant which managed to take root in the early environment of bare gravelly terrain sprinkled with ponds would have an unimpeded field for expansion, and after many seasons passed the landscape could be transformed.

Whether the revegetation of the ice-scraped surface took place by the steady advance of a vegetation front along the continental shelf, or by spreading from foci haphazardly determined by wind or bird transportation, the results lie around us in forest and barren and bog, often modified by the activities of man since he has occupied the island.

SUMMARY

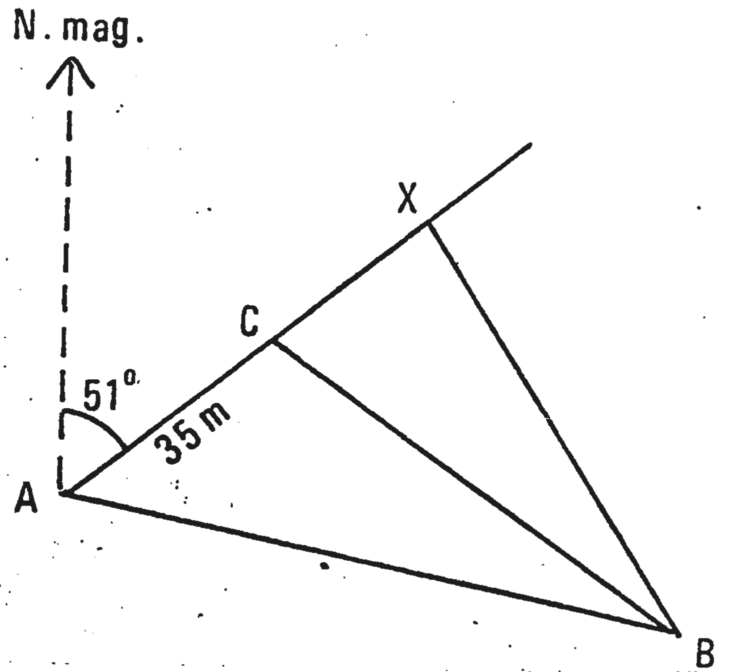
Island Pond, a typical bog pond in the Avalon Peninsula, has been described. Its vegetation, including aquatic, mat, and marginal elements, conforms to classical descriptions of bog ponds in the formerly glaciated areas of North America. Its plants are mostly common North American plants of comparable latitude. There are several Atlantic coastal plain species, including *Utricularia purpurea* Walt, which is here recorded for the first time in Newfoundland. Specimens of plants collected are deposited in the Agnes Marion Ayre Herbarium (Nfld.)

Changing water levels, caused by former lumber operations and a present-day beaver dam, may have affected the process of filling-in by mat vegetation.

Mention has been made of possible routes of revegetation after melting of the Wisconsin ice cover.

APPENDIX A

Calculation of Distances from 80-328 m. on Transect Line



A is the base mark

C is a stake at 35 m. along the transect

B is a reference stake

Any distance AX along the transect is given by

$$AX = AB \times \frac{\sin ABX}{\sin AXB}$$

$$= AB \times \frac{\sin ABX}{\sin (180 - XAB - ABX)}$$

All these quantities can be calculated from the observed compass bearings of AC, AB, BC, and BX, and from the known length AC. The only variable in the expression is the angle ABX. When the fixed quantities are inserted, the expression becomes

$$AX = 87.7 \times \frac{\sin ABX}{\sin (129 - ABX)}$$

APPENDIX B

List of Vascular Plants

	Accession Number	Collection Number
ISOETACEAE		
Isoetes muricata Dur. (megaspores only)		
I. Tuckermani A. Br.	169	373
EQUISETACEAE		
Equisetum fluviatile L.	182 183 184 185	149 323 314 323
SPARGANIACEAE		
Sparganium angustifolium Michx.	716	319
S. fluctuans (Morong) Robins.	732	327
ZOSTERACEAE		
Potamogeton epihydrus Raf.	763	214
GRAMINEAE		
Agrostis scabra Willd.	638	355
Calamagrostis canadensis (Michx.) Nutt.	1022 1023	311 356
Glyceria borealis (Nash) Batchelder		486
G. canadensis (Michx.) Trin.	1191 1192	310 353
Muhlenbergia uniflora (Muhl.) Fern.		392

	Accession Number	Collection Number
CYPERACEAE		
Carex canescens L.	3342	151 386 388
C. exilis Dew.		381
C. interior Bailey	3514	329
C. limosa L.		385
C. Michauxiana Boeckl.	3630 3615	156 328
C. rostrata Stokes	3769 3767 3768 3774	145 307 324 359
Eleocharis acicularis (L.) R. & S.	4035	372
E. palustris (L.) R. & S.	4052	322 383
Eriophorum spissum Fern.		382
Scirpus atrocinctus Fern.	4191 4190	146 360
ERIOCAULACEAE		
Eriocaulon septangulare With.	4945	366
JUNCACEAE		
Juncus brevicaudatus (Engelm.) Fern.		378
J. bulbosus L.		389
J. canadensis J. Gay	5276 5275	308 361
J. effusus var. Pylaei (Laharpe) Fern.& Wieg.	5293	357

	Accession Number	Collection Number
J. effusus var. *compactus* Lej. & Court	5310	358
J. pelocarpus Mey.	5353 5351	315 331
IRIDACEAE		
Iris versicolor L.	62	150
MYRICACEAE		
Myrica Gale L.		
NYMPHAEACEAE		
Nuphar variegatum Engelm.		
RANUNCULACEAE		
Ranunculus reptans L.	6816	374
CRUCIFERAE		
Subularia aquatica L.	2542	371
DROSERACEAE		
Drosera intermedia Hayne		316
D. rotundifolia L.		459
ROSACEAE		
Potentilla palustris (L.) Scop.	7093 7091	152 312
Sanguisorba canadensis L.	7313	354

	Accession Number	Collection Number
CALLITRICHACEAE		
Callitriche heterophylla Pursh	2550	363
HYPERICACEAE		
Hypericum boreale (Britton) Bicknell	5148	365
H. canadense L.		391
HIPPURIDACEAE		
Hippuris vulgaris L.		461
ERICACEAE		
Chamaedaphne calyculata (L.) Moench		
Ledum groenlandicum Oeder		
Vaccinium Oxycoccos L.		
Andromeda glaucophylla Link		
MENYANTHACEAE		
Menyanthes trifoliata L.	5764	148
	5767	313
Nymphoides cordata (Ell.) Fern.	5960	332
	5899	332 a
LENTIBULARIACAE		
Utricularia intermedia Hayne	5586	320 b
	5587	
	5594	362
	5588	367
	5595	364
U. minor L.		458

	Accession Number	Collection Number
U. purpurea Walt.	5597	320 c
	5596	368
	5598	369
		455
U. vulgaris L.		317
	5609	318
	5610	320 a
	5601	370
		398
		485
COMPOSITAE		
Aster nemoralis Ait.		460
CHARACEAE		
Nitella flexilis (L.) Ag.		440
		483

APPENDIX C

List of Bryophytes

MUSCI

Classification, except for Nos. 419, 442, 465, as given in Crum, Steere, & Anderson - List of the mosses of North America, in Bryologist, 68, pp. 377 to 434, 1965.

No. 419 was identified by Dr. Damman as *Sphagnum inundatum* Russ. Duncan's "Illustrated key to Sphagnum mosses" led to *S. subsecundum* var. *inundatum* (Russ.) C. Jens. Neither name appears on the list of Crum, Steere, & Anderson. "Index muscorum" gives the two names as synonymous, the second being preferred, and this usage was followed.

SPHAGNOBRYA

SPHAGNACEAE	Accession Number	Collection Number
Sphagnum cuspidatum var. *torreyanum* (Sull.) Braithw.		420 443 466
S. imbricatum Hornsch. ex Russ.	126	422
S. papillosum Lindb.	128	411 399 415
	127	416
S. pulchrum (Lindb. ex Braithw.) Warnst.		418 462

	Accession Number	Collection Number
S. subsecundum Nees ex Sturm.		417
S. subsecundum var. inundatum (Russ.) C. Jens.		419 442 465
S. tenellum (Brid.) Pers. ex Brid.	129	414

EUBRYA

DICRANACEAE

Dicranum scoparium Hedw.	121	407 412

GRIMMIACEAE

Rhacomitrium aciculare (Hedw.) Brid.		449 479 450 480

BRYACEAE

Bryum pseudotriquetrum (Hedw.) Gaert., Meyer, & Scherb.		432

MNIACEAE

Mnium cinclidioides Hub.		426

AULACOMNIACEAE

Aulacomnium palustre (Hedw.) Schwaegr.		444 c

BARTRAMIACEAE

Philonotis fontana (Hedw.) Brid.		427

	Accession Number	Collection Number
FONTINALACEAE		
Fontinalis antipyretica Hedw.		451
F. dalecarlica Schimp. ex B. S. G.		453
F. flaccida Ren. & Card.		424 437 452
AMBLYSTEGIACEAE		
Drepanocladus exannulatus (B.S.G.) Warnst.		421 428 441
D. uncinatus (Hedw.) Warnst.		404 413
ENTODONTACEAE		
Pleurozium schreberi (Brid.) Mitt.	123	409
PLAGIOTHECIAE		
Plagiothecium denticulatum (Hedw.) B. S. G.		406
HYPNACEAE		
Isopterygium turfaceum (Lindb.) Lindb.		405
RHYTIDIACEAE		
Rhytidiadelphus loreus (Hedw.) Warnst.		400 410

	Accession Number	Collection Number
POLYTRICHACEAE		
<u>Polytrichum</u> <u>commune</u> Hedw.		438
<u>P.</u> <u>juniperinum</u> Hedw.		402

HEPATICAE

Classification as in Conard, "How to know the mosses".

ORDER JUNGERMANNIALES

	Accession Number	Collection Number
PTILIDIACEAE		
<u>Ptilidium</u> <u>pulcherrimum</u> (Web.) Hampe	124	444 b
CALYPOGEIACEAE		
<u>Calypogeia</u> <u>sp</u>. Raddi emend. Nees		482
JUNGERMANNIACEAE		
<u>Lophozia</u> <u>ventricosa</u> (Dicks.) Dumort.		401
SCAPANIACEAE		
<u>Scapania</u> <u>undulata</u> (L.) Dumort.	125	403

ORDER METZGERIALES

	Accession Number	Collection Number
PELLIACEAE		
<u>Pellia</u> <u>epiphylla</u> (L.) Corda		396 433 447

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Figure 19

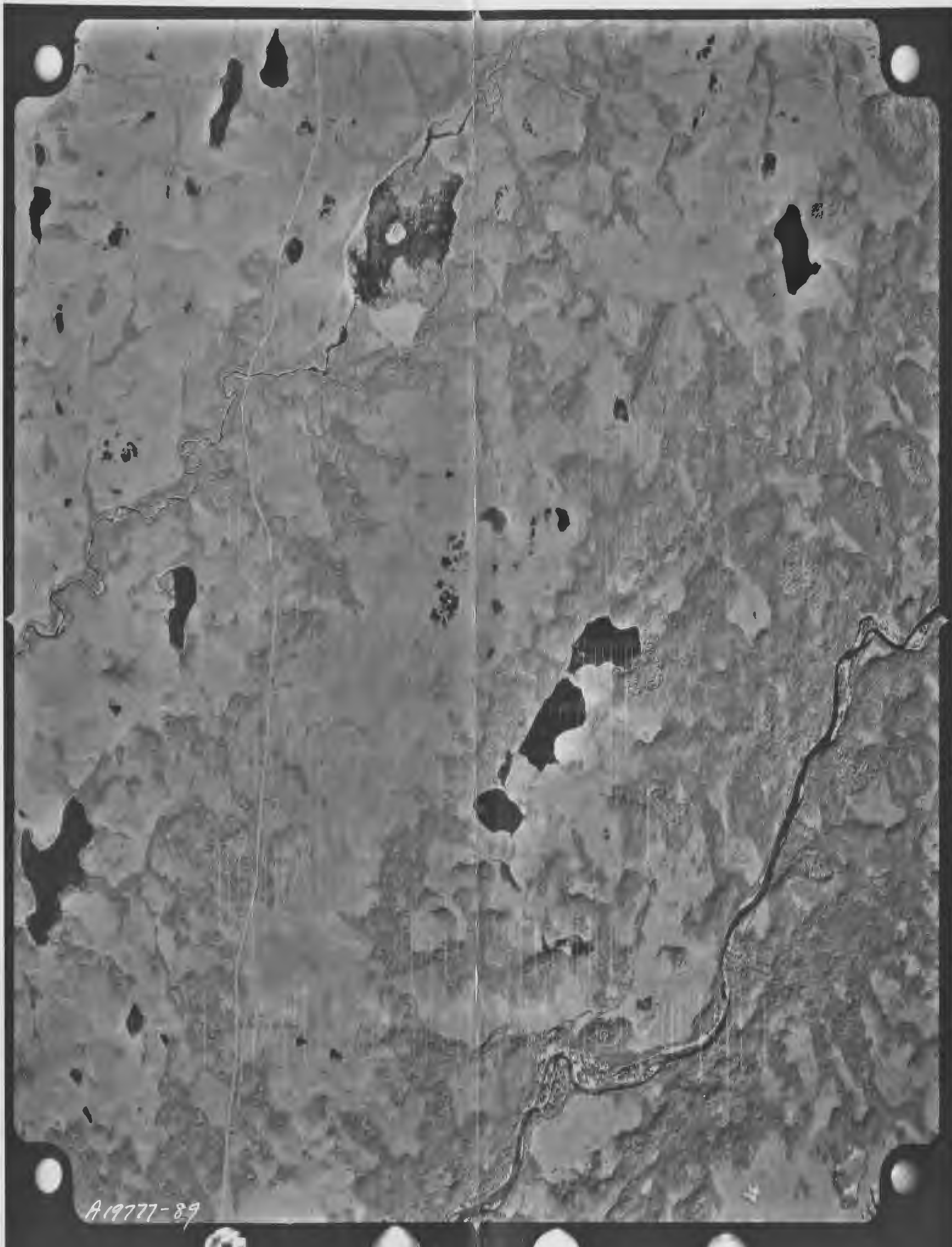

Figure 1

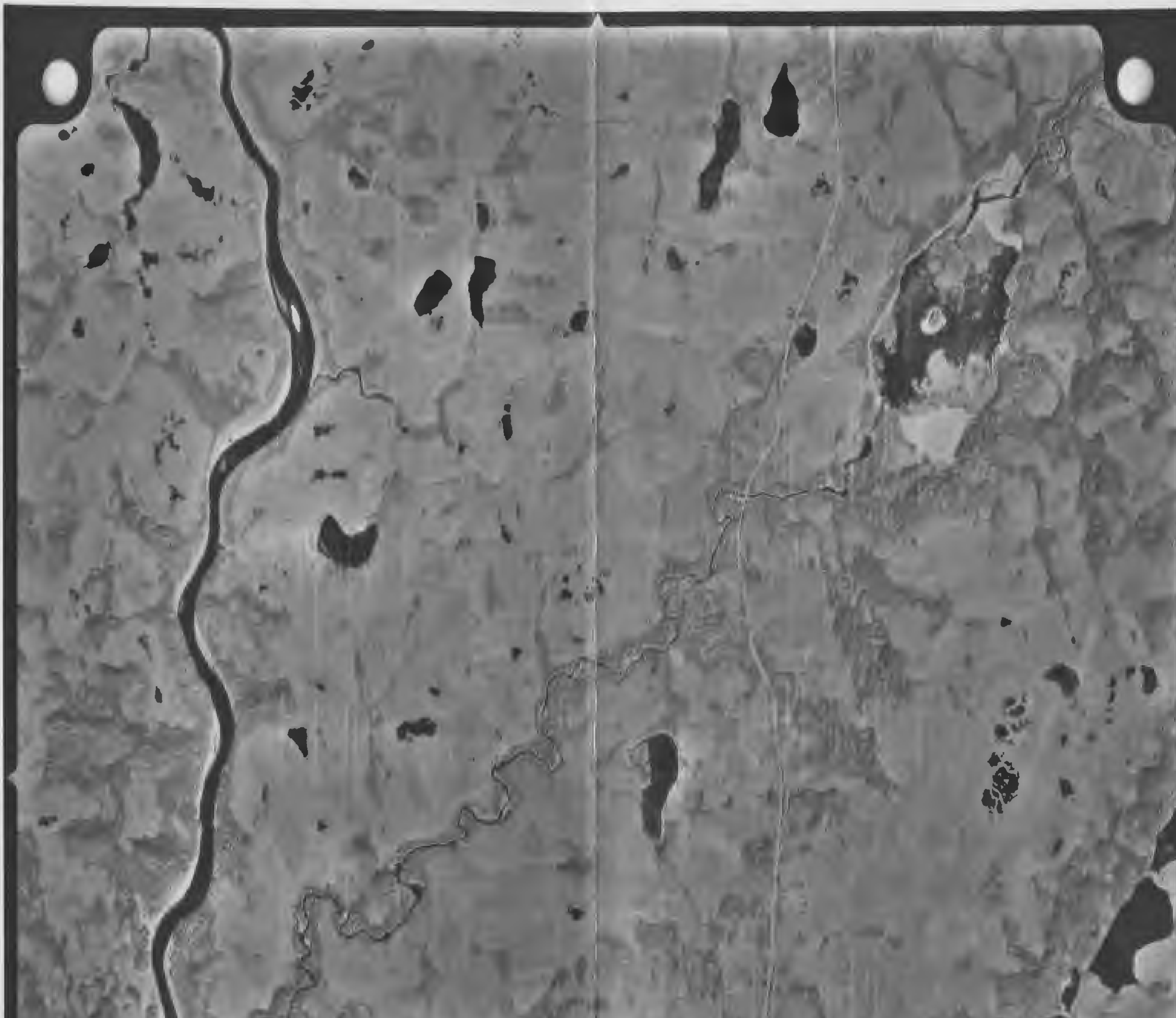

Figure 2

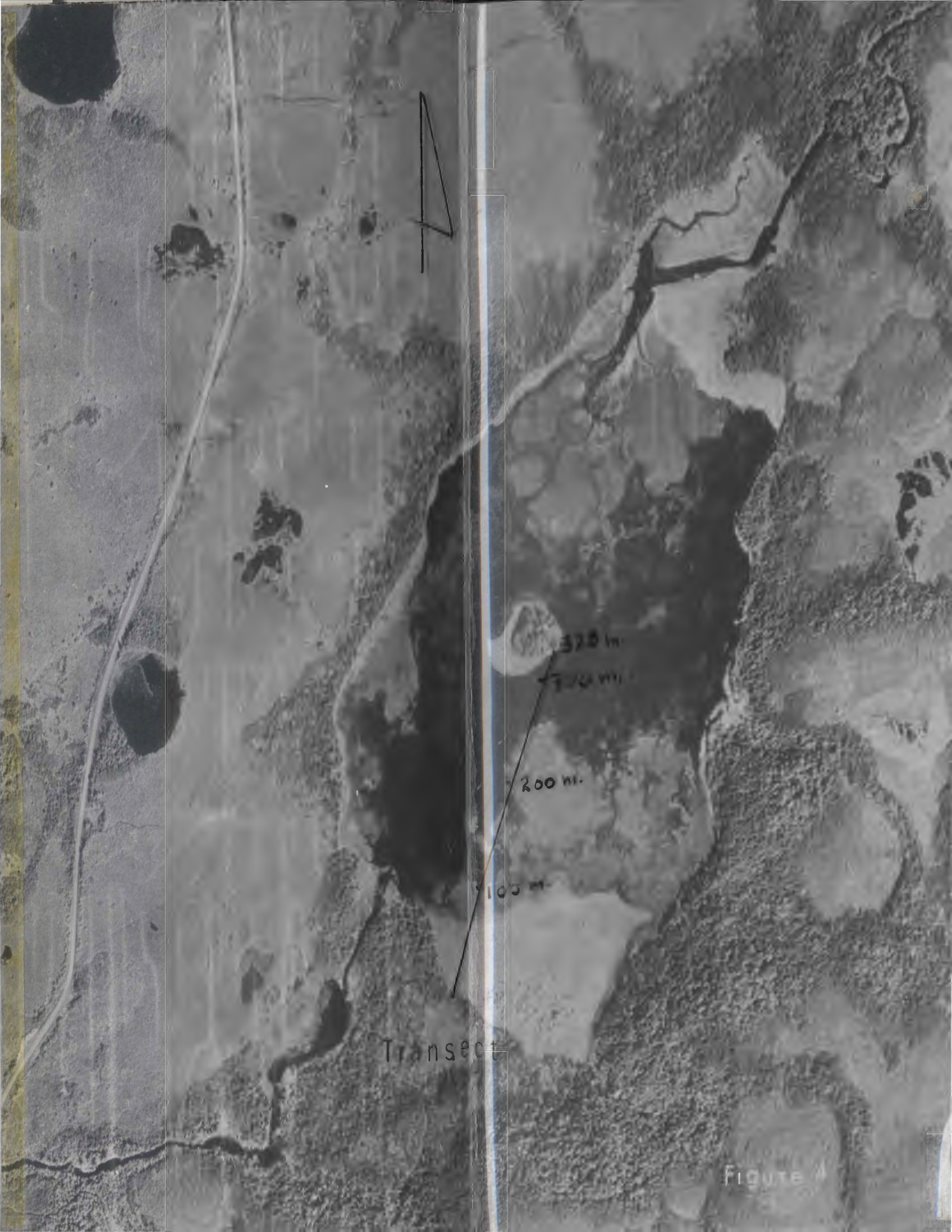

Figure 4