AN HEPATIC FLORA OF SOUTHWEST THUNDER BAY DISTRICT ONTARIO

by

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ABSTRACT

A checklist is provided of the hepatics recorded from an area of 15,700km^2 adjacent to the northwest shore of Lake Superior, based on extensive field sampling and an examination of the existing literature and collections. In order to determine objectively the distribution and frequency of each species, its habitat preferences and other aspects of hepatic ecology in the area, species presence and habitat data were recorded on a 100m transect at each of 101 sites, selected from an 8 mile grid, and the results were analyzed by computer. A phytogeographical analysis has been undertaken, the distribution of each species has been mapped using the international 10km grid and an artificial key to all species recorded from the study area has been prepared. Four additional species, likely to be found in the study area, are included in the key, three of these are also dealt with in the check list because of their special interest.

During the course of this study 75 species were recorded from a total list of 94. The majority of species have boreal affinities and there are small arctic and temperate elements: 80% of species are either circumpolar or amphi-atlantic in distribution, 12% are subcosmopolitan. The richness of the hepatic flora on a given site was found to be affected mainly by moisture, vascular vegetation and human interference. Most species were restricted to one type of substratum and this was a most important factor in determining their distribution.

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SECTION I
INTRODUCTION

Objectives

This study has attempted to determine the occurrence, distribution and ecology of hepatics in an area of 15,700km^2, being the southwestern portion of Thunder Bay District, Ontario. This region has been very little investigated botanically and the present work forms part of a general study of the bryophyte and vascular flora initiated by Dr.P.Barclay-Estrup.

The principal objectives of this survey have been:-

1. To prepare an up-to-date hepatic check list and a distribution map for each species within the study area, based on extensive field collections and on information from all other available sources.

2. To determine the frequency of each species by routine sampling throughout the area.

3. To determine the ecological preferences of each species and to compare the importance of general site features and microhabitat in controlling hepatic distribution.

4. To determine the geographical affinities of the various elements within the hepatic flora, in order to elucidate the history of plant colonization of the region.

5. To produce a simple artificial key to assist other workers in the area in identifying hepatic collections.

The investigation may be particularly valuable at this time as the study area is, so far, relatively free from atmospheric pollution, but it is anticipated that industry, possibly including smelting, will be established in the near future. The base line data being recorded now may thus allow significant conclusions to be drawn about the effects of such industry on the hepatic flora in the years to come. Previous studies have shown that bryophytes and lichens are markedly affected by the presence of built up areas and heavy industry (Rydzak, 1959; Gilbert, 1965; Leblanc & Rao, 1966; Rao & Leblanc, 1967) and that cryptogamic epiphytes may provide sensitive indicators of the level of atmospheric pollution (Leblanc & De Sloover, 1970).

In addition, certain hepatic species may indicate the degree of superficial disturbance of an area, as for example, by fire, logging or construction. Others are characteristic of certain stages in succession after such disturbance (Benson & Blackwell, 1926; Skutch, 1929). Some pioneer species of hepatics occupy niches unsuitable for other groups of plants. In other cases, however, they help to modify the substratum making it available for species requiring less rigorous conditions. Also, it has been observed that hepatic communities provide shelter and food for a number of minute species of invertebrate. Thus, a knowledge of hepatic species may be of value in a variety of ecological studies, especially where microenvironments such as rocks and rotting logs are under scrutiny.

Distribution Patterns of Hepatics

At one time it was thought that because bryophytes produce small spores easily spread by the wind, they were widely dispersed and that the distribution patterns of most species were consequently highly generalized. There are a number of cosmopolitan species, especially thallose hepatics, which could easily create this impression (Steere, 1969). More recent work, however, has led to a realization that the "majority of species of Hepaticae exhibit a relatively narrow distribution, usually restricted to one or a few vegetational zones" (Schuster, 1958). Indeed, it is now recognized that "Their patterns of geographic distribution are as clear and illuminating as those of higher plants, which they often, but not always, parallel remarkably closely." (Steere, 1965). For example, Diplophyllum apiculatum shows a similar distribution to ferns such as Asplenium cryptolepis (Schuster, 1958), both being found in the ancient, unglaciated Appalachian region with disjunct occurrences in areas such as the Keeweenaw Peninsula in Michigan.

There are two factors, however, which appear to have led to some hepatic species showing disjunct distributions not always paralleled by vascular plants. Firstly, the ancient origins of some species (Fulford, 1965), combined with numerous geological vicissitudes through which they have passed, have created extremely disjunct distributions in a number of species which are still not well understood. An example is the anomalous distribution of Clevea hyalina which will be referred to later (see page 99).

Secondly, while it may often be true that " bryophytes appear to have migrated in the same foot by foot manner as higher plants and were probably associated with them" (Steere, 1965), it seems to be not uncommon for mosses and hepatics " to persist in small pockets where a suitable microenvironment persists long after the general climate of the area has become very definitely inimical." (Schuster, 1958). One example is provided by Solenostema sphaerocarpum which is essentially arctic-alpine but also occurs near the periphery of Lake Superior (Schuster, 1958). These factors give hepatics considerable potential value in elucidating phytogeographical relationships.

The hepatic flora of any given area may be divided into floristic elements such as arctic, boreal, temperate or cosmopolitan, consisting of species sharing a similar geographical distribution pattern. Thus, it is sometimes possible to identify relict species which may help establish the previous vegetational history of the region. Indeed, the many disjunctions which occur among the hepatics and the reasons for their distribution are one of the most fascinating aspects of hepaticology.

Habitats of Hepatics

Hepatics exhibit as wide a variety of preferences for special climatic, edaphic and biotic conditions as vascular plants and there are also " physio-genetic features of a species such as its ability to compete, its toleration, its reproductive potential which are poorly understood but which help to determine its occurrence and frequency." (Schuster, 1957).

The most general requirement of hepatics is considered to be a higher than average supply of moisture. Thus, areas with a high mean relative humidity are generally rich in hepatic species. Even so, some species are capable of resisting desiccation, so that Dr.Carol Woodfin (personal communication) has found a surprising number of species of *Riccia* in Texas. Their lack of complex tissues and, therefore, their relative inability to avoid loss of moisture tends to reduce the chances of finding hepatics in situations exposed to strong solar radiation, where desiccating forces are extreme. Curiously, hepatics do not develop growth forms best adapted to conserving water such as those described for mosses by Gimingham & Smith (1971). Mostly, they produce loose mats and not compact turfs and carpets. Also, most species are ectohydric rather than endohydric (Watson, 1967). This considerably limits the habitats available to hepatics.

Providing their moisture requirements are satisfied hepatics may be found on a variety of substrata from bare inorganic surfaces to every kind of organic material including living trees. In tropical regions there are even many epiphyllous liverworts (Richards, 1932). Hepatic species vary in their habitat specificity, some being confined to one type of substratum while others are found on several. Similarly, some species seem to be found on a narrow range of substrate pH, whereas others are much less specific (Schuster, 1958).

A number of substrate types are exploited by hepatics to a greater extent than by vascular plants, examples being logs, living trees and rocks. Hepatics are most often found as members of microcommunities associated with other cryptogamic species and invertebrates.

SECTION II

DESCRIPTION OF THE STUDY AREA

Location

A map is provided in Fig.1. The area is bounded by Lake Superior to the east, the United States border to the south, the 49th parallel to the north and the border of Rainy River District to the west. The boundaries were chosen to allow reasonable daily access from the city of Thunder Bay and also to cover areas likely to be affected by future industry, as for example at Lake Shebandowan where mining is already in progress. The area is roughly trapezoidal in shape and the elevations range from approximately 195m at the level of Lake Superior to more than 500m to the northwest.

Geology

The study area lies completely within the Canadian Shield and the underlying rocks are precambrian throughout (Harrison, 1963). Early precambrian rocks, such as various types of granite, predominate to the northwest (Zoltai, 1963). The early precambrian zone is a peneplain (Zoltai, 1961) and differences in elevation rarely exceed 70m (Zoltai, 1963). Along the Lake Superior shore late proterozoic sediments and intrusive rocks are important (Zoltai, 1965). These are underlain by early precambrian rocks which are often rich in minerals. In this zone buttes, mesas and cuestas occur giving sudden differences in elevation of 200m or more (Zoltai, 1963). Especially important is the line of hills, recently named the Nor'westers which include Mt. McKay and Mt. McRae. These

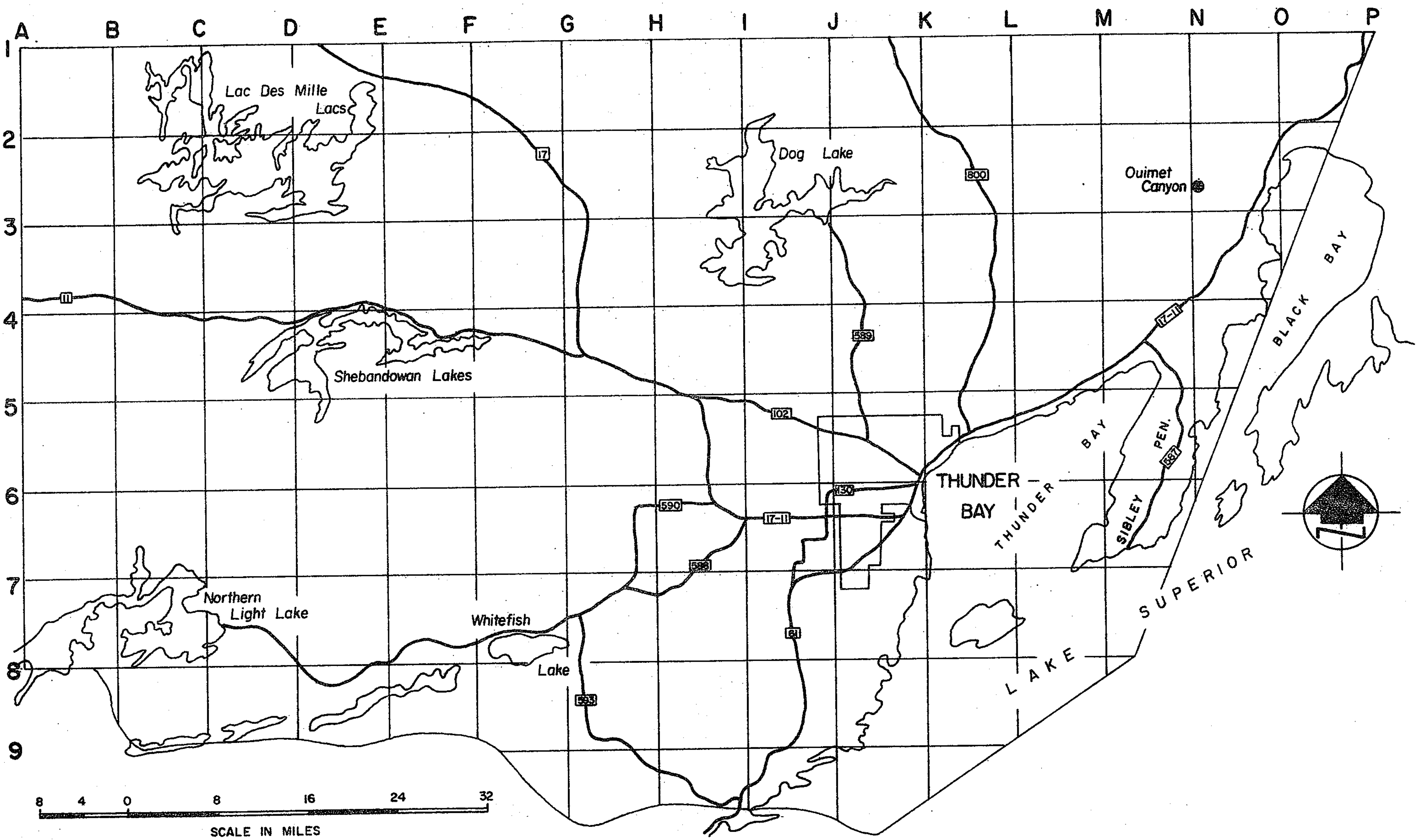


Fig.1 Map of Study Area

parallel the shore of Lake Superior and shelter the area in the southeast. There is no evidence of paleozoic rocks within the area, but many of the precambrian sediments are calcareous (Zoltai, 1965) and have given rise to predominantly calcareous soils. Tanton (1931) notes one small deposit of marl in the Lakehead area but this was on private property and was not available for this study.

The whole of the study area was probably covered in ice throughout the Wisconsin glaciation, and most likely also during earlier glaciations, although the completeness of the last glaciation eliminated much of the direct evidence for this (Zoltai, 1965). Most of the area is now covered in glacial till of varying depths, although there are many bedrock outcrops. However, Zoltai (1965) states that 'in general, the lithology of the till reflects the composition of the bedrock in the vicinity.' Occasionally, however, stones which have been transported long distances can be found.

There are many moraines throughout the area; eskers and drumlins have also been noted and there is a series of raised beaches adjacent to Lake Superior. The general movement of ice was to the south and southwest (Zoltai, 1965) but minor variations in direction occurred as various lobes moved independently. Much of the lower part of the area was inundated either during the pleistocene inter-glacial periods or after the ice retreated. Lakes were formed during the inter-glacial periods in areas such as the present-day Kaministiquia Valley (Zoltai, 1963) and these were responsible for thick deposits of clay. Spillways are visible and, at one time glacial Lake Agassiz is thought to have drained eastward through the area. Recent peat deposits are very common (Zoltai, 1965).

There is little likelihood of any plants having survived in the study area throughout the entire Pleistocene period (Butters & Abbe, 1953), although every recession of the ice sheets must have seen a re-invasion of plant species. Indeed, it seems probable that the present flora has invaded the area since the recession of the Wisconsin ice sheet began approximately 10,000 years ago.

Climate

The study area is characterized by moderate precipitation, warm summers and prolonged frost and snow cover during the winter. Despite its small size, however, there is considerable variation in climate within the area, due to the local modifying effect of Lake Superior, while high ground to the south and the configuration of the lake may exert a slight rain shadow effect thus reducing precipitation in the study area compared with adjacent areas.

These features are illustrated by the climate data in Tables 1 and 2, while Fig.2 is a graph of the monthly mean temperature and rainfall for Thunder Bay Airport. The tables indicate a tendency for temperatures to become more extreme and the growing season shorter as distance from the lake increases, as for example at Kakabeka Falls and Upsala. At

Table 1

30-year mean temperature data at five stations in or near the study area

Location and Elevation		Temperature in Centigrade degrees					
		January			July		
		Min.	Mean	Max.	Min.	Mean	Max.
Cameron Falls 88°23' W 49°09' N	225m	-22.2	-16.5	-10.65	10.25	16.15	23.1
Thunder Bay Airport 89°19' W 48°22' N	193m	-20.65	-14.75	-8.85	10.75	17.5	24.15
Kakabeka Falls 89°37' W 48°24' N	274m	-21.85	-15.25	-8.65	10.70	18.9	25.7
Upsala 90°28' W 49°03' N	475m	-25.2	-18.75	-12.3	10.65	17.15	23.5
Schreiber 87°16' W 48°49' N	298m	-19.7	-14.5	-9.35	9.7	14.8	19.4

Data from: Temperature and Precipitation 1941-1970, Department of the Environment, Canada, 1972.

Mean daily maxima and minima.

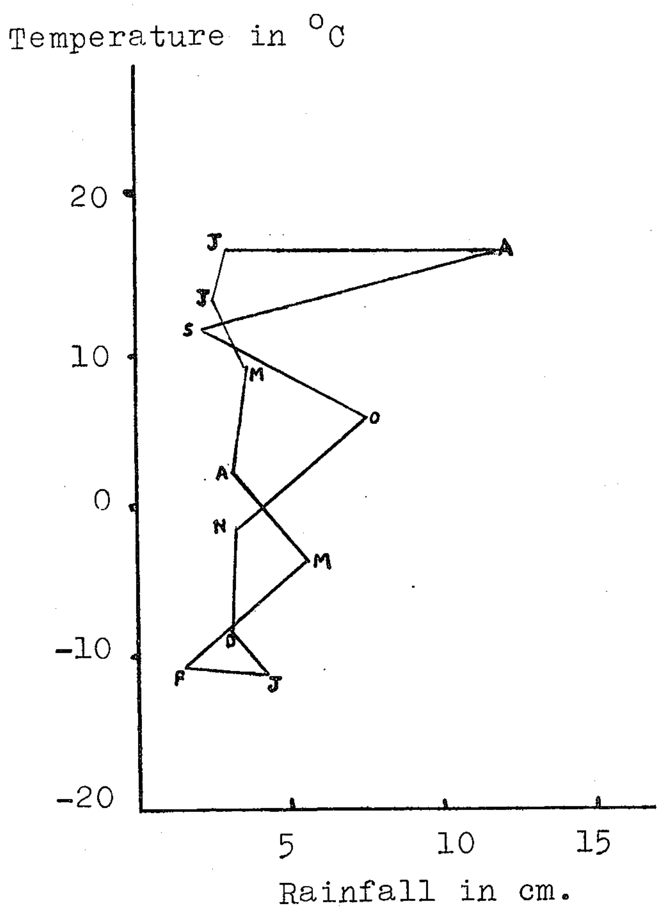
Table 2

30-year mean annual data for precipitation and frost at five stations in or near the study area

Location and elevation	Total precipitation	Days with precipitation	Days with frost
Cameron Falls 88°23'W 49°09'N 225m	75.4 cm	125	207
Thunder Bay Airport 89°19'W 48°22'N 193m	73.7 cm	141	205
Kakabeka Falls 89°37'W 48°24'N 274m	71.9 cm	122	209
Upsala 90°28'W 49°03'N 475m	78.5 cm	137	215
Schreiber 87°16'W 48°49'N 298m	82.7 cm	109	199

Data from: Temperature and Precipitation 1941-1970, Department of the Environment, Canada, 1972.

Fig.2 Hythergraph of Temperature and Rainfall at Thunder Bay Airport



Based on 30-year mean data from: Temperature and Precipitation 1941-1970, Department of the Environment, Canada, 1972.

the same time, precipitation is greater at Upsala and other localities to the northwest. The data for Schreiber, which is well outside the study area, show clearly that the climate along the shore of Lake Superior to the east is both wetter and more moderate in temperature range. This is also true in Minnesota, to the west (Carlson, 1963). This may be important in determining the ranges of some species.

Another interesting aspect of the local climate relates to the dry season which occurs from April, just after the snow has melted and the frost is leaving the ground, until July. Thunder storms during this period, which are rarely accompanied by much rain, frequently cause forest fires. The hythergraph indicates this seasonal variation. It is, therefore, easier to collect hepatics in the early part of the spring or in the autumn. In late spring and summer they shrivel and become difficult to see.

Vegetation

The dominant vegetation of this region is forest, which is considered by Rowe (1959) to represent an ecotone between the Superior and Nipigon sections of the Boreal Forest and the Quetico section of the Great Lakes-St. Lawrence Forest. The commonest trees are Black Spruce (Picea mariana*), White Spruce (Picea glauca), Balsam Fir (Abies balsamea), Balsam Poplar (Populus balsamifera), Aspen (Populus tremuloides), Jack Pine (Pinus banksiana),

* Nomenclature for trees follows Hosie (1969).

Cedar (Thuja occidentalis) and Paper Birch (Betula papyrifera). The only true hardwoods in the area are occasional stands of Black Ash (Fraxinus nigra) in river valleys, Sugar Maple (Acer saccharum) and Red Maple (Acer rubrum) along the Nor'Westers, and Bur Oak (Quercus macrocarpa) in one small stand at Stanley near the Kaministiquia River. The origin of the latter is uncertain and they may have been introduced recently (Van Natto, 1970). The maples, which are more extensive, may be a relic of a thermal maximum 3,000 years ago (Butters & Abbe, 1953). They only grow in sheltered areas where they may benefit from rising thermals and avoid frost hollows. The oaks are in a similar situation.

Much of the present day composition of the forest has been determined by man's activities in the area within the last hundred years. Both mining and logging have been extensive and fires have probably been more common than under natural conditions. In a few locations around the city of Thunder Bay frequent burning has produced heath areas but these are rapidly disappearing under development. Areas which have been burned within the last sixty years have extensive stands of aspen (Fig.3). White spruce and fir associations represent a later stage in succession and there are also black spruce and cedar swamps. The activity of beaver in building dams maintains the cycle of these swamps and these animals are still very common. Birch is often found mixed with other species but seldom occurs in pure stands. Balsam poplar is found in damper areas, often associated with black ash along sheltered river valleys while drier, sandy areas

Fig.3 Regenerating Forest (ca 30 years)

Trail to Ravine Lake, Sibley Park
October, 1972

support stands of jack pine. White Pine (Pinus strobus) is no longer common but relic stands occur, for instance in Sibley Provincial Park. Common understorey trees are Alders (Alnus crispa and Alnus rugosa) and Moose or Mountain Maple (Acer spicatum).

Except along roads and in man-made clearings the ground flora consists of characteristic boreal species such as; Carex* spp, Clintonia borealis, Linnaea borealis Pyrola spp, Trientalis borealis, Trillium cernuum, Viola spp and numerous ericaceous species such as Kalmia polifolia, Ledum groenlandicum and Vaccinium spp.

Of particular phytogeographical significance is the presence of arctic species in Ouimet Canyon, a valley 3km long and 120m deep, approximately, lying in the late precambrian region (Fig.4). The basalt capped rims are nearly 200m apart and the steep block scree at the base of the walls leads to the floor which is covered with a jumble of very large talus blocks. Examples of arctic species growing there are Saxifraga aizoon and Aulacomnium acuminatum (Garton, personal communication). Arctic species also occur along the shore of Lake Superior, for example, Empetrum nigrum at Middlebrun Bay, Sibley (see page 8). Some prairie species are found around the city of Thunder Bay but these have probably been introduced accidentally as grain has been transported through the area.

* Nomenclature for vascular plants follows Scoggan (1957) with the exception of trees.

Fig.4 View northeast from rim of Ouimet Canyon

September 1966

Previous Studies of Plant Distribution in the Great Lakes Region

The Great Lakes have long been of considerable interest to botanists. The special climatic conditions created by them enable surrounding areas to support a more varied flora than would be expected in mid-continental regions. They must, also, have had a controlling influence on plant recolonization since the pleistocene glaciations. In addition, there are present in their vicinity a large number of indigenous species showing widely disjunct ranges involving the Great Lakes region and either the arctic, the mountains of western North America or other areas. There is too the possibility that certain areas around them acted as refugia from which recolonization took place.

Many studies have been made of vascular plants in the area by authors such as Cooper (1928) on Isle Royale, Fernald (1935) in the Upper Great Lakes region of Ontario and Michigan and, more recently, Butters & Abbe (1953) in Cook County, Minnesota (adjacent to the study area), and Soper & Maycock (1963) in the northeastern part of the Lake Superior shore. Lindsay (1968) has also investigated the vascular flora in the Canadian Lakehead region. Much of their work, particularly with reference to phytogeography, is relevant to bryophytes. Conklin (1927) worked with hepatics in the Lake Superior region of Minnesota and Steere (1937) drew attention to disjunct bryophytes found on the Keeweenaw Peninsual in Michigan and in unglaciated regions elsewhere. Schuster (1953) studied the hepatics found in the Lake Superior region. His earlier (1949) work on hepatics in New York state also touches on the Great Lakes region.

There are two basic viewpoints with respect to the flora of the Great Lakes. One is that plants survived in small unglaciated regions, probably on higher altitude nunataks, and these areas acted as centres of post-glacial recolonization. The arctic disjuncts are thus seen as glacial relicts. This theory was propounded by Fernald (1935) with respect to vascular plants and was supported by Steere (1937) with reference to bryophytes. The other viewpoint holds that plants followed the retreat of the ice fields, moving in from warmer regions to the south as the climate became less severe. For example, Butters and Abbe (1953) and Soper and Maycock (1963) are of the opinion that the north shore of Lake Superior, at least, was completely glaciated during Wisconsin times. According to this theory the disjunct species are considered to represent survivals from early stages of the post glacial colonization of the area. Peattie (1932) and Wynne Edwards (1937) indicated that the presence of disjuncts on the shores of the Great Lakes was due to the continuing instability of their shore areas throughout the centuries which have passed since the ice retreated (see Fig.5). Soper and Maycock (1963) also believe that arctic species, such as Primula mistassinica found on the north shore of Lake Superior have been able to survive where suitable microclimates have persisted since the initial phase of post-glacial recolonization. This would indicate an age of the order of 10,000 years for lake shore

Fig.5 Lake Superior Shore

View to the west from Silver Islet, Sibley Peninsula.

October 1972.

colonies of arctic plants. A third possibility is that arctic disjuncts have been introduced recently (Turesson, 1927 as quoted by Soper & Maycock, 1963) and are, in fact, pseudo-relics. This theory is not generally treated very seriously, except in the case of more temperate disjuncts with western affinities such as the Devil's Club (Oplopanax horridum), found on Porphyry Island (C.Garton, personal communication), which could have been established recently in view of the practice of shipping western products through the Lakehead region.

Although a number of disjunct species are recorded from the north shore of Lake Superior, no endemic species have been found so far. This would seem to indicate that there has not been a sufficiently long period of isolation in recent geological periods during which genetic variation could develop to the point of separation of species. This lends support to the idea that the north shore was completely covered with ice during the pleistocene glaciations.

Previous Studies of Hepatic Distribution in the Study Area

One of the attractions of working in this region has been that it is a comparatively neglected one which, until the construction of the Trans-Canada Highway (11) in 1946 was only accessible by rail or water. Although there has been little activity by professional botanists, the constitution of the vascular flora is well known due to the work of amateur botanists associated with the Thunder Bay Field Naturalist Club. Little of this information has been published, however, and the difficulty of identifying hepatics and other cryptogams has tended to steer amateurs away from them.

Undoubtedly, Macoun passed through this area in the early part of this century as he reported Anastrophyllum michauxii and Diplophyllum taxifolium from the Dawson route west of Port Arthur (Cain & Fulford, 1948). However, the Dawson route extended to the Red River Settlement (Winnipeg) and the exact distance west of Port Arthur is not specified. Collections relating to Thunder Bay may have been made at locations anywhere in Thunder Bay District, which extends as far north as Hudson Bay, although it is most likely that they would have come from the vicinity of Lake Superior. That other collectors have passed through the area is evident from the report of A.michauxii from Little Fluor Island (near Nipigon) by O.E.Jennings (Cain & Fulford, 1948), although this is just outside the limits of the present study. By far the majority of hepatic collections in the study area in the last quarter century have been made by a Thunder Bay resident, Mr. Claude Garton. Since retirement from his position as a school principal in 1966 he has devoted himself to enlarging his extensive collection of plants from the area around the city of Thunder Bay. This is now housed in Lakehead University Herbarium, which in 1967 contained 75 hepatic species collected by Garton within the study area.

The work of Cain and Fulford (1948) marks the beginning of the systematic investigation of the hepatic flora in Ontario.

However, their list was largely confined to collections in the University of Toronto Herbarium. In 1956 Crum published a short paper which commented on two of Garton's specimens Asterella ludwigii and Mannia sibirica. It was followed by an additional list of Ontario hepatics which included some of the species collected in the study area by Garton (Williams & Cain, 1959).

Since 1967, collecting has been undertaken by Dr.P.Barclay-Estrup and his students from Lakehead University. Five new records are supported by specimens in Lakehead University Herbarium or Dr.Barclay-Estrup's private collection. Subsequently, the present author prepared an hepatic check list for the study area, based mainly on the collections of Garton and Barclay-Estrup, as a requirement for an Honours B.Sc. degree at Lakehead University (Crowe, 1970; Crowe & Barclay-Estrup, 1971). This represented the first attempt to examine critically the distribution of hepatics in the study area and to establish their phytogeographical relationships. It was found that past collecting patterns had been highly subjective and did not properly reflect the true composition of the local hepatic flora. Rocky and boggy areas, specially favourable to hepatics, had been visited a number of times. Forested areas, which make up the major part of the region were largely neglected. An analysis of the species list, which then numbered 80, showed 10% were of arctic affinity, 21% arctic-boreal, 31% boreal, 18% boreal-temperate, 6% temperate and 14% sub-cosmoplitan.

The aim of the present study was to conduct systematic sampling of hepatics throughout the study area in order to refine the phytogeographical analysis and to determine the importance of each species in the vegetation.

SECTION III

METHODS

Collection and Determination

The major part of the work in this study has consisted of the collection of specimens and their subsequent identification. Each specimen was placed in a packet made from absorbent paper immediately on collection in the field. The packet was numbered and the relevant data recorded in a field notebook. Although an attempt was made to restrict each specimen to one species, this proved impossible in the case of species growing intermixed, as indicated in Table 3.

The specimens were dried in the field packet, subject to minimal pressure. It was found that excess pressure and quick drying often caused specimens to become very faded and fragile. In this state they did not soak up water well for subsequent examination. *Calypogeia* spp were determined within ten days of collection while the oil bodies were still present.

Determinations were made with the aid of keys and descriptions from Schuster (1953, 1966, 1969), MacVicar (1926) and Arnell (1956). For the earlier study (Crowe, 1970) all determinations were checked by Mr. Harry Williams who identifies hepatics for the Herbarium of the National Museum of Canada, Ottawa. Mr. Claude Garton's collections (all determined by outside referees such as Dr. H. Crum, Dr. R. Schuster and Mr. H. Williams), were used as reference specimens. In the early stages, some assistance in collection and determination were given by Miss Ursula Duncan, an eminent Scottish botanist.

Table 3

Percentage Frequency of Multiple Collections

Number of Species per packet	Percentage of all packets
1	55.47
2	20.90
3	11.28
4	6.63
5	3.07
6	1.99
7	.25
8	.33
9	.00
10	.08

Total number of packets 1244

For the present study, on Dr. Barclay-Estrup's advice, it was decided to send Mr. Williams only new species or doubtful specimens for checking.

Most determinations were made using a Leitz binocular dissecting microscope with magnifications of x10, x40, and x100. This range was adequate for determining the gross morphology of most plants. A Reichert microscope with transmitted light was used to investigate the morphology of very small species such as members of the Cephaloziellaceae, and for examining stem sections and cellular detail such as the presence and form of oil bodies. Only occasionally was it necessary to use an oil immersion lens (giving a maximum magnification of x1000).

The presence of Mr. Claude Garton's collections in the Lakehead University Herbarium has been of immense value in learning to identify these plants. It is possible that additional older specimens from the area may exist in several American or European herbaria. However, duplicates of Garton's collections were found to be the only ones of any significance from the study area in the National Herbarium of Canada (personal communication, Dr. R. Ireland). Contact was also made with the herbaria of the New York Botanic Garden, the University of Minnesota and the British Museum. It was found in every case, that it would be necessary to search for relevant specimens in person. This was not considered worth the time involved, in view of the limited value of many older specimens because of inadequate labelling.

Sampling Procedure

A field sampling programme was devised for the purpose of obtaining objective information on the presence of hepatic species which could be related to the characteristics of the site and types of substrate. Completely random sampling is often recommended (Brown, 1954) but according to Greig-Smith (1964) systematic sampling is advantageous when, as in the present case, interest centres on variability within the area. A systematic sampling technique was therefore adopted. Sites were selected using a grid system comparable with that employed successfully in mapping the vascular flora of the British Isles (Perring and Walters, 1962) and subsequently extended to the bryophytes (Smith, 1971). Prior to the initiation of this investigation the study area had been divided by Dr. P. Barclay-Estrup into 8 mile (12.8km) squares (see Fig.1, p.8). It was originally planned that sampling would be undertaken where the grid lines crossed, these points being called A1, B3 after the grid lines in Fig. 1. However, the squares were found to be too large for Dr. Barclay-Estrup's purposes, and thus sampling was also undertaken at the centre of the squares, these points being named after the grid lines intersecting at the northwest corner of the square plus the letter C, i.e. B3C etc.

This procedure was also adopted for the hepatic sampling in order that results could be related to those of Dr.Barclay-Estrup's other studies. During the first field season (1970) the writer and Dr. Barclay-Estrup worked together in the field but in 1971 and 1972 sites were visited by the writer independently. Lack of access by road made it impossible to sample throughout the study area, but observations were made at the 101 sites indicated in Fig.6. In seven cases, when a site was approached it was found impossible to reach it over difficult terrain and in these cases sampling was carried out at the nearest possible point to the chosen one. Sites were pre-selected on the topographical map. As they were always approached by car it was possible to measure the distance from the nearest landmark, such as a road intersection, with reasonable accuracy. Although this was not very precise the large size of the squares made an inaccuracy of a few metres negligible. All observations were made at least 100m from the nearest road in order to avoid disturbed ground.

There are four main methods used in vegetation sampling: (a) Quadrats (b) Transects (c) Isonome studies (d) Plotless samples, of which the first two are generally employed in primary studies (Shimwell, 1971). Kershaw (1964) emphasizes that "the sampling procedure most suitable for a given problem is usually chosen or designed for that individual problem. The choice of measure, the size of quadrat, the size of sample and the random or regular position of the quadrats can all be decided more by common sense than by resorting to complex statistical theory." As this was a primary survey over a comparatively large area the choice of sampling methods lay essentially between quadrats and transects. Since it was hoped to make a reasonable estimate of the characteristics of the total hepatic population, and since

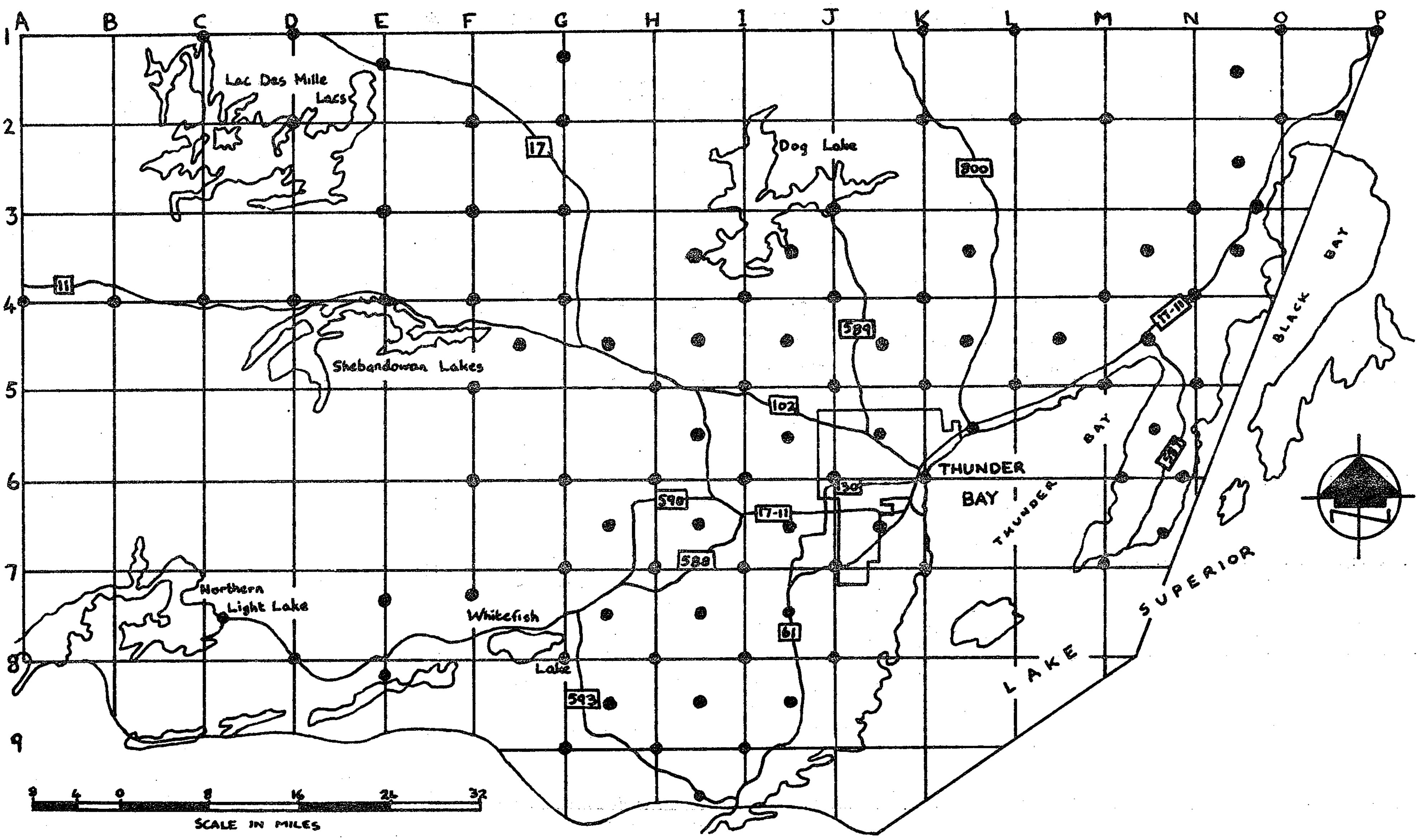


Fig.6 Map of study area showing position of sites

the liverworts are a relatively minor part of the entire flora of an area, the sample size would need to be large. Cain(1932) recommended a quadrat size of .01 to .1m^2 for the cryptogam layer in a general vegetation survey. A quadrat of that size would have to be thrown a large number of times in order to obtain an adequate sample and this would not be practical in a densely forested area in such rugged terrain. Further, this method would not include epiphytic species on trees. On the other hand, a large quadrat would involve either an unwieldy frame or time-consuming measuring and stringing.

For practical reasons therefore, a paced 100m line transect was chosen. It was found possible to penetrate the densest bush encountered in a straight line and 100m covered most changes in terrain on a given site. Thus it was possible to sample the complete range of microhabitats. The line always started at least 100m from a road and was chosen to provide a cross section of any variation in the area. In practice, few species new to the site were recorded on the second 50m of each line. The width of the transect was determined by the distance the operator could reach. Sampling was only for presence, the aim being to collect all species growing along the line. Trees in the direct path of the line were sampled. Obvious repeats were avoided but where one species was growing on a different substratum or in a different community it was collected more than once. Records were made of the habitat of each specimen and details of the location, vegetation and other characteristics of the site were noted. Human influence was assessed from the presence or absence of buildings, signs of trampling and recent construction. The type of ground vegetation and its degree of coverage were assessed according to the criteria listed in Table 5(page 51). The age of the tree stand was estimated from the girth of the trees and the stage in succession. The moistness of the site was determined from its general drainage pattern and the type of soil. Soil pH readings were made in the laboratory by Dr. Barclay-Estrup from samples taken in the field (top 5cm), air dried, sieved with a 2mm mesh and moistened with distilled water for 30 minutes before testing.

Although the method of sampling was crude, it had at least two advantages which helped reduce bias. First, all samples and assessments of site characteristics were made by one person. Second, the density of the forest and the irregularity of the terrain made it impossible to see for 100m so that, even if the beginning of the line was chosen subjectively, the end was unpredictable.

Analysis of Results

Statistics were compiled from the recorded information and these were used to attempt to establish the effect of various environmental factors in determining the composition of the hepatic flora.

Many of the collections contained more than one species (see Table 3) but for the purpose of analysis each specimen of each species was treated as a separate item. Its number and all relevant data was coded in digits and entered on a punched card. This was done to enable the data to be analyzed from a number of different aspects but it resulted in 2292 cards on which much of the information was repeated. Approaching the problem from the point of view of the site would have greatly reduced the number of cards but would have made it difficult to analyze the data with respect to individual species. However, the large number of cards did lead to excessive demands on the capacity of the computer when more complex analysis was attempted. In consequence the computer was used mainly for sorting and preparing lists and percentages. For example, lists of species related to each habitat factor were prepared and these are summarized in the text. The programmes were written in Fortran IV by Mr Walter Crowe specially for this study and are available from the Department of Biology, Lakehead University. All figures quoted in the text are drawn from the computer analysis.

From the available information, it was possible to determine the habitat preferences of individual species (see Section IV) and their relationships in hepatic communities. Tables were prepared showing the mean number of species per transect related to a variety of environmental factors (see Section V). An analysis of variance (David, 1971) was applied to each set of data and, where the results were significant at the .05 level, this was followed by an S-test (Guenther, 1964). An exception was made of the table related to human influence which had only two classes so that a t-test was applied instead of the analysis of variance. Finally, the species were sorted into phytogeographical groups and analyzed to show the importance of each group in the total hepatic flora of the study area.

Distribution Maps

A map was prepared for each species showing its distribution within the study area (Appendix IV). The maps were based on the $10km^2$ international mercator grid on the local topographical maps, Canada 1:250,000 maps, Edition 1, ASE series A501, sheets 52A and 52B, rather than on the 8 mile grid arbitrarily chosen for the sampling. The grid thus corresponds with that used by Perring and Walters (1969) and Smith (1971). A single point was inserted in all the squares in which a given species has been recorded in the present or previous studies.

As two sheets of series 501 had to be combined for the distribution maps a special code was set up. In order that the grid on the distribution maps may be related to that on the topographical maps it should be noted that:

01 horizontal corresponds to 542000m N on sheet 52A

12 vertical corresponds to 290000m E on sheet 52B

The coding of the grid lines (see Appendix I and IV) enabled a four digit number to be assigned to each square. This was included on the punched card for each specimen. The computer was thus able to identify the squares in which each specimen was found. The maps were produced using a simple binomial graph programme devised by Dr.C.Kent of Lakehead University. The vertical grid numbers were taken as one axis and the horizontal numbers as the other. The computer plotted all squares in which the species had been found and it was a simple matter to transfer the points by hand to the blank gridded maps. Earlier records were plotted manually.

Finally, an annotated check list and an artificial key were prepared for all species recorded in the study area. Three additional species considered likely to occur have also been included. These are Odontoschisma denudatum, Odontoschisma macounii and Scapania nemorosa which have been found on the off-shore islands. A fourth species, Riccia fluitans, which has not yet been recorded from the vicinity but may be found in future, has been included in the key for completeness and to enable Riccia cavernosa to be identified clearly.

SECTION IV

HEPATIC HABITATS AND COMMUNITIES IN THE STUDY AREA

Hepatics are essentially plants of the contact area between solid surfaces and the atmosphere, neither rising above nor penetrating into the substratum for more than a few millimetres. Thus subsurface conditions are less limiting for hepatics than for vascular plants, and liverworts may grow on substrata not freely available to the latter, such as tree trunks and rock faces. Here, and in other characteristic habitats, hepatics compete mainly with mosses and algae. At least in the study area, lichens tend to occur under different microclimatic conditions, and seldom compete with hepatics except those of wide ecological amplitude such as Ptilidium pulcherrimum.

Hepatic habitats in the study area occur on five principal types of substratum, i.e. rotting wood, living trees, soil, peat and rock. The substratum was recorded for each species in the field data, from this information the number of sites at which each species occurred on each substratum type was determined. These data are shown in Table 4.

Most hepatics in the study area, particularly those on rotting logs, were associated with algae, fungi, mosses and small animals such as rotifers, collembola and other minute arthropods in unistratose microcommunities which will be referred to as associules (Clements, 1936, as quoted by Schuster, 1957). The composition of associules

Table 4

Species associated with main types of substratum

Substratum code:

A	Dead trees or rotting wood
B	Live trees
C	Soil
D	Bog Peat
E	Rocks

The number of sites at which each species was collected from each substratum type is shown.

Continued:

Table 4

A. Species found mainly on dead trees or rotting wood.

	A	B	C	D	E
Anastrophyllum hellerianum	25				
Blepharostoma trichophyllum	60	1	5	5	5
Calypogeia suecica	9				
Cephalozia media	70	1	11	4	3
Cephaloziella hampeana	5		3	1	2
Cephaloziella rubella	11				
Chiloscyphus pallescens	6		3	2	1
Geocalyx graveolens	57		6	4	2
Jamesoniella autumnalis	65	1	6		4
Jungermannia lanceolata	15				
Harpanthus scutatus	9		1		
Lepidozia reptans	60		6	4	8
Lophocolea heterophylla	78	4	25		4
Lophocolea minor	5	1	2		2
Lophozia ascendens	5		1		
Lophozia incisa	23	1	1		1
Lophozia longidens	17	2	1		5
Lophozia porphyroleuca	4				
Lophozia ventricosa	19	1	3		6
Nowellia curvifolia	25				
Riccardia latifrons	24		6		
Scapania apiculata	1				
Scapania glaucocephala	12				
Tritomaria exsectiformis	8				

B. Species found mainly on live trees.

	A	B	C	D	E
Cololejeunea biddlecomiae		3			
Frullania asagrayana		1			
Frullania bolanderi		8			
Frullania brittoniae		3			
Frullania eboracensis	2	60			2
Frullania inflata		2			
Frullania oakesiana		3			
Frullania selwyniana		2			
Lejeunea cavifolia		2			
Radula complanata	8	40			2

Continued:

Table 4

C. Species found mainly on soil.

	A	B	C	D	E
Blasia pusilla			18		
Chiloscyphus polyanthus			1		
Conocephalum conicum			18	6	1
Lophozia bicrenata			3		
Lophozia capitata			1		
Fossombronia foveolata			1		
Marchantia polymorpha			7		
Pellia endiviifolia			4		
Pellia epiphylla			6		
Pellia neesiana			7		
Plagiochila asplenioides	4	2	15	5	5
Preissia quadrata			3		
Riccardia palmata			1		
Riccardia pinguis	6		14	5	1

D. Species found mainly on bog peat.

	A	B	C	D	E
Cephalozia affinis				1	
Cephalozia pleniceps				2	
Lophozia marchica				1	
Lophozia rutheana				1	
Mylia anomala				1	

E. Species found mainly on rock.

	A	B	C	D	E
Anastrophyllum michauxii					1
Anastrophyllum minutum					1
Anastrophyllum saxicola					1
Cephaloziella starkei					2
Chandonanthus setiformis					1
Diplophyllum taxifolium					1
Lophozia barbata	6	2	10	1	20
Lophozia heterocolpa					1
Porella platyphylla					2
Tritomaria quinquedentata					6

Continued:

Table 4

Species showing no preference for a single substratum

	A	B	C	D	E
Bazzania trilobata	3		4		
Calypogeia integristipula	16		17	6	1
Cephalozia bicuspidata			2		1
Cephalozia connivens	5		4	3	
Cephalozia lacinulata	1	1	2		1
Lejeunea cavifolia		1			1
Lophozia attenuata	1				1
Ptilidium pulcherrimum	57	53	6	4	6
Ptilidium ciliare	1		2	1	2
Riccardia multifida			1	1	
Scapania irrigua	4		2	5	5
Scapania mucronata	4		2		5
Scapania paludicola				1	1

is very variable. In general, observations were made during this study only on those which contained hepatic species. In some cases an individual species may assume dominance within an associule, while other microcommunities are formed by a mixture of species with some, such as Cephaloziella spp,occurring only as isolated stems intertwined among larger plants. Schuster (1957) defined the associules by their constant species and this method has been adopted here.

Much of the study area is forested and logging during the past century has provided a variety of stumps and logs of all ages and all stages of decay. These habitats supported the most complex and varied associules recorded during the survey. In general, the hepatic communities of rotting wood form mats, often adhering tightly to the substratum by means of rhizoids. Prostrate, leafy hepatics generally predominate but some are more erect, especially gemmiferous species such as Anastrophyllum hellerianum, Lophozia ascendens and Tritomaria exsectiformis. A.hellerianum occasionally forms extensive pure stands on decorticated logs. Thallose species are less common (Table 4).

Small mosses may be found intermixed with hepatic communities on logs, but hepatics seem to be excluded when extensive closed moss cover develops. Similarly, pure stands of an alga resembling Fritschiella sp were noted occasionally which lacked associated hepatics. The age of the log appears to be important in determining the composition of the plant cover. For example, <u>Lophozia incisa</u> is found in almost pure stands on extremely disintegrated stumps but is not common on less decayed wood.

The most widespread hepatic communities on rotting wood (see Category A, Table 4) are a <u>Geocalyx-Cephalozia</u> associule on moist logs and a <u>Jamesoniella-Lophocolea</u> associule on drier logs. <u>Geocalyx graveolens</u> and <u>Cephalozia media</u> are the principal components of the former, associated with <u>Blepharostoma trichophyllum</u>, <u>Lepidozia reptans</u>, <u>Lophozia longidens</u>, <u>Lophozia ventricosa</u>, <u>Anastrophyllum hellerianum</u> and, less frequently, with <u>Tritomaria exsectiformis</u>, <u>Dilophozia</u> spp and small thread like species such as <u>Cephaloziella rubella</u>. Constant members of the drier log associule are <u>Jamesoniella autumnalis</u> and <u>Lophocolea heterophylla</u> while associated species include <u>Ptilidium pulcherrimum</u>, <u>Blepharostoma trichophyllum</u>, <u>Lepidozia reptans</u> and, less frequently, <u>Nowellia curvifolia</u>. The thallose species <u>Riccardia latifrons</u> and <u>Riccardia pinguis</u> were also recorded in the rotting log associules, but they appear to grow over rather than among the other species, particularly in the case of <u>R.pinguis</u>.

It may be noted that Schuster (1957) recorded a <u>Jamesoniella-Nowellia</u> associule as frequent on rotting logs in Minnesota. <u>Nowellia curvifolia</u>, which was one of the characteristic species of this associule, was found to be much more irregular in occurrence in the study area and was not dominant in any stands of the hepatic microcommunities examined. Conversely, <u>Geocalyx</u>

graveolens and Cephalozia media appear to be less prominent in Minnesota (Schuster, 1953) than near Thunder Bay. Differences in associule composition between the two areas are probably due to climatic variation, with the more temperate species such as Nowellia curvifolia being near the limit of their range in the study area.

Communities of epiphytic hepatics (see category B, Table 4) were recorded on living tree trunks and this is one type of habitat in which liverworts are sometimes found associated with lichens, as well as mosses. A few hepatic species seem to be specifically adapted to living under the conditions of intermittent water supply provided by this habitat. The hepatics generally form thin mats at the base of the tree, but higher on the trunk they occur as more isolated, rambling shoots tightly adpressed to the bark. Cedar, ash and balsam poplar are richer in epiphytic hepatics than other trees. This may be due both to their smooth bark and their prevalence in moister areas. Cedar swamps, in particular, are well known to be rich in liverworts (Schuster, 1957).

There is zonation with height (Barkman, 1958) in specific composition as well as in the growth form of the hepatic associules. Thus Ptilidium pulcherrimum, which is almost as common on live trees as on dead wood (Table 4, page 41), frequently predominates near the base of a tree, often in association with mosses. At a slightly higher level this species gives way to Radula complanata with which Cololejeunea biddlecomiae is occasionally associated. Higher still, often at about eye level, Frullania eboracensis is the predominant hepatic on many trees, sometimes growing mixed with other species of Frullania and with mosses and lichens.

The local epiphytic associules appear to be less varied than those from Minnesota (Schuster, 1957), Porella platyphylloidea and Lejeunea cavifolia being among the species which were absent or rare in the study area but frequent in Minnesota. Schuster (1957) suggested that chance is one of the most important factors determining the composition of an associule but climatic and micro-climatic factors, particularly humidity, also appear to operate. For example, it was noted that Ptilidium pulcherrimum grows at higher levels on tree trunks found in more humid areas.

Hepatic communities on soil (see category C, Table 4) are best developed in moist areas and on ground containing a high proportion of organic material. The most abundant species on many sites is Calypogeia integristipula often with Cephalozia media. These species commonly form an associule in mesic areas where the vascular flora is sparse, although it must be noted that Cephalozia media is much more frequent on rotting wood (see category A, Table 4). Plagiochila asplenioides and Bazzania trilobata often form pure colonies or occur associated with mosses rather than other hepatics. The soil-borne leafy hepatics typically form compact mats, with abundant rhizoids penetrating the surface of the substratum.

Thallose liverworts are most frequent on predominantly inorganic soils in areas subject to water seepage. In these habitats Marchantia polymorpha, Blasia pusilla and Pellia spp locally form extensive colonies sometimes up to 50cm or more in width and it is possible that each colony represents a single clone. Few leafy hepatics are associated with these colonies, even on the moister inorganic soils, and inorganic soils in dry situations are normally devoid of hepatics.

Peat substrata support a variety of hepatics which are frequently associated with Sphagnum and other mosses. Blepharostoma trichophyllum, Calypogeia integristipula, Cephalozia media, Conocephalum conicum, Geocalyx graveolens Lepidozia reptans and Riccardia pinguis have been found most often (see Category D. Table 4). No well defined hepatic communities were recorded, however, as the liverworts normally occurred as isolated shoots or small patches among the mosses.

Finally, a characteristic assemblage of hepatics was found associated with rock surfaces (see category E). They typically grow in colonies of a single species rather than in mixed communities, the individual mats reaching up to 15cm in diameter in the case of vigorous species such Lophozia barbata and Porella platyphylla. Such mats can usually be lifted easily from the surface, indicating little penetration of the substratum by rhizoids. Hepatics are most frequent on rocks in sheltered situations. None was recorded on dry exposed rock such as the block scree at the foot of basalt walls, although scree was frequently colonized by lichens. However, *Scapania irrigua* and several other hepatics were collected from exposed rock slabs with a continuous water supply. This occurred, for example, at Tee Harbour where the exposed rocks are moistened by spray from Lake Superior.

From the habitat profiles given in Table 4 it can be seen that most hepatic species in the study area show a distinct preference for one of the five substratum types considered. *Calypogeia integristipula* and *Ptilidium pulcherrimum* were the only common species recorded approximately the same number of times on more than one type of substratum. Of these, the latter is the commonest species throughout the study area. It is unusual in being the only species found frequently on both dead and living trees as well as occurring on rock and soil. Moreover, it shows a wide range of tolerance for the site factors considered in Table 5 (page 51) and thus there are few places in the study area not open to colonization by this species.

Most of the species found exclusively on one substratum type were rare but two quite frequent species, *Nowellia curvifolia* and *Anastrophyllum hellerianum* were completely specific to rotting wood as were the somewhat less common species, Calypogeia suecica, Jungermannia lanceolata, Scapania glaucocephala and Tritomaria exsectiformis (see category A, Table 4). The majority of rotting wood species were found occasionally on other substrata.

Species commonly associated with living trees were generally found only on that substratum. The two commonest, Frullania eboracensis and Radula complanata were, however, also found on dead trees. In the case of the former it had probably colonized a living tree and persisted after its death. These two species were also found twice on rock. They are cited elsewhere as rock species, for example in Schuster (1953), but they do not seem to exploit this substratum very often in the study area.

The species in category C (Table 4) tend to be confined to soil with the exception of Conocephalum conicum, Plagiochila asplenioides and Riccardia pinguis. All the thallose species except two species of Riccardia are found under this heading. They are clearly adapted in general to living on soil and very few are found on lignified substrata or even on rock surfaces. On the other hand, the leafy Jungermanniales are most often associated with living or dead trees. Schuster (1966) believes that the leafy hepaticae evolved with the tropical forest and this association with trees appears to have continued into the present. It is apparent from the fossil record that the thallose and leafy hepaticae diverged at a very early stage in their evolution (Lacey, 1969). From the observations made here it seems that they are widely separated in their physiological adaptations.

A few species were found exclusively on bog peat but the number of sites which provided this type of habitat was very small so little can be deduced from these collections. The physically rigorous rock substrata also yielded a number of rarities. These were found on unusual sites such as the tops of rocky elevations or the bottom of Ouimet Canyon. Only one species, Lophozia barbata, was regularly found on isolated rocks and boulders in forested sites. A few of the rotting wood species, such as Lophozia longidens and Lophozia ventricosa, were also found on this type of rock surface.

SECTION V

STATISTICAL ANALYSIS OF HEPATIC DISTRIBUTION IN RELATION TO HABITAT FACTORS

A total of 94 hepatic species has so far been recorded from the study area, as indicated in the check list (Appendix II). Of these 75 were collected from the routine sample sites. The data from these latter collections were analysed by computer in an attempt to determine the effect of site factors on the diversity of the hepatic flora and also to provide objective information on the habitat preferences of individual species. The check list (Appendix II) indicates the percentage of the 101 routine sample sites at which each species was recorded, thus giving an indication of its frequency within the area. Frequency varied widely from 93% for *Ptilidium pulcherrimum* to 1% for species such as *Chiloscyphus polyanthus*, while 19 species previously recorded from the area were not collected during the present study.

The Relationship between site factors and number of species recorded

Information on the location, geology and other general features of each site is shown in coded form in Appendix I, together with more detailed information on the vegetation and other factors. The coding system for the site characters is shown in Table 5, while Tables 6 to 14 show the relationship between the site variables and the numbers of species recorded. These tables were prepared to illustrate the effect of the major site characteristics on the richness of the hepatic flora.

Table 5

Key to the site character code employed in Tables 6 to 15 and in Appendix I

DI Distance from Lake Superior (km)	A	0 - 1
	B	2 - 10
	C	11 - 25
	D	26 - 50
	E	51 - 100
	F	Over 100
HI Altitude (m)	A	150 - 200
	B	201 - 250
	C	251 - 300
	D	301 - 350
	E	351 - 400
	F	401 - 450
	G	Over 450
GL Geology	A	Mafic metavolcanics
	B	Intermediate to felsic volcanics
Rock classification: Ontario geological map West Central Sheet 2199 Dept. of Mines and Northern Affairs	C	Early mafic and ultramafic igneous
	D	Early felsic igneous
	E	Animickie greywacke shale and basalt
	F	Keeweenawan sedimentary and volcanic
	G	Late mafic igneous
pH Soil pH	A	4.0 - 4.5
	B	4.6 - 5.1
	C	5.2 - 5.7
	D	5.8 - 6.3
	E	6.4 - 6.9
MT Ground Moisture	A	Hydric, pools of standing water, forested
	B	Hydric/mesic, very moist but no standing water, forested
	C	Mesic, moist, no standing water, forested
	D	Mesic/xeric, very well drained, forested
	E	Xeric, rocky, exposed
	F	Hydric, pools of standing water, exposed

Continued:

Table 5

HI Human Influence	A	Within 250m of farm, cottages, permanent camp site or other area of sustained human activity
	B	Not recently subject to sustained human activity, relatively undisturbed
ST Age of Forest Stand Determined by the history of the site, stage in succession and diameter of the trees	A	Under *ca* 20 years, or none
	B	*Ca* 20 to 100 years
	C	Over *ca* 100 years
GF Ground Vegetation	A	90 to 100% cover of vascular plants
	B	50 to 90% cover of vascular plants, remainder mosses or bare ground
	C	90 to 100% cover of feather moss or *Sphagnum*
	D	Less than 50% cover of vascular plants or mosses

Table 6

Relationship between mean number of species per site and distance of site from Lake Superior

	Distance from lake *					
	A	B	C	D	E	F
Number of sites	10	22	19	28	16	6
Mean number of species per site	8.7	10.0	8.7	8.0	9.0	8.5
Standard deviation	3.5	3.17	5.5	5.14	4.0	4.93
Total number of species	37	59	45	48	38	20

Analysis of Variance	Sum of squares	d.f.	Mean square	F
Within site classes	1929	95	20.3	0.54
Between site means	55	5	11.0	

The difference between means is not significant at .05 level.

* See code in Table 5.

Table 7

Relationship between mean number of species per site and altitude

	Height above sea level *						
	A	B	C	D	E	F	G
Number of sites	10	11	13	7	14	35	11
Mean number of species per site	9.0	9.8	9.5	9.2	6.0	9.1	8.8
Standard deviation	3.17	2.28	4.86	5.03	4.10	4.42	6.0
Total number of species	39	40	44	27	35	62	32

Analysis of variance

	S.S.	d.f.	Mean square	F
Within site classes	1854	94	19.7	1.23
Between site means	145	6	24.2	

The difference between means is not significant at the .05 level.

* See code in Table 5

Table 8

Mean number of species per site in relation to altitude and and distance from Lake Superior

Distance from Lake Superior (km)

Altitude (m)	A 0-1	B 2-10	C 11-25	D 26-50	E 51-100	F 101-150
G 451+			15.0 (1)	9.8 (5)	7.4 (5)	
F 401-450		12.0 (2)	13.0 (4)	7.3 (14)	10.0 (11)	8.5 (6)
E 351-400		6.0 (2)	5.0 (5)	5.6 (6)		
D 301-350		12.0 (2)	8.4 (2)	14.5 (2)		
C 251-300		10.2 (7)	8.4 (5)	10.0 (1)		
B 201-250	9.3 (3)	9.8 (7)		11.0 (1)		
A 150-200	8.4 (7)	10.0 (2)	11.0 (1)			

Number of sites in parentheses.

Table 9

Relationship between mean number of species per site and bedrock

	Type of rock *						
	A	B	C	D	E	F	G
Number of sites	14	1	9	34	20	11	12
Mean number of species per site	11	16	6.5	8.1	9.3	9.2	7.7
Standard deviation	4.6	-	3.7	4.5	3.8	4.36	4.9
Total number of species	43	16	30	52	48	41	46

Analysis of variance

	S.S.	d.f.	Mean square	F
Within site classes	1775	94	18.4	1.9
Between site means	209	6	35.0	

There is no significant difference between means at the .05 level.

* See code in Table 5

Table 10

Relationship between mean number of species per site and soil pH

	Soil pH **				
	A	B	C	D	E
Number of sites*	5	7	28	9	6
Mean number of species per site	8.4	7.1	9.7	8.5	10.5
Standard deviation	5.48	2.02	3.73	6.45	5.33
Total number of species	35	33	51	28	33

* Data are incomplete as pH was not recorded at all sites.

Analysis of variance

	S.S.	d.f.	Mean square	F
Within site classes,	791	50	15.8	0.65
Between site means	41	4	10.3	

There is no significant difference between the means at .05 level.

** See code in Table 5.

Table 11

Relationship between the mean number of species per site and moisture

	Type of site*					
	A	B	C	D	E	F
Number of sites	3	21	34	35	3	5
Mean number of species per site	15.6	11.3	9.93	7.15	6.33	7
Standard deviation	4.67	5.6	3.15	4.35	5.69	5.13
Total number of species	30	46	54	55	23	25

* See code in Table 5

Analysis of variance

	S.S	d.f.	Mean square	F
Within site classes	1685	97	17.3	5.9
Between site means	300	3	100	

There is a significant difference between the means at the .01 level.

S-Test

	$\bar{x}_j$	$\bar{x}_j-\bar{x}_E$	$\bar{x}_j-\bar{x}_F$	$\bar{x}_j-\bar{x}_D$	$\bar{x}_j-\bar{x}_C$	$\bar{x}_j-\bar{x}_B$
$\bar{x}_A$	15.6	9.27	8.6	8.45	5.67	4.3
$\bar{x}_B$	11.3	4.97	4.3	4.15	1.37	
$\bar{x}_C$	9.93	3.6	2.93	2.78		
$\bar{x}_D$	7.15	.82	.15			
$\bar{x}_F$	7.0	.67				
$\bar{x}_E$	6.33					

$$S^2 = (r-1)\ F_{95;r-1,N-r}$$
(Guenther, 1964)

$$S = 3.391$$

All differences above the dotted line are significant at the .05 level.

Table 12

Relationship between mean number of species per site and human influence

	Type of site*	
	A	B
Number of sites	33	68
Mean number of species per site	6.3	9.9
Standard deviation	4.47	4.0
Total number of species	48	72

T-test

$$O_{\bar{x}_1-\bar{x}_2} = .924$$

$$t = 3.9$$

The difference between the means is significant at the .05 level.

*See code in Table 5.

Table 13

Relationship between number of species per site and age of forest stand

	Type of stand *		
	A	B	C
Number of sites	12	84	5
Mean number of species per site	7.4	8.7	14.4
Standard deviation	5.81	4.02	3.4
Total number of species	40	57	36

Analysis of variance

	S.S.	d.f.	Mean square	F
Within site classes	1739	98	17.6	5.2
Between site means	181	2	90.5	

The difference between means is significant at the .01 level.

S-Test

	$\bar{x}_j$	$x_j - x_A$	$x_j - x_B$
$\bar{x}_C$	14.4	7.0	5.7
$\bar{x}_B$	8.7	1.3	
$\bar{x}_A$	7.4		

$S = 2.486$

The mean for class C is significantly higher than those for A and B at the .05 level.

*See code in Table 5

Table 14

Relationship between mean number of species per site and type of ground vegetation

	Type of ground vegetation* A	B	C	D
Number of sites	23	36	29	13
Mean number of species per site	6.45	10.4	7.3	10.3
Standard deviation	4.5	3.85	3.75	5.36
Total number of species	17	58	24	56

* See code in Table 5.

<u>Analysis of variance</u>

	S.S	d.f.	Mean square	F
Within site classes	1636	95	17.1	6.1
Between site means	316	3	105.3	

The difference between the means is significant at the .01 level.

<u>S-Test</u>

	$\bar{x}_j$	$\bar{x}_j-\bar{x}_A$	$\bar{x}_j-\bar{x}_C$	$\bar{x}_j-\bar{x}_D$
$\bar{x}_B$	10.4	3.95	3.1	.1
$\bar{x}_D$	10.3	3.85	3.0	
$\bar{x}_C$	7.3	.85		
$\bar{x}_A$	6.45			

S = 2.857

The means for class B and D are significantly higher than those for class C and A at the .05 level

Factor 1: Distance from Lake Superior

Lake Superior has an area of 82,362 km^2 with a maximum depth of 407m. The mean annual temperature of the water is 5^oC, with very little variation throughout the year. In summer the water is therefore, generally much cooler than the adjacent land and air, while in winter it is warmer than its surroundings and never completely freezes over. The lake thus has a marked effect on the local climate and consequently on vegetation in its immediate vicinity, an effect which might be expected to fall off in geometric progression as distance from the lake increases.

In Table 6 an arbitrary scale of distance has been used which is based on this assumption. There was little difference between the mean number of species per site recorded at different distances from the lake except for a slightly higher value for zone B (2-10 km). An analysis of variance (David, 1971) shows that this difference is not significant at the .05 level. However, zone B has also supported the highest total number of different species. It thus seems possible that this zone is slightly more favourable to hepatics.

Factor 2: Altitude

The study region shows considerably greater differences in altitude than many parts of the Canadian Shield. A number of studies have shown that elevation is an important factor in controlling bryophyte populations (e.g. Siefriz, 1924; Slack, 1972). Table 7 shows the relationship between the number of species collected and the altitude of the site. The sites have been grouped in altitudinal zones at 50m intervals. With the exception of the low mean number of species found at sites 351-400m in altitude, the results give little indication that the richness of the hepatic flora in the study area is influenced by the height of the site. An analysis of variance shows that there is no significant difference between the means at the .05 level.

The data in Table 8 attempt to relate the number of species recorded at each site to both altitude and distance from the lake, as the two factors are correlated to some extent. Thus, most sites between 150 and 200m above sea level fall into distance zone A. Similarly, most sites in the next altitude class fall into distance zone B, although there are some exceptionally high sites in distance zone B because of the presence of mesas not far from the lake. Some of the higher sites near the lake seem to have been unusually rich in hepatics, for example sites above 401m altitude in zone B and above 451m in zone C. It seems probable that a combination of factors is operating which tends to make the higher zones near the lake more favourable to hepatics. Unfortunately, the number of sites visited in each cell of Table 8 is too variable to permit formal statistical analysis, so firm conclusions cannot be drawn.

Factor 3: Underlying Bedrock

Pleistocene deposits in the study area are generally thin (Zoltai, 1961) and bedrock is frequently exposed. Moreover, the till is usually related to the underlying rock (Zoltai, 1965). The nature of the bedrock may thus influence the availability of mineral nutrients, and this could be an important limiting factor to hepatics as it is to vascular plants. Richards (1959), however, cautioned that " the mineral economy of bryophytes is a subject on which so little is known that a connected discussion is hardly possible." While some progress has been made since that time very few species of hepatics have been investigated at all and, for practical reasons such as the feasibility of laboratory culture, those chosen may be atypical (e.g. Machlis, 1962; Hedger et al, 1972).

The data in Table 9 indicate differences between the mean numbers of species recorded at sites on different rock types but an analysis of variance shows that these differences are not significant at the .05 level. Type B was omitted from the calculations as only one site in this category was visited.

Factor 4: <u>Soil pH</u>

Table 10 shows the number of different species collected from sites of different pH ranges. The readings were made available by Dr.P.Barclay-Estrup from the 55 sites visited mutually (see page 33). The figures show approximately half the sites with readings between 5.2 and 5.7. This is fairly high for a forested area and probably indicates a high proportion of calcium ions in the soil (Tanton, 1931). There is little variation between the means and an analysis of variance shows these differences are not significant at the .05 level.

Factor 5: Moisture

Each site was classified subjectively according to its general degree of ground moisture. Allowance was made for the effect of spring run-off and prolonged dry spells. The field work was spread over several years but most of the collecting was done either in May or June or September when the moisture regime is quite comparable. It was thus possible to judge the general nature of the site from the amount of standing water, the type of soil and pattern of drainage of the area.

The mean number of species per site related to this classification is shown in Table 11. It can be seen that there is a decline in the mean number of species with increasing dryness. An analysis of variance shows a highly significant difference between the means. S-tests show that the mean for A (hydric and forested) is significantly higher than all other means, while the mean for B (very moist but with no standing water) is significantly higher than all except A and C. The mean for the rocky sites which have little ground moisture and dry out quickly in absence of precipitation is clearly the lowest. However, the three rocky sites yielded almost as many species as the five wet sites without forest, which also have a low mean. Epipetric communities are often subject to severe desiccation but there are some pioneer species, able to survive this stress, which do not occur elsewhere (Table 15, page 69). This is also true of Sphagnum bogs which, while not lacking in moisture, have other physiological drawbacks. Hepatics are usually considered to be favoured by moisture and this is borne out here.

Factor 6: Human Influence

Table 12 shows that a higher mean number of species was recorded at relatively undisturbed sites (class B) than at those in areas of recent, sustained activity. A t-test shows that this difference is significant at the .05 level. Moreover, the total number of species recorded in class B was 50% higher than in class A. Table 12 indicates that twice as many sites were scored in class B as in class A and this may have contributed to the higher number of species. However, examination of Tables 6,7,9-11,13 and 14 shows that the proportional increase in the number of species with increase in the number of sites is greater in the present case than normal, suggesting that human influence may appreciably reduce the richness of the hepatic flora.

Factor 7: Age of Forest Stand

By far the majority of sites visited in the study area bore a mature stand of trees. Most of the area is readily accessible to the Lakehead cities and much of it was logged or burned in the early part of the century. There has been much less of such activity during the past 40 years, however, and most forest stands have now regenerated. Table 13 shows that the mean number of species per site increased with increasing age of the stand. An analysis of variance indicates that the difference between the means is highly significant, while S-tests confirm the mean number of species recorded in stands over 100 years old is significantly higher than those for younger stands.

Factor 8: Ground Vegetation

The type of ground vegetation on each site visited was noted and classified subjectively as shown in Table 5. The mean number of species found on sites of each type is shown in Table 14. It can be seen that sites with a well developed ground cover of either vascular plants (A) or mosses (C) yielded fewer species of hepatics than those with more open ground cover (B and D), possibly due to increased competition from the larger and more vigorous plants. Vascular plants, particularly, often completely shade logs and also produce a dry surface soil. An analysis of variance shows that the difference between the means is highly significant and S-tests indicate that the means from sites of classes A and C are significantly lower than those from B and D.

Conclusions

It is difficult to draw firm conclusions from the present data due to the limited number of sites that it was possible to visit, and the wide variation in the number of sites examined in each habitat class. For example, the mean number of species per site may be distorted by one exceptionally rich or exceptionally poor site when the sample number is low. In addition, some important factors such as temperature and humidity were not considered, while no attempt was made to investigate the undoubtedly important effects of interactions between several factors in controlling hepatic distributions.

Nevertheless, the results do indicate that high moisture availability combined with shading, sparseness of ground vegetation, relative freedom from human influence and increasing maturity of the forest stand are all factors generally associated with a relatively rich local hepatic flora. In contrast, soil pH and the nature of the underlying bedrock appear to have little effect on the number of hepatics recorded at a site. The effects of altitude and distance from Lake Superior are difficult to distinguish as these factors are correlated to a large extent. The results suggest that sites situated above 400m altitude between 2 and 25 km from the Lake may be particularly rich in hepatics, but further data are required to confirm this.

Habitat Ranges of Individual Species

In addition to investigating the effects of site factors on the richness of the hepatic flora an attempt has also been made to analyse the field data in order to show the tolerances of individual species to the factors considered. Table 15 lists the species collected during the field work in the same systematic order as that employed in the check list (Appendix II), and shows the complete range of site classes in which each species was recorded at least once, according to the classification in Table 15.

Table 15 also indicates the total number of sites in which each species was recorded, and Fig.7 gives a frequency distribution showing the numbers of species recorded at different numbers of sites. It can be seen that these data

Table 15

A profile of habitat tolerances for each species according to the code given in Table 5

	Distance from lake	Altitude	Geology	pH	Moisture	Human Influence	Stand Age	Ground Veg'n	% of Sites
Blepharostoma trichophyllum	ABCDEF	ABCDEFG	ABCDEFG	ABCDE	ABCD F	AB	ABC	ABCD	70
Ptilidium ciliare	ABCD	A C EF	DE	BCD	B DE	AB	BC	B D	7
Ptilidium pulcherrimum	ABCDEF	ABCDEFG	ABCDEFG	ABCDE	ABCDEF	AB	ABC	ABCD	93
Lepidozia reptans	ABCDEF	ABCDEFG	ABCDEFG	ABCDE	ABCDEF	AB	ABC	ABCD	61
Bazzania trilobata	ABCDE	B DEF	A CDEF	BC E	ABCD	AB	BC	B D	6
Calypogeia integristipula	ABCDEF	ABCDEFG	ABCDEFG	ABCDE	ABCDEF	AB	ABC	BCD	33
Calypogeia suecica	ABCD	AB F	A CDEFG	C E	ABCD F	AB	BC	B	9
Chandonanthus setiformis	B	F	G		E	B	A	D	1
Lophozia ascendens	CD	D G	A DE	BC E	BCD	AB	B	B D	6
Lophozia attenuata	B	C	G		D	B	B	B	1
Lophozia barbata	A CDE	ABC EFG	AB EFG	ABCDE	ABCDE	AB	ABC	B D	26
Lophozia bicrenata	CD F	EF	CD	B	C F	AB	A	D	3
Lophozia capitata	C	F	D	A	D	B	B	B	1
Lophozia excisa	BC	C E	EFG	C	CD	B	B	D	2
Lophozia heterocolpa	B	F	E	C	E	B	A	D	1
Lophozia incisa	ABCDEF	ABCDEFG	A CDEFG	ABC E	ABCDEF	AB	ABC	B D	18
Lophozia longidens	BCDE	ABC EFG	ABCDEFG	BC	ABCDEF	AB	ABC	BCD	16
Lophozia marchica	A	A	F		F	B	A	C	1
Lophozia porphyroleuca	BCDE	B E G	D G	C	BCD	B	BC	B D	4
Lophozia rutheana	A	A	F		F	B	A	C	1
Lophozia ventricosa	ABCDEF	ABC FG	A CDEFG	A CDE	ABCDEF	AB	ABC	ABCD	23
Tritomaria exsectiformis	ABCDE	ABC EF	A CDEFG	ABC E	ABCDEF	AB	BC	B D	13
Tritomaria quinquedentata	B E	BC F	DEFG	ABC	CDE	B	A	D	6
Anastrophyllum hellerianum	ABCDEF	ABCDEFG	A CDEFG	A CD	BCD	AB	BC	B D	20
Anastrophyllum michauxii	B	F	G	A	E	B	A	D	1
Anastrophyllum minutum	B	F	G	A	E	B	A	D	1
Anastrophyllum saxicola	B	F	G	A	E	B	A	D	1
Jamesoniella autumnalis	ABCDEF	ABCDEFG	ABCDEFG	ABCDE	ABCDEF	AB	ABC	ABCD	73
Jungermannia lanceolata	ABC	BCD FG	A CDE G	CDE	ABCD	AB	BC	B D	15
Mylia anomala	B	B	F	C	C	B	B	C	1
Diplophyllum taxifolium	B	F	E	C	E	B	A	D	1

Continued

Table 15

	Distance from lake	Altitude	Geology	pH	Moisture	Human Influence	Stand Age	Ground Veg'n	% of Sites
Scapania glaucocephala	BCDE	AB D FG	A DEFG	BC E	ABCD	AB	BC	B D	12
Scapania irrigua	AB DE	A C F	DE G	AB D	BCD	AB	AB	BCD	13
Scapania mucronata	AB DE	BC EFG	A DE G	C E	BCD	AB	BC	B D	10
Scapania paludicola	B F	C	E		D F	AB	AB	AB	2
Lophocolea heterophylla	ABCDEF	ABCDEFG	ABCDEFG	ABCDE	ABCDEF	AB	ABC	ABCD	80
Lophocolea minor	ABCDE	ABCDEFG	A DE	BC	BCD	AB	BC	B D	8
Chiloscyphus pallescens	BCDE	AB DEF	A CDEFG	ABCDE	ABCD	AB	BC	BCD	10
Chiloscyphus polyanthus	B	E	E	C	D	B	B	B	1
Harpanthus scutatus	AB D	ABC F	A DEFG	CD	BCD	AB	B	B D	10
Geocalyx graveolens	ABCDEF	ABCDEFG	ABCDEFG	ABCDE	ABCDEF	AB	ABC	ABCD	60
Plagiochila asplenioides	ABCDE	ABCDEFG	ABCDEFG	ABCDE	ABCD	AB	BC	BCD	25
Cephalozia affinis	B	B	F		B	B	B	B	1
Cephalozia bicuspidata	A D	A F	E		D	B	B	B	3
Cephalozia connivens	ABCDE	ABCD FG	AB DEFG	A CD	ABCD F	AB	BC	BCD	14
Cephalozia media	ABCDEF	ABCDEFG	ABCDEFG	ABCDE	ABCDEF	AB	ABC	ABCD	74
Cephalozia lacinulata	BCD	AB EF	A D FG	E	ABCD	AB	B	B D	4
Cephalozia pleniceps	AB	A C	A F	C	D F	B	AB	BC	2
Nowellia curvifolia	ABCDEF	ABC EFG	A CDEF	ABCDE	BCD	AB	BC	ABCD	21
Cephaloziella hampeana	BC D	ABCDEF	A DEFG	ABCDE	BCD	AB	BC	B D	10
Cephaloziella rubella	ABCDE	ABCDEFG	CDEFG	BC E	BCD F	AB	BC	B D	13
Cephaloziella starkei	B	B F	E	BC	E	B	A	D	2
Radula complanata	ABCDE	ABCDEFG	ABCDEFG	ABCDE	ABCDEF	AB	ABC	ABCD	40
Porella platyphylla	A D	C F	A G	C	D	B	A	D	2
Frullania asagrayana	C	F	A	E	A	B	C	B	1
Frullania bolanderi	ABCD	BCDEF	A DEFG	BCDE	BCD	AB	BC	AB D	8
Frullania brittoniae	BC	C FG	E	CD	CD	B	B	AB	3
Frullania eboracensis	BCDEF	ABCDEFG	ABCDEFG	ABCDE	ABCDEF	AB	ABC	ABCD	56
Frullania inflata	CD	C G	DE	E	BC	A	B	B	2
Frullania oakesiana	DE	FG	D G	A C	BC	B	BC	AB	2
Frullania selwyniana	E	F	BC		A C	AB	B	B	2
Lejeunea cavifolia	B E	C F	A G		B D	B	C	B D	2
Cololejeunea biddlecomiae	B D	F	A G	A	A C	B	BC	B	3

Continued:

Table 15

	Distance from lake	Altitude	Geology	pH	Moisture	Human Influence	Stand Age	Ground Veg'n	% of Sites
Fossombronia foveolata	F	F	D		F	A	A	D	1
Blasia pusilla	BCDEF	A EFG	CDE	A C	BCD	AB	AB	ABCD	18
Pellia endiviifolia	B D	C F	D G		CD	AB	A	D	4
Pellia epiphylla	BCD	C F	A CD G	A C	A CD	B	A	D	6
Pellia neesiana	DEF	FG	A CD	AB	BCD	AB	A	D	7
Riccardia latifrons	ABCDEF	ABCDEFG	ABCDEFG	ABCDE	ABCD F	AB	ABC	ABCD	24
Riccardia multifida	C	A	EF	CD	BC	B	B	B	2
Riccardia palmata	E	F	A		B	B	B	B	1
Riccardia pinguis	ABCDEF	ABCDEF	A C EFG	ABCDE	ABCD F	AB	AB	ABCD	24
Conocephalum conicum	ABCDE	ABCDEFG	A CDEFG	ABCDE	BCD	AB	AB	BCD	25
Preissia quadrata	A C E	A C F	D F		BCD	AB	AB	B D	3
Marchantia polymorpha	BCD	BCDEF	A DEF	C	BCD	AB	AB	B D	7

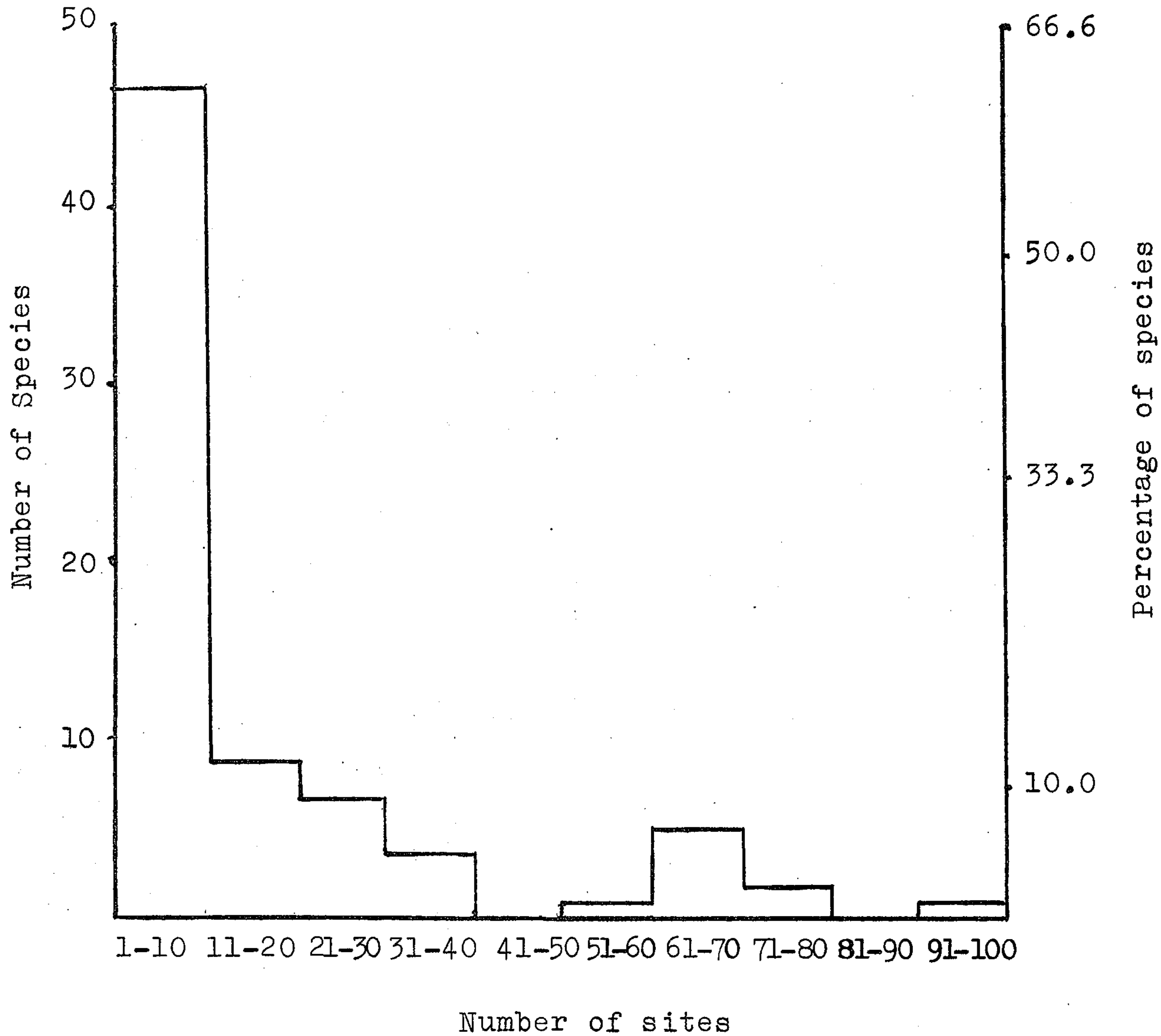


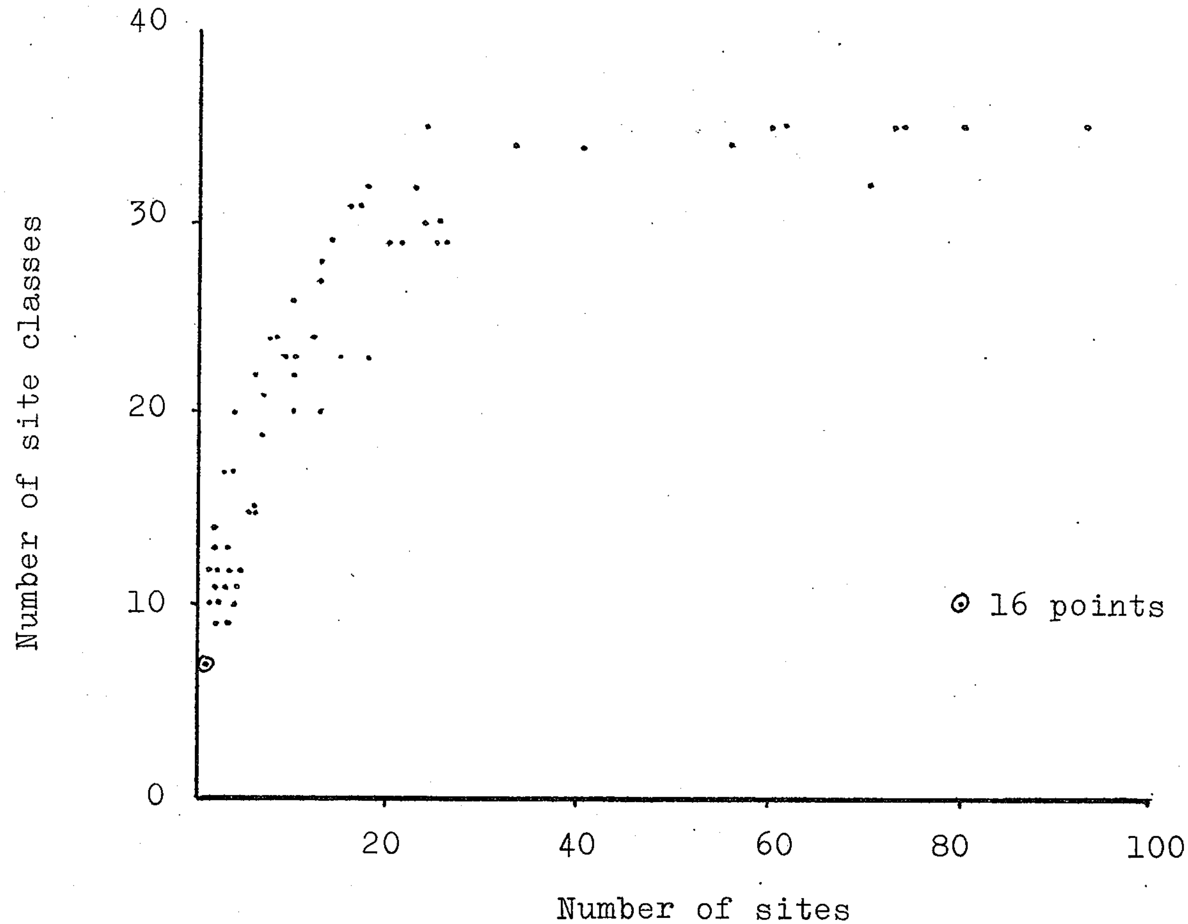
Fig.7 Histogram showing the numbers of species recorded at different numbers of sites.

fit a hollow curve distribution of the type to which Willis (1922) drew attention and which indicates the presence of a small number of widely distributed species and a large number of rarer ones. Thus approximately 63% of the 75 species collected were recorded at less than 11 of the 101 sites, while only one species, Ptilidium pulcherrimum was recorded at over 90 sites, and Blepharostoma trichophyllum, Cephalozia media, Geocalyx graveolens, Jamesoniella autumnalis, Lepidozia reptans, and Lophocolea heterophylla were the only other hepatic species recorded at 60 or more sites.

Fig. 8 shows the relationship between the number of sites and the range of habitats in which each species was recorded. Total number of site classes relates to seven of the eight factors considered in Table 15, the incomplete data for pH being excluded. The possible range of values for the total number of site classes thus runs from 7 to 35, higher values indicating presence at a greater variety of sites.

Fig. 8 shows that, as expected, all the more widely distributed species showed a broad tolerance range for the site factors considered. Thus 11 of the 12 species recorded at more than 30% of the sites were recorded in 31 or more of the 35 site classes. This group included such species as Jamesoniella autumnalis and Lophocolea heterophylla which were also tolerant of a variety of substratum types (Table 4) and others such as Frullania eboracensis which were largely restricted to a single type of substratum. Conversely, all the species recorded in 10 or fewer site classes were found on between 1 and 3 sites, and the data thus provide

Fig.8 Scatter diagram showing, for each species, the number of site classes plotted against the number of sites at which it was recorded



little evidence that the low frequency of these species in the study area is due to narrow habitat preference.

It has already been noted (page 62) that distance class B (2-10km from Lake Superior) supported the greatest variety of hepatic species, and Table 15 indicates that 11 species were collected only in this zone, all of them being restricted to one or two sites. Their presence may be related to the wide variety of microhabitat found in this area. In some cases the rarer species occur in microhabitats which appear to be generally unfavourable, thus reducing competition from other species. For example, talus blocks in Ouimet Canyon provide the only known habitat in the study area for Chandonanthus setiformis. Poor dispersal ability is another factor which may be responsible for the low frequency of some species. It was noted that all the widespread species regularly produce spores or gemmae (Appendix II) while most of the more restricted ones, such as Bazzania trilobata and Ptilidium ciliare were not observed to produce propagules of any kind in the study area.

Hepatic distribution in the study area thus conforms to the typical pattern in showing a greater frequency of narrowly as compared with widely distributed species. Poor dispersal ability, restricted habitat tolerance and inability to compete with more vigorous species are suggested as factors which could account for the rarity of individual species but it is not clear which of these factors is the most important.

SECTION VI
PHYTOGEOGRAPHY

There is general agreement that the world may be divided into floristic regions, each with its characteristic assemblage of plant species (Good, 1974). Certain species of plants are endemic to a particular region, although a few are almost cosmopolitan and most lie somewhere between these two extremes. When considering the flora of a given area it is common practice to classify the species present into a series of floristic elements, each element comprising species which share a common general distribution.

Such an analysis can be of considerable value in suggesting migration pathways into an area and in shedding light on the area's floristic history. Hepatics are particularly valuable in this regard since many are essentially plants of microenvironments (Schuster, 1958). Thus they may frequently survive in isolated pockets in areas where the general climate or other conditions have become inimical and so may provide indications of former conditions.

An attempt has been made in this section to classify the hepatic species recorded from the study area into floristic elements, in order to define the geographical affinities of the local hepatic flora. Only distribution in the Northern hemisphere has been considered although a few species are bipolar, as indicated in the annotated check list. The classification into phytogeographic elements is similar to that used previously (Crowe, 1970). This was a synthesis derived from Bird & Hong (1969), Brodo (1968), Porsild (1958), Scoggan (1957) and Wetmore (1967). The terms used in the classification are defined in Table 16. Changes have been made as further information on the distribution of species has come to light, while additional species have been recorded and Calypogeia muelleriana and Calypogeia neesiana have been omitted from the analysis for reasons stated in the check list (Appendix II). The following works were consulted when assigning the species to the appropriate elements: Schuster (1953; 1966; 1969), Arnell (1956), Bonner (1962-1966).

The floristic elements, together with the species from the study area assigned to each one are listed in Table 17. It will be seen that six major latitudinal groupings are recognized, each of these being subdivided into up to three elements on a longitudinal basis. Tables 18 and 19 indicate the percentage of species from each of these elements. They also show the percentage of sites from which at least one species from each group was collected.

Table 18 shows clearly that, in terms of species representation, the hepatic flora of the study area is predominantly boreal but with a substantial number of temperate, arctic and subcosmopolitan species. The arctic species have only been collected a few times, either from

Table 16

Definition of phytogeographic terms used

Arctic	most widespread in arctic tundra zones
Arctic-boreal	widespread in both arctic tundra and boreal forest zones
Boreal	most widespread in the boreal forest zone
Boreal-temperate	widespread in both the boreal and eastern deciduous forest zones
Temperate	most widespread in the eastern deciduous forest zone
Subcosmopolitan	widely distributed in a number of zones
Circumpolar	widely distributed at appropriate latitudes across N.America and Eurasia
Amphi-atlantic	found on both sides of the Atlantic but absent from western N.America and eastern Eurasia

Table 17

Phytogeographical distribution of species

1. Arctic		
	a. Circumpolar	Arnellia fennica
		Asterella ludwigii
		Chandonanthus setiformis
		Mannia pilosa
	b. Amphi-Atlantic	Anastrophyllum saxicola
		Clevea hyalina
		Lophozia heterocolpa
		Lophozia rutheana
		Scapania gymnostophila
		Tritomaria scitula
2. Arctic-Boreal		
	a. Circumpolar	Anastrophyllum minutum
		Blepharostoma trichophyllum
		Cephalozia pleniceps
		Diplophyllum taxifolium
		Mylia anomala
		Gymnocolea inflata
		Ptilidium ciliare
		Scapania paludicola
		Tritomaria quinquedentata
	b. Amphi-Atlantic	Lophozia alpestris
		Lophozia badensis
		Lophozia marchica
		Scapania cuspiduligera
		Scapania microphylla
		Scapania undulata
3. Boreal		
	a. Circumpolar	Anastrophyllum hellerianum
		Anastrophyllum michauxii
		Cephalozia bicuspidata
		Cephalozia connivens
		Cephaloziella rubella
		Cladopodiella fluitans
		Jamesoniella autumnalis
		Lepidozia reptans
		Lophozia attenuata
		Lophozia incisa
		Lophozia porphyroleuca
		Pellia neesiana
		Scapania apiculata
		Scapania mucronata

Cont'd... Table 17

	b. Amphi-Atlantic	*Calypogeia sphagnicola* *Calypogeia suecica* *Cephalozia affinis* *Cephalozia lacinulata* *Cephaloziella elachista* *Frullania oakesiana* *Jungermannia lanceolata* *Lophozia ascendens* *Lophozia excisa* *Lophozia longidens* *Lophozia ventricosa* *Moerckia hibernica* *Riccardia multifida* *Scapania glaucocephala* *Scapania irrigua* *Tritomaria exsectiformis*
	c. North American	*Frullania asagrayana* *Frullania selwyniana*
4. Boreal-Temperate		
	a. Circumpolar	*Bazzania trilobata* *Cephaloziella starkei* *Chiloscyphus pallescens* *Chiloscyphus polyanthus* *Geocalyx graveolens* *Harpanthus scutatus* *Lophocolea heterophylla* *Lophocolea minor* *Nowellia curvifolia* *Riccardia latifrons*
	b. Amphi-Atlantic	*Calypogeia integristipula* *Lophozia barbata* *Lophozia bicrenata*
	c. North American	*Frullania bolanderi* *Frullania brittoniae* *Frullania eboracensis* *Cololejeunea biddlecomiae*
5. Temperate		
	a. Circumpolar	*Blasia pusilla* *Conocephalum conicum* *Lejeunea cavifolia* *Pellia endiviifolia* *Riccia cavernosa*
	b. Amphi-Atlantic	*Fossombronia foveolata* *Lophozia capitata*
	c. North American	*Frullania inflata*

Cont'd... Table 17

6. Sub-cosmopolitan	Cephaloziella hampeana Cephalozia media Marchantia polymorpha Pellia epiphylla Plagiochila asplenioides Porella platyphylla Porella platyphylloidea Preissia quadrata Ptilidium pulcherrimum Riccardia palmata Riccardia pinguis Radula complanata

Based on complete species list from all sources.

Not all species were collected during this study.

Table 18

Phytogeographical Characteristics of the Hepatic Flora of the Study Area

Element	Number of species		Percentage of Total Flora		Percentage of sites*
Arctic					
Circumpolar	4)	10	5.0)	12	1
Amphi-Atlantic	6)		6.5)		2
Arctic-Boreal					
Circumpolar	9)	15	9.5)	16	70
Amphi-Atlantic	6)		6.5)		1
Boreal					
Circumpolar	14)		14.5)		84
Amphi-Atlantic	16)	32	17.5)	34	49
North American	2)		2.0)		2
Boreal-Temperate					
Circumpolar	10)		11.5)		88
Amphi-Atlantic	3)	17	3.0)	18	42
North American	4)		4.0)		47
Temperate					
Circumpolar	5)		5.0)		31
Amphi-Atlantic	2)	8	2.0)	8	1
North American	1)		1.0)		2
Sub-Cosmopolitan		12		12	97

* Percentage of the 101 sample sites from which at least one species of an element was recorded.

Table 19

Longitudinal Distribution of Species Collected

Distribution	No. of species	Percentage of species	Percentage of sites*
Circumpolar	42	45	92
Amphi-Atlantic	33	36	64
North American	7	7	48
Sub-cosmopolitan	12	12	97

* Percentage of the 101 sample sites from which at least one species of an element was recorded.

Ouimet Canyon or from the shore of Lake Superior and some of them have not been found at all in the course of the present study. In contrast, several temperate species are widely distributed throughout the area: for example, *Blasia pusilla* and *Conocephalum conicum* (see Appendix IV). There are also some very common species included in the boreal-temperate list: for example *Geocalyx graveolens* and *Frullania eboracensis*.

Table 18 also shows that boreal, boreal-temperate and subcosmopolitan species were recorded at a high proportion of sites. The temperate element was found at a higher percentage of sites than might be expected from the number of species represented, while, as indicated above, the arctic element is very restricted in distribution. A number of the boreal species found in the area extend into the tundra but the high value (70%) for the proportion of sites at which arctic-boreal species were recorded is due in part to the inclusion of the particularly widespread species *Blepharostoma trichophyllum* in this group. Similarly, there is a low representation of truly temperate species, but a considerable proportion of species occur both in the temperate zone and in the boreal. The arctic-boreal element in the study area is probably composed of species of wide ecological amplitude. Their tolerance of fairly rigorous climatic conditions may enable them to move into an area in the early stages of recolonization and, at the same time, they may resist competition from species which follow as the climate becomes warmer. Likewise, it is suggested that boreal-temperate species may also have a wide range of tolerance but are not adapted to the more rigorous conditions found further north.

The occurrence of a wide variety of phytogeographical elements within the study area correlates well with the local climate which is not an extreme continental type because of the proximity of Lake Superior. The dominant vegetation is an ecotone with elements from neighbouring regions and the hepatic flora seems to follow this pattern.

Apparently, most of the hepatic flora within the study area is circumpolar or widely distributed throughout the world (Table 19). Quite probably, some of the amphi-atlantic species will be found to be circumpolar eventually although some of them may be oceanic types which exist in the study area because of its oceanic characteristics (Peattie, 1932). The proportion of endemic North American species is very small compared with that found in the vascular flora (Lakela, 1965; Scoggan, 1957), but these species are found on quite a high percentage of sites. This seems to indicate that they are fairly well adapted to the area.

SECTION VII
DISCUSSION

One of the principal objectives of this study was to collect hepatics systematically throughout the study area, in order to compile a comprehensive check list and to determine the distribution and habitat preferences of each species. In spite of difficulty of access, sites have been examined in about three fifths of the chosen area. At least some points from the extreme south to the extreme north and from east to west of the area have been visited. Substantial gaps exist in the Dog Lake region, south of Lac des Mille Lacs, between Lake Shebandowan and Northern Light Lake and, to a lesser extent, east of Highway 800 (Fig.6). It may be significant, however, that routine sampling added only 6 species to the list in both 1970 and 1971 and none in 1972.

The results suggest that most of the widespread species have been found in the course of the fieldwork, although it is probable that additional species of more restricted distribution will be found from time to time. For example, in 1972 Williams collected three new species in Ouimet Canyon and Garton found <u>Riccia cavernosa</u> near Whitefish Lake for the first time. New species may also be discovered when gaps in the areas sampled are reduced; as there may be habitat differences in these more inaccessible regions. The recent visits by Garton to the Cavern Lake Canyon have produced a number of species previously known only from Ouimet Canyon and there may be other unusually rich sites which have not yet been visited. A careful search of the shale ledges and rock walls along the local rivers would probably result in the rediscovery of some of the species collected only once by Garton, such as Gymnocolea inflata and Scapania cuspiduligera. The study area was chosen somewhat arbitrarily but it has turned out to be fairly self-contained and sufficiently varied to be interesting. Appendix II, which provides a check list of 94 species from the comparatively small area of 15,700km^2, emphasizes this variety. An artificial key to the species is provided in Appendix III. Three additional species, from the periphery of the study area, have been included in the check list and key for the sake of completeness. These species (Odontoschisma denudatum, Odontoschisma macounii and Scapania nemorosa) will most likely be found in the study area eventually.

Routine sampling has provided data concerning the frequency and distribution of each species within the study area. From Table 15 and the maps in Appendix IV, it may be seen that Ptilidium pulcherrimum and Lophocolea heterophylla are very frequent, occurring on 80% or more of sample sites. Blepharostoma trichophyllum, Cephalozia media, Frullania eboracensis, Geocalyx graveolens, Jamesoniella autumnalis and Lepidozia reptans are also common, with over 55% frequency. The most surprising of these is C.media which was reported for the first time in 1969 but was the third most frequent species found in the course of this study. This species is small and was probably formerly overlooked. Lophozia barbata, previously regarded as the most frequent species, (Crowe & Barclay-Estrup, 1971), was found on only 26% of the sites visited. The three commonest thallose species, Conocephalum conicum, Riccardia latifrons and Riccardia pinguis ,were recorded with between 24% and 25% frequency. This emphasizes the relatively unimportant part played by the thallose hepatics in the total hepatic flora of the study area. Of the remaining 82 species in the check list, 35 were either not recorded or recorded from only one site in the course of this study. This amounts to 37% of the species list and includes all the arctic element.

The statistical analysis indicates that certain basic site factors influence the richness and variety of the hepatic flora in a given locality. The collecting pattern, which was designed for systematic coverage of the area, resulted in a wide variation in class size when the separate characteristics of the sites were investigated. For example, when the effects of human activity were considered (Table 12) one class contained 33 samples and the other 68. However, enough has been shown to indicate that further investigation might be interesting. In particular, it would be useful to examine the effects of combinations of habitat factors as it seems likely that there is interaction.

Of the site factors considered, the proximity of Lake Superior seems to have some importance (Table 6) but it is possible that this may be the result of a wider variety of habitat in that zone, rather than the effect of Lake Superior on the local climate. Altitude (Table 7) does not seem to be an important factor within the study area, possibly because the range of elevation, although wide compared with much of the Canadian Shield, is small when compared with more mountainous regions.

There seems little doubt that hepatic growth is favoured in sites with an ample supply of ground water (Table 11), such as in cedar swamps and other hydric forested sites. Brinkman (1929) found that hepatics were indicators of the drainage of a site: they do not flourish in well drained areas. He noted that, in his sample area which was on a gradient by a river, the zone nearest the river supported fewest hepatics. Further from the river, where the soil was less well drained, they were more plentiful. In the course of the present study also, hepatics were not found in abundance on riverside sites, with the exception of a few thallose species. River banks are often well drained and dry underfoot because of their slope and locally occurring gravel deposits (Ritchie, 1960). They are also subject to inundation periodically, which may be limiting for some species. Hepatics respond well to moisture but the species in the study area are by no means aquatic and excess water may well be as detrimental as extreme dryness.

In spite of being favoured by moisture many hepatic species are surprisingly resistant to temporary desiccation (Hinshiri & Proctor, 1971). In general, summer temperatures in the study area are moderate, the mean relative humidity is usually high, and therefore plants are unlikely to be subjected to severe desiccation for long periods. However, there is normally a dry season with frequent forest fires in spring and early summer, as intense insolation leads to evaporation of most of the water liberated from the snow before the ground has thawed and can absorb it. Desiccation often found on first exposure in the spring may be a protection against the rigorous night frosts experienced during this season, as hepatics are more resistant to freezing in the desiccated state (Clausen, 1964).

In the forest, the poorly developed soils are often not well drained and the forest floor tends to remain relatively moist. Exposed rocky sites, however, almost invariably dry up for some time during the summer as the rainfall is not high (Table 2). The study area is not, therefore, rich in continuously wet rock sites (cliffs or slabs) as are areas further east. Even superficially, it is possible to see a vast difference in the lushness of the bryophyte flora in, for example, Lake Superior Provincial Park as compared with that found in similar situations in the study area. The lack of wet rock sites almost certainly accounts for the absence of some species and the rarity of others which are frequent in adjacent areas. Moisture is probably the controlling factor but temperature range must also be important especially on exposed rock sites. Virtually nothing is known of the microclimate in the study area and such knowledge would probably elucidate many anomalous species distributions.

The results show that human influence is another significant site factor which may reduce the variety and frequency of hepatic species (Table 12). This is probably due to trampling which may cause erosion, to removal of trees, to changes in drainage and soils, and to ground cover disturbance. The mean number of species per site was found to increase with the age of the tree stand (Table 13). Trees affect both the ground moisture and the atmospheric humidity. At the same time, a mature forest provides an increased number of habitats both on the living trees and the greater amount of deadfall. The vascular ground flora is also partially controlled by the age of the tree stand. In the study area it is generally more flourishing under younger stands. There is, therefore, less competition at the ground level in mature stands. The ground vascular flora has been shown to affect the hepatic flora (Table 14). Thus extensive logging in an area is likely to reduce considerably the diversity of the hepatic flora, at least temporarily.

The data in Table 9 indicate no significant differences between the mean numbers of species at sites on different bedrock types. A more detailed survey might produce positive results. It may be significant that, excepting the felsic to intermediate volcanics (Type B) on which only one site was visited, the two types of rock with the highest average number of species are both ore bearing. The very early precambrian rocks (mafic metavolcanics, A) produce silver, lead and zinc, while Animikie sediments (E) contain copper and iron (Tanton, 1931). It seems likely that the presence of these metallic ions may inhibit competition from other species (Schutz, 1955; Shacklette, 1961) rather than actively stimulating hepatic development. Garton has made interesting collections on St Ignace Island (just outside the study area) comprising two species of Odontoschisma and other rare species, including several with arctic affinities. It is suggested that the presence of these species may be more due to the fact that the area is rich in copper (personal communication, Dr J.Franklin,* Lakehead University), than to its being an arctic habitat. This could explain the presence of both species of Odontoschisma in the same area in spite of their very different phytogeographical affinities (Appendix II). These species are also found in copper bearing areas in Minnesota (Schuster, 1953; 1957).

The number of hepatic species found on a given site showed no correlation with the pH of soil samples taken from the surface to a depth of 5 cm. It is probable that this only affects species which grow directly on soil and that the pH of the immediate substrate is more important to most species than the general soil pH. Schuster (1957) suggests that the concentration of calcium ions is probably most important to the hepatic flora and that pH is often a reflection of this. There seems to be considerable evidence that the presence or absence of calcium ions is

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limiting to different species (Watson, 1918; Schuster, 1957). However, Streeter (1970) suggests that it is the pH and not the calcium ion content which is important even in so-called calcicole species. There are indications that an excess of calcium ions is severely inhibiting to some bryophytes (Streeter, 1970) and it may well be that some species are excluded from the study area because of a high average calcium content in the soil from the predominantly basic rocks. Lack of calcium seems unlikely to be a limiting factor except in very specific microhabitats.

The phytogeographical analysis undertaken during this study has yielded interesting results in terms of reconstructing the vegetational history of the region. A comparison of the 94 species recorded from the area with the collections made by Williams and Garton to the east and with those recorded by Schuster (1953) from Minnesota to the southwest indicates that, while all three areas have many species in common, there are also noteworthy differences. This is also true of the vascular flora (D.Lindsay, personal communication).

It is clear from Table 16 that the hepatic flora of the study area comprises essentially boreal species, many of which range widely into either temperate or arctic regions. There is also a substantial subcosmopolitan element, characteristically including species of wide ecological amplitude, and an arctic element representing a number of local post-glacial relicts.

Undoubtedly, one of the most potent factors determining the composition of the present hepatic flora in the study area has been glaciation. This has largely decided the present surface geology and it almost certainly eliminated all the pre-pleistocene flora (Butters & Abbe, 1953). Nunatak areas have been postulated in the past (Fernald, 1935). Schuster (1958) thinks them unlikely on the north shore of Lake Superior and Butters & Abbe (1953) and Soper & Maycock (1963) are in agreement with this viewpoint. Certainly, the elevations here are not very great and even if some small areas of rock remained uncovered, conditions on them would have been extremely rigorous and would have permitted only the very hardiest species to survive. This view is supported by the fact that members of the Tertiary bryoflora of high arctic refugia (Steere, 1969) have not been found in the study area. Hepatics are well known to be a slowly evolving group (Fulford, 1965) in which the genera and, probably, even most species were established before the Pleistocene (Gams, 1932). Thus the presence of endemic species in a northern region might be regarded as evidence that the region served as a glacial refugium but no endemic hepatic species have been found in the study area.

The study area thus appears to have been recolonized by plants since the pleistocene glaciations. Due to the topography of Lake Superior there are only two possible routes by which this may have occurred,at least in a stepwise manner, one from the southwest and the other from the northeast. The study area has many species in common with adjacent areas of Minnesota (Schuster, 1953) and the angling of the ice front in the Valders sub-stage and its withdrawal to the northeast (Zoltai, 1963) make it much more likely that recolonization did take place from the southwest. A substantial number of distributions run parallel to the lake shore (Appendix IV).

There are three main requirements which enable a species to establish and maintain itself in a new area. These are a suitable means of propagation and dispersal, a suitable habitat, and the ability to resist competition from other plants. Tryon (1969) writing of ferns, which are far more active producers of propagules than hepatics, questions the reason for their absence from obviously suitable habitats if they are, as has been suggested, capable of dispersing spores over hundreds of miles. Sharp(1972) mentions the dangers of desiccation and ultra-violet radiation to air borne spores. On the other hand, long range dispersal was suggested as the probable explanation of the temperate and sub-antarctic bryophyte flora associated with fumaroles on the recently developed and highly isolated South Sandwich Islands in the Antarctic (Longton & Holdgate, 1967).

It seems possible that some of the more temperate species are entering the study area at the present time in the form of spores, for example, Riccia cavernosa (an ephemeral species, found so far in only one location which must rely on viable spores for propagation) and Conocephalum conicum. The latter, although quite frequent, has not been found fertile in the study area, yet it is both well established and fertile in Minnesota (Schuster, 1953). It has large spores which start to divide within the capsule, they are thus less likely to become desiccated than smaller ones. It is physiologically adapted to dying back in winter and regenerating from innovations in the spring. This may pre-adapt it to surviving the long winters in the study area but it may be that the growing season is at present too short for it to produce spores. Similar problems must have been encountered by species entering the area after glaciation. However, even greater difficulties are experienced by species entering an area with an existing vegetation where most niches are already occupied. It may be significant that both the species just mentioned occur in rather unstable habitats, liable to flooding, where bare areas may be found.

Crum (1965) postulates that recolonization after glaciation would be by vigorous and aggressive species but their main characteristic would have to be the ability to endure waves of cold air coming from the ice. Peattie (1932) suggests that insolation at that time would have been high, in view of rapid ice melting, so that there would have been adequate energy for plant growth. This may have been so but the proximity of the ice fields would have produced low night temperatures resulting in the rapid freezing and thawing which is probably a limiting factor for many species in the Arctic and Antarctic today (Greene & Longton, 1970). When the climate ameliorated,competition from increasing vegetation cover would cause the first invaders to disappear or move into newly exposed areas. It seems that, while these species are physiologically adapted to rugged climatic conditions, they are not usually resistant to competition from other species (Tallis, 1958). However, if the arctic climate was able to persist in some isolated area then pioneer arctic species would also persist.

It seems probable that this has occurred in Ouimet Canyon. From personal observation, it is very noticeable when descending into the canyon on a warm day that a layer of very cold air is encountered about 20m from the bottom. This originates from the jumble of huge talus blocks on the canyon floor, which trap snow and ice during the winter. Visible snow persists in the canyon until July and ice may be found in deep crevices even in mid-summer. Water also moves below the blocks keeping them cool and moist. Yet, the degree of insolation is high because of the north-south orientation of the canyon. These rigorous conditions have prevented the establishment of trees and larger vascular plants. Thus arctic species have been able to persist through the centuries as the tide of migration has swept around them, even though both Chandonanthus setiformis and Anastrophyllum saxicola, for example, are sterile. The height of the floor of the canyon above the level of Lake Superior has also probably contributed to the establishment of an arctic refuge as it was probably not flooded for any length of time. It is possible that some of the infertile arctic species may be on the verge of extinction. Chandonanthus setiformis seems to be restricted to one very small area and only a trace of Arnellia fennica has been found so far. Even a limited number of people visiting the canyon might well administer the coup de grâce to these delicately poised species.

Watson (1967) notes that in unstable areas bryophytes may constitute a microclimax that is never superseded. Such a situation is found on the shore of Lake Superior (Fig. 5), where wind and wave action prevent the establishment of a typical vascular flora. Thus rare species, including several members of the arctic element, are found in this zone. The gradual rise of the land since the Ice Age has continued to create new beaches on which pioneer arctic species can become established (Nuttall, 1971). Soper & Maycock (1963) believe that certain species found on the Lake Superior shore and again near Hudson Bay must be relics of earlier climates at their southern stations. It seems to be a generally acceptable theory, but a note of caution must be sounded as many apparently disjunct distributions in the past have eventually merely revealed a disjunct pattern of collectors (Steere, 1969). There is certainly a large, almost uninhabited gap between Lake Superior and Hudson Bay. Collecting around the shores of

Lake Nipigon, for example, might produce significant results.

Two puzzling disjuncts within the area do not seem to fit the theory of arctic relicts. Clevea hyalina, regarded by Schuster (1958) as a species of the driftless area of Wisconsin and of unglaciated regions further north and not a species of the Great Lakes region at all, is found at the mouth of a sandstone cave on the shore of Cavern Lake. This location must have been affected by glaciation and inundation. It seems more probable that its occurrence is controlled by specific habitat requirements as the situation in which it grows is very similar to those described in Minnesota (Schuster, 1953). The discovery of Frullania asagrayana,on a live cedar in the same general area, is even more puzzling because of its unusual habitat and apparent lack of any means of propagation. The nearest recorded stations are in the northeast of Minnesota (Schuster, 1953) and near Schreiber (Williams, personal communication). Both these collections were made on the periphery of one of the gaps in the collecting pattern and it is possible that they may be found again in the course of a more comprehensive survey.

A number of taxonomic problems have been encountered in the course of this study and these are mentioned where appropriate in the check list. Difficulty is often experienced with uncommon species of families of minute hepatics such as the Cephaloziaceae and Cephaloziellaceae. Hepaticologists are understandably wary of making definite determinations of these poorly defined species. Very little has been done to establish if the many, very widespread hepatic species are really the same in all parts of the world. Fulford (1963) points out that hepatic species have not been worked over according to the "new systematics". In some cases there has been an unnecessary proliferation of species, such as in Stephani's work from which Schuster (1966) considers as few as 25% of the species will prove valid.

Fulford (1963) suggests that hepatics have evolved very little since Carboniferous-Jurassic times. This assumption is based purely on external appearances and there is no evidence that physiological changes have not taken place. This may account for apparent differences in the ecological preferences of species such as Scapania microphylla, Scapania paludicola and Lejeunea cavifolia which appear to exist between Scandinavia (Arnell, 1956) and North America (Schuster, 1953, 1969). There seems to be a high probability that ecotypes do exist and that in many cases plants of the same species which are collected in different parts of the world are widely separated ecologically. Perhaps the stresses placed on plants during the pleistocene glaciations may have produced some changes even in a group generally considered to have little adaptability (Schuster, 1966).

With these and other questions unanswered, the present study must be regarded as a preliminary survey of the hepatic flora of the study area. However, it is hoped that the information assembled in this thesis will provide a foundation for future students of hepaticology in this interesting region.

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APPENDIX I

DESCRIPTION OF ROUTINE SAMPLE SITES

The principal features of the 101 sites where transect sampling was undertaken are summarized in Tables 1 and 2.

The code name for each site e.g. A4, B4 etc., is derived from its position on the original grid (see Fig.1).

Table 1 relates the sites to their position on the 8 mile and 10 km. grids and indicates the general site characteristics according to the code given in Table 5. The numbers of species recorded on each transect are also shown.

More detailed information on the location, geology and vegetation of the sites is presented in Table 2, together with the date of sampling.

Table 1

General characteristics of routine sample sites

For explanation of code see Table 5, page 51.

Site	10 Km Grid	DI	HT	GL	pH	MT	HI	ST	GF	No. of species on Transect
A4	2004	127	450	.D	-	B	B	C	A	2
B4	1904	109	450	C	-	B	B	A	C	12
C1	1801	122	450	D	-	B	B	B	B	11
C4	1804	114	450	C	-	D	B	B	B	9
C7	1809	58	450	C	-	C	A	B	C	10
D1	1700	130	450	D	-	F	A	A	B	6
D2	1701	110	450	D	-	B	A	B	B	3
D4	1604	95	450	B	-	A	B	B	C	16
D8	1610	47	480	C	-	D	A	B	B	6
E2	1610	99	450	D	-	A	A	B	C	11
E3	1503	96	450	D	-	D	A	B	B	10
E4	1504	87	480	A	-	D	B	B	B	11
E7	1509	47	480	D	-	D	A	B	B	10
E8	1510	47	480	G	-	D	A	B	A	0
F2	1401	68	450	D	-	C	B	A	D	8
F3	1404	71	450	C	-	D	A	B	B	8
F4	1405	78	450	A	-	B	B	B	B	14
F4C	1305	67	420	A	-	D	B	B	C	11
F5	1406	61	420	D	-	D	B	A	B	6
F6	1407	52	480	D	-	F	A	A	C	2
F7	1409	42	405	D	-	D	A	B	A	4
G1	1701	68	420	D	-	F	B	A	D	4
G2	1302	63	480	D	-	D	B	B	D	1

Continued:

Table 1

Site	10 km Grid	DI	HT	GL	pH	MT	HI	ST	GF	No. of species on Transect
G3	1303	60	495	D	-	C	B	B	B	10
G4	1304	47	390	C	-	D	B	B	D	1
G4C	1205	36	360	A	-	D	A	B	A	2
G6	1307	52	480	D	-	C	B	B	A	2
G6C	1208	45	435	E	5.6	C	B	B	B	6
G7	1308	38	435	D	4.6	B	A	B	A	3
G7C	2909	30	390	G	5.7	D	B	B	A	7
G8	1309	30	405	G	5.7	D	B	B	D	7
G8C	1210	21	480	E	5.4	C	B	C	A	15
G9	1311	21	360	G	5.4	C	B	B	A	9
H3C	1104	43	420	D	-	D	A	C	B	2
H4C	1105	36	360	D	-	C	A	B	A	4
H5	1106	40	345	A	-	C	A	B	D	3
H5C	1106	30	345	A	5.3	D	B	B	D	14
H6	1207	30	345	A	5.3	B	B	C	A	15
H6C	1108	36	225	E	5.6	C	B	B	A	11
H7	1208	32	270	G	5.9	D	A	B	D	10
H7C	1109	26	405	G	5.4	C	B	B	A	8
H8	1209	23	375	G	6.0	D	A	B	A	1
H8C	1110	12	270	E	5.3	C	B	A	A	2
H9	1211	10	345	E	6.3	C	B	C	B	13
H9C	1211	2	225	E	4.8	E	B	B	D	8
I3C	1004	34	450	D	5.6	C	B	B	D	13
I4	1005	34	360	D	5.6	D	B	B	B	14
I4C	1005	33	390	D	4.6	D	B	B	D	7
I5	1005	30	405	C	6.5	D	A	B	D	4

Continued:

Table 1

Site	10 km Grid	DI	HT	GL	pH	MT	HI	ST	GF	No. of species on transect
I5C	1006	17	345	A	4.6	C	A	B	D	8
I6	1007	22	300	E	6.8	B	A	C	D	13
I6C	1008	19	195	E	6.2	B	B	C	D	11
I7	1008	19	390	E	5.9	D	A	B	D	6
I7C	1109	16	300	E	5.8	C	B	C	B	16
I8	1109	19	330	G	6.5	C	A	B	D	3
I8C	1010	6	195	E	5.8	C	B	B	D	9
I9	1011	4	240	E	5.2	C	B	B	B	11
J3	0903	36	420	D	5.0	C	A	C	D	4
J4	0904	27	435	D	5.6	C	B	B	B	16
J4C	0805	16	360	C	-	C	A	A	D	2
J5	0906	17	405	A	6.5	B	B	C	B	13
J5C	0806	6	288	E	4.4	C	B	B	C	10
J6	0907	8	255	E	5.6	B	B	B	C	11
J6C	0908	5	390	E	5.2	D	A	B	A	2
J7	0908	8	450	E	5.5	E	B	B	D	11
J8	0910	1	210	G	5.5	B	B	C	B	9
K1	0801	58	450	D	-	B	B	B	B	13
K2	0802	44	450	D	-	D	B	B	C	8
K2C	0702	34	465	D	5.3	B	B	B	A	14
K3C	0704	21	435	D	4.4	D	B	B	A	10
K4	0805	11	390	C	-	F	B	B	D	7
K4C	0705	14	435	D	5.2	D	B	B	A	8
K5	0806	9	375	A	4.9	D	B	B	B	10
K5C	0706	0.2	195	A	-	B	B	B	B	12

Continued: Table 1

Site	10 Km Grid	DI	HT	GL	pH	MT	HI	ST	GF	No. of Species on Transect
K6	0809	0.2	195	E	4.2	C	A	B	C	2
K7	0808	0	195	E	4.5	B	B	B	A	10
L1	0601	36	420	D	-	C	B	B	A	7
L2	0602	38	510	D	-	C	A	A	B	19
L4C	0605	5	285	D	5.2	D	B	B	B	4
L5	0606	4	285	A	5.2	D	B	B	B	11
M2	0502	26	360	D	-	C	B	B	B	11
M3C	0404	15	420	A	6.4	A	B	C	C	20
M4	0505	6	315	A	-	B	A	B	D	11
M4C	0405	1	210	E	5.3	C	A	B	D	9
M5	0506	0.5	210	E	5.8	C	A	B	D	10
M5C	0506	4	240	F	5.6	C	B	B	B	8
M6	0507	3	255	F	5.5	B	B	C	D	13
M7	0508	0	195	F	4.9	D	B	B	D	8
N1C	0301	13	300	F	-	C	B	B	B	11
N2C	0303	5	225	G	6.4	B	B	B	B	13
N3	0303	5	405	G	4.4	C	B	B	B	13
N3C	0304	3	225	D	5.5	D	B	B	D	5
N4	0404	5	210	F	6.3	B	B	B	A	13
N5	0406	0.5	195	F	5.7	C	B	A	B	9
N6	0407	3	195	F	5.7	C	B	C	B	9
N7	0508	0	195	F	-	F	B	C	C	14
O1	0301	19.5	255	F	-	E	A	A	D	0
O2	0302	8	300	G	-	D	B	B	B	15
O3	0303	0	195	F	-	D	A	B	B	4
P1	0101	5	270	D	-	D	B	B	A	8
P2	0202	8	210	F	-	B	B	B	C	9

Table 2

Location, Geology, Vegetation and other features of routine sample sites.

A4

90° 58'W 48° 42'N — May 13 1972.

N. of Hwy 11. Edge of Rainy River District near Quetico Park sign.
Very mature stand of Pinus banksiana and Picea glauca.
Exposed calcite. Some swampy areas but generally well drained.

B4

90° 45'W 48° 42'N — May 13 1972.

S. of Hwy 11. 3 Km. E of Height of Land.
Glacial till with granite boulders. Tilted sediments with quartz and iron. Young Betula papyrifera and Populus tremuloides. Picea glauca, Salix sp and Alnus sp.
Moist but fairly well drained.

C1

90° 40'W 49° 00'N — June 9 1972.

6.5 km S. of Hwy 17 on Blind Bay Road.
Mature Picea sp Alnus sp and well developed understorey
No exposed rock, rather swampy.

C4

90° 35'W 48° 38'N — May 13 1972.

50 m. N. of Hwy 11.
Mature Betula papyrifera, Pinus banksiana, Picea spp.
Populus balsamifera plentiful. Glacial till. Well drained.

C7

90° 33'W 48° 16'N — May 27 1972.

E. of car park. Northern Light Lake.
Thick understorey. Mixed stand of Thuja occidentalis, Betula papyrifera, Salix sp and Picea sp. Mature.
Moist and peaty, no exposed rock.

D1

90° 33'W 48° 16'N — June 9 1972.

500 m. N. of Hwy 17, 1st side road, Upsala.
Swampy area, partially cleared, at terminus of gravel road.
Fairly mature stand of Picea sp Populus balsamifera and Populus tremuloides. No exposed rock.

Continued:

Table 2

D2 — June 9 1972.

90^{o} 20'W 48^{o} 57'N

9.5 km. S. of Hwy 17 at fork in road to Lac Des Mille Lacs.
Moraine. Sandy soil at edge of very shallow, almost overgrown lake. Mature Picea sp and Populus tremuloides. Rather swampy.

D4 — May 13 1972.

90^{o} 23'W 48^{o} 41'N

Hwy 11, 3 km. E. of Kashabowie.
Thuja occidentalis, Picea mariana swamp. Alnus sp, Salix sp. Very thick understorey. No exposed rock. Mature stand.

D8 — May 27 1972.

90^{o} 25'W 48^{o} 11'N

Prelate Lake, Northern Light Lake Road. Sandy soil. Xeric. Populus tremuloides and Pinus banksiana stand. Mature.

E2 — June 9 1972.

90^{o} 13'W 48^{o} 57'N

2 km. E. of Little Savanne River on Hwy 17.
Picea mariana and Ledum groenlandicum. Swampy area, no exposed rock. Mature stand.

E3 — May 20 1972.

90^{o} 15'W 48^{o} 39'N

Pine Ridge Road.
Mature Populus tremuloides, Picea sp, young Betula papyrifera. Dense patches of Abies balsamea. Moraine, gravel pit. Very well drained.

E4 — May 20 1972.

90^{o} 15'W 48^{o} 39'N

Junction of Pine Ridge Road and Hwy 11.
Mature Populus tremuloides, Picea glauca and young Betula papyrifera. Well drained gravel area.

E7 — May 27 1972.

90^{o} 12'W 48^{o} 14'N

Picnic site at E. end of Sandstone Lake. Mature Betula payrifera, Picea sp. Steep, rocky slope away from lake. Well drained moraine. Fairly open.

E8 — May 27 1972.

90^{o} 15'W 48^{o} 10'N

Arrow Lake Provincial Park.
Populus tremuloides, Picea glauca with Betula papyrifera coming in. Rather mature trees and well developed ground flora. Sandy spit. Well drained.

Continued:

Table 2

F2 — May 29 1971.

90° 04'W 48° 55'N

In wood near river, S. of Hwy 17. Savanne Portage. Abies balsamea stand near river. Cleared area at edge of park. Well drained sandy bank but lower part subject to flooding. No exposed rock. Young trees.

F3 — May 20 1972.

90° 03'W 48° 42'N

Edge of Drift Lake, 9.5 km. N. of Hwy 11 on Great Lakes Paper Company road.
Betula papyrifera, Populus tremuloides, Abies balsamea and Picea sp. Sandy soil. No exposed rock. Mature stand. Well drained.

F4 — May 20 1972.

90° 05'W 48° 38'N

Near picnic site. S. side of Hwy 11. 3 km. W. of Drift Lake Road.
Mature Populus tremuloides, Picea sp and Abies balsamea. Well developed understorey, including Salix sp Acer spicatum and Alnus sp. Rather swampy, no exposed rock.

F4C — May 20 1972.

89° 58'W 48° 36'N

Mabella, 1 km. E. of station, near Shebandowan River.
Abies balsamea, Populus tremuloides and Picea sp.
Fairly mature and open. Rock shelves with thin layer of peaty soil. Rather dry.

F5 — June 18 1972.

90° 08'W 48° 24'N

Matawin River, unmaintained paper company road.
3 km. N.W. of junction with Marks Lake Road.
Recently logged. Relic stand of Populus tremuloides and Picea sp and 1 to 1.5m high regenerating brush. Well drained.

F6 — June 18 1972

90° 10'W 48° 23'N

Old paper company camp on Marks Lake Road. Swampy but exposed due to logging. A few old Picea mariana and young Populus sp. Rocky outcrops, gravel and small boulders. Glacial till. Well drained.

F7 — May 27 1972.

90° 00'W 48° 14'N

Whitefish Lake, road to Dorchester Club.
Mature Picea sp, young Populus tremuloides and well developed understorey. Rather dry, exposed bed rock.

Continued:

Table 2

G1	89° 55'W 48° 58'N 13 km. N. of Hwy 17. Dog River Road, Argon. 1.5 km. S. of Dog River. Swampy but exposed. Sandy soil. *Pinus banksiana* *Picea* sp, *Populus* sp, *Alnus* sp. Grassy with old stumps. No exposed rock. Mostly young growth with a few old trees.	May 29 1971.
G2	89° 56'W 48° 54'N 9.5 km. N. of Hwy 17, 5 km. N.E. of junction with Dog River Road. Mature *Pinus banksiana* stand. Sandy soil. Glacial till. Well drained.	May 29 1971.
G3	89° 43'W 48° 46'N E. of Hwy 17, on track just north of Michener-Soper townline. Fairly well developed stand of *Picea glauca*, *Abies balsamea* and *Betula papyrifera*. *Alnus* sp understorey. Moist peaty soil, granite boulders near surface.	May 8 1971.
G4	89° 54'W 49° 38'N 5.6 km. N. of Shabaqua corners. Gravel track to W. by creek. *Pinus banksiana*, *Picea glauca*, *Ledum groenlandicum*, *Lycopodium* sp and *Arctostaphylos uva-ursi*. Mature stand. Very well drained sandy slope. Glacial till.	May 8 1971.
G4C	89° 46'W 48° 34'N S. of bridge over creek at Finnmark. Open stand of *Populus tremuloides*, with well developed ground flora, including *Ledum groenlandicum*. Mature trees. Well drained moraine.	June 14 1972.
G6	89° 53'W 48° 25'N 12 km. W. of Hwy 590 on a paper company road to Marks Lake. Mature *Populus tremuloides*, *Picea* sp, *Pinus banksiana* Well developed understorey. Close to open swampy area near creek. Glacial till. Fairly moist.	June 18 1972.
G6C	89° 47'W 48° 22'N W. of Hwy 590 between Whitewood and Pitch creeks. Rather open, fairly mature stand of *Abies balsames*, *Picea glauca*, *Fraxinus nigra*, *Populus tremuloides* and *Salix* spp. Peaty soil, no exposed rocks. Fairly moist.	June 5 1970

Continued:

Table 2

G7

89° 53'W 48° 18'N — June 5 1970.

2.5 km. W. of Nolalu on Hwy 588, then 3 km. N.W. on gravel road.
Near abandoned farm. Exposed rock surfaces. Mature *Larix laricinaa*, *Picea* sp, *Betula papyrifera* and *Salix* spp. Well developed ground flora. *Sphagnum* sp present but generally well drained.

G7C

89° 48'W 48° 14'N — June 15 1970.

Road parallel to Palisades, 3 km. E from junction with Nolalu road.
Mature stand of *Picea* sp, *Pinus strobus*, *Abies balsamea*, *Salix* spp, *Populus balsamifera*, *Populus tremuloides* and *Betula papyrifera*. Some understorey but rather open with well developed ground flora. Peaty soil, no exposed rocks. Rather dry.

G8

89° 53'W 48° 11'N — June 15 1970.

Hwy 593, 10 km. S. of Silver Mountain.
Mainly *Populus tremuloides* with *Populus balsamifera*, *Pinus banksiana*, *Picea glauca* and *Abies balsamea*. Well developed stand, with some understorey but little ground flora. Rocky slope with peaty soil. Rather dry.

G8C

89° 48'W 48° 09'N — June 8 1970.

800 m. N. of Falling Snow Lake.
Very steep north facing slope. Rocky block scree.
Very mature *Picea glauca*, *Pinus strobus* and *Populus tremuloides*. Well developed ground flora.
Moist with seepage from rocks but well drained.

G9

89° 52'W 48° 04'N — June 16 1970.

Devon township, 6 km. S. of Jackpine.
Pinus banksiana plentiful. *Picea glauca*, *Betula papyrifera* and *Populus tremuloides*. Profuse ground flora. Moist area near creek. Peaty soil, no exposed rocks. Mature stand.

H3C

89° 36'W 48° 42'N — June 14 1972.

W. side of Dog Lake on campsite at end of access road.
Very mature *Betula papyrifera*, *Populus tremuloides* and *Pinus banksiana*. Rather open site with quite well developed ground flora. Glacial till. Well drained.

Continued:

Table 2

H4C	89° 38'W 48° 37'N Forbes Concession Road 3 and 4, 1 km. W. of Kam River. Mature Picea glauca, Betula papyrifera and Abies balsamea. Well drained slope. Well developed ground flora. Old settlement. Peaty soil, no exposed rock.	June 14 1972.
H5	89° 45'W 48° 32'N S. bank of Matawin River, 0.5 km. upstream from Sunshine Hotel. Well drained north facing slope. Signs of burning and old clearing. Abies balsamea, Populus balsamifera Pinus banksiana and Picea glauca. Rather open with sandy soil. Mature stand.	May 8 1971.
H5C	89° 37'W 48° 28'N Mokomon Road, E. of first bridge over creek from Hwy 17. Dry north-facing slope. Moist near creek. Populus balsamifera, Populus tremuloides, Betula papyrifera, Abies balsamea and Picea sp. Lycopodium sp among ground flora. Peaty soil, no exposed rocks. Mature stand.	June 4 1970.
H6	89° 47'W 48° 25'N O'Connor Township, 5 km. W. of Hwy 11/17, 3 km. N. of Hwy 590. Thuja occidentalis stand. Creek with Alnus sp swamp. Well developed ground flora. Peaty soil with boulders, in some cases granite, below the surface. Very moist. Mature stand.	June 1 1970.
H6C	89° 37'W 48° 25'N 400 m. W. of Harstone Bridge over Kaministiquia River, S. of road. Alnus sp, Populus tremuloides, Larix laricina, Populus balsamifera and Abies balsamea etc. Well developed ground flora, well drained. Peaty soil, no exposed rocks. Mature stand.	June 2 1970.
H7	89° 46'W 48° 18'N 200 m. S. of creek, Hymers. Well drained slope to creek. Well developed stand of Betula papyrifera, Fraxinus nigra, and Populus sp. Cattle are run in the area. Loamy soil, no rock outcrops.	June 1 1970.
H7C	89° 37'W 48° 14'N 900 m. N. of Hwy 608 on Oliver Lake Road. Mature Populus balsamifera, Populus tremuloides, Picea sp Larix laricina and Salix spp. Peaty soil, no rock outcrops. Fairly moist.	June 2 1970.

Continued:

Table 2

H8

89° 42'W 48° 11'N June 8 1970.

Hwy 595, 6 km. S. of South Gillies, 1 km. W. of junctions with Walmsley Road.
E.facing slope. Fraxinus nigra, Populus tremuloides Picea glauca, Pinus banksiana, Abies balsamea.
Mature stand, well developed ground flora. Near abandoned farm. Rather dry, with exposed rock faces.

H8C

89° 37'W 48° 06'N September 13 1970.

Near bridge over Pine River, Hwy 597.
Young stand, dense undergrowth with few epiphytes.
Peaty soil, no exposed rocks. Fairly moist.

H9

89° 45'W 48° 04'N May 26 1970.

Devon Road, 5 km. W. of junction with Hwy 597.
Pinus strobus and Pinus resinosa, old Populus balsamifera and Picea glauca. Mature stand with little undergrowth. Creek with swampy area. Peaty soil, no exposed rock. Fairly moist.

H9C

89° 42'W 48° 00'N May 26 1970.

Bluffs above Pigeon River, near High Falls.
Pinus banksiana, Abies balsamea, Betula payrifera Populus tremuloides, Picea glauca. Exposed bed rock and boulders and profuse lichen flora. Dry. Mature stand.

I3C

89° 30'W 48° 40'N June 25 1970.

Opposite entrance to garbage dump, W. end of Hawkeye Lake.
Mature Pinus banksiana, Pinus strobus, Betula papyrifera, Acer spicatum and Alnus sp.
Well drained ridge with north and south facing slope. Sandy soil with small open swamp at foot of south slope.

I4

89° 33'W 48° 38'N June 25 1970.

4 km. E. of S. end of Little Dog Lake, along gravel road.
Steep moraine with creek at bottom. Mature stand of Pinus banksiana, Abies balsamea, Betula papyrifera.
Quite well developed ground flora. Charred wood in soil.
Rather dry.

Continued:

Table 2

I4C

89° 28'W 48°34'N June 25 1970

Ware twp. 7 km. W. of Mapleward Road. By creek, 1 km. N. of road junction.
Fairly mature Abies balsamea, Picea sp and Pinus banksiana. Well developed understorey. Well drained, sandy soil.

I5

89°32'W 48°32'N May 8 1970

Alpilla Road. 3 km. N. of Dawson Rd 1km. past gas pipeline. Fairly open mature stand of Betula papyrifera, Populus tremuloides, Abies balsamea and Pinus banksiana. Near farm. Dry, east facing slope with scattered rocks.

I5C

89° 26'W 48° 28'N May 19 1970

0.5 km. up track at junction of Government and Townline Rds. Mature Abies balsamea and Picea sp. Some B. papyrifera and Sorbus decora. Peaty soil, no exposed rocks. Moist slope.

I6

89° 28'W 48° 22'N May 20 1970

Gravel road. 1 km. N. of Hwy 590. 3 km. W. of Murillo. Mature Fraxinus nigra, Abies balsamea, Populus balsamifera. Few Larix laricina. Moist area near Corbett Creek, subject to flooding. Silty soil, no exposed rock.

I6C

89° 32'W 48°20'N May 13 1970

S. side of Hwy 130. 0.5 km W. of Kaministiquia River. East facing slope of narrow, steep-sided valley. Mature Thuja occidentalis stand on very moist valley floor. Peaty soil. Well drained and sandy on slope.

I7

89° 31'W 48° 18'N May 19 1970

4 km. W. of McClusky's Corners. S.W. slope of Candy Mtn. Well drained, open stand. Mainly mature Populus tremuloides. Little ground flora. Farming area. Moraine.

I7C

89° 27'W 48° 14'N May 28 1970

S. side of Blake Hall Road. 200m. W. of Dept. of Transport entrance.
Populus balsamifera, Abies balsamea, Pinus strobus and Picea glauca. Very mature. Well developed understorey. Run-off area with small creek. Peaty soil on exposed shelves of sedimentary rock. Fairly moist.

Continued:

Table 2

I8 — 89° 34'W 48° 11'N — May 20 1970.

5 km. E. of Walmsley. Gravel road, 1 km. S. of right angle bend on Hwy 597. Sandy area. *Abies balsamea* and *Populus balsamifera*, rather mature. Fairly swampy.

I8C — 89° 20'W 48° 07'N — May 28 1970

S. side of Cloud Bay Road. 0.5 km. E. of Hwy 61. Mature *Populus balsamifera* and *Abies balsamea*. Some *Betula papyrifera*. Swampy area in spring. Peaty soil, no exposed rock.

I9 — 89° 31'W 48° 04'N — May 28 1970.

N. side of Pine Bay Road, 1 km. from Hwy 61. Mature *Fraxinus nigra*, *Picea glauca*, *Populus balsamifera*. Rather swampy in spring, old logging roads. Peaty soil, no exposed rock.

J3 — 89° 23'W 48° 45'N — June 24 1970.

200 m. S. of Dog Lake Resort, East Bay, Dog Lake. Well developed stand of *Picea glauca*, *Abies balsamea*, *Populus balsamifera*, *Betula papyrifera*, and *Pinus strobus*. Thick underbru sh, sparse ground flora with some *Ledum groenlandicum*, *Salix* sp and *Alnus* sp. Very rocky shore area with open grassy areas between rounded boulders. Fairly moist.

J4 — 89° 21'W 48° 40'N — June 24 1970.

S.W. corner of Two Island Lake. Mature *Picea glauca* and *Picea mariana*, *Pinus banksiana*, *Populus tremuloides* *Betula papyrifera* and *Abies balsamea*. Well developed understorey, including *Acer spicatum* and quite well developed ground flora. Well drained moraine.

J4C — 89° 17'W 48° 34'N — June 15 1971.

Gorham Township, W. of road by E. arm of Hazelwood Lake. *Populus balsamifera*, *Picea* sp and *Salix* spp. Mature. Near abandoned farm, still used for grazing. Creek subject to flooding. Peaty soil, no exposed rock. Fairly moist.

Continued:

Table 2

J5 — May 8 1970.

89° 20'W 48° 32'N

Dog Lake Road. 1 km. on first turning E. north of gravel pit.
Thuja occidentalis swamp, very wet in spring. Very mature.
Glacial till and exposed bedrock in immediate area.

J5C — September 13 1970.

89° 17'W 48° 27'N

W. side of Hazelwood Road, 1 km. N. of Hwy 11/17A.
Mature *Larix laricina*, *Picea mariana*, *Betula papyrifera*, *Populus* spp, *Sorbus decora* and *Abies balsamea*. Rather open stand with thick hummocky moss carpet. *Ledum groenlandicum* and *Lycopodium lucidulum* present.
Quite swampy, boulders below surface.

J6 — May 14 1970.

89° 20'W 48° 20'N

Jackpine Road, off Hwy 130. At N.E. corner of area by Grandview Skating rink.
Populus tremuloides, *Abies balsamea*, *Thuja occidentalis*, *Fraxinus nigra*, *Betula papyrifera* and *Corylus* sp. Mature
Rather wet with hummocks of *Sphagnum* sp. Peaty soil.
No exposed rock.

J6C — July 22 1970.

89° 17'W 48° 20'N

Shelf above ski club, N. side of Mt. McKay.
Pinus banksiana, *Picea glauca*, *Populus tremuloides*, *Betula papyrifera* and *Sorbus decora*. Well developed ground flora. Rather dry. On edge of block scree at foot of mesa. Mature stand.

J7 — May 21 1970.

89° 19'W 48° 18'N

S.W. slope of Mt. McRae.
Abies balsamea and *Populus balsamifera* at foot of block scree below mesa. Mature trees. Dry, exposed, little soil.

J8 — May 21 1970.

89° 18'W 48° 11'N

S. side Sturgeon Bay Road, 200 m. from bay. Very mature *Thuja occidentalis*, *Abies balsamea*, *Betula papyrifera* and *Acer spicatum*. Old river bed or spillway with underground water. Boulders below surface of peaty soil.

Continued:

Table 2

K1 — June 19 1971.

89° 16'W 48° 58'N

19 km. N. of Dorion Road on Hwy 800. Mature *Betula papyrifera*, *Abies balsamea*, *Pinus banksiana* and *Picea glauca*. Swampy area, peaty soil over moraine.

K2 — June 19 1971.

89° 12'W 48° 53'N

W. side of Hwy 800, 7 km. N. of Dorion Road. Rocky area, large boulders, possibly part of old river bed. Sedimentary rock outcrops. Thick moss cover under *Picea mariana*. Mature. Fairly dry.

K2C — June 17 1970.

89° 13'W 48° 48'N

Hwy 800, 1 km. N. of Hicks Lake Portage. Well developed stand of *Betula papyrifera*, *Picea* sp. and *Populus tremuloides*. Understorey of young *Abies balsamea* and *Sorbus decora*. Well developed ground flora. Peaty soil, no exposed rock. Moist, but not swampy.

K3C — June 17 1970.

89° 05'W 48° 40'N

Milepost 17, W. side of Hwy 800. Mature stand of *Pinus banksiana*, *Picea mariana*, *Betula papyrifera* and *Populus tremuloides*. Well developed understorey and ground flora. Old logging roads. Peaty soil, no exposed rock. Rather dry area.

K4 — June 15 1971.

89° 14'W 48° 36'N

6.5 km. S. of Onion Lake Dam. *Pinus banksiana* and *Picea glauca*. Plentiful ground lichen flora and *Ledum groenlandicum*. Very swampy, peaty soil over glacial till. Mature trees.

K4C — June 12 1970.

89° 06'W 48° 34'N

Milepost 9, E. side of Hwy 800. Sedimentary rock outcrops and granite boulders. *Picea glauca*, *Sorbus decora* and *Betula papyrifera* in well developed stand with *Alnus* sp and *Acer spicatum* understorey. Well developed ground flora. Rather dry area.

Continued:

Table 2

K5

89° 11'W 48° 32'N

June 12 1970.

W. turn at N. end of Copenhagen Road.
Quite open stand with well developed Picea glauca Abies balsamea, Pinus banksiana, Populus tremuloides, Betula papyrifera and small Thuja occidentalis. Sedimentary rock outcrops and glacial deposits. Fairly dry.

K5C

89° 03'W 48° 30'N

June 1 1971.

400 m. E. of Lakeview Hotel.
Stand of Populus tremuloides, Picea glauca and Abies balsamea. Underground water. Old spillway or river bed. Boulders under peaty soil. Mature trees.

K6

89° 13'W 48° 25'N

August 11 1970.

S. side of McIntyre River near Keefer Terminal. Larix laricina, Picea mariana, Betula papyrifera, Alnus sp. and Populus tremuloides. Dwarf shrubs including Ledum groenlandicum and Chamaedaphne calyculata. Low lying and swampy with thick layer of Sphagnum sp but dry in summer. No exposed rock. Trees mature but small.

K7

89° 10'W 48° 18'N

August 11 1970.

N. edge of Brule Bay, Fort William Indian Reserve. Well developed open stand, including Thuja occidentalis, Abies balsamea, Picea spp. Populus sp and Betula papyrifera, understorey includes Alnus sp and Sorbus decora. Well developed ground flora. Peaty soil, no exposed rock. Moist.

L1

88° 57'W 48° 47'N

June 19 1971.

2.5 km. N. from Wolf Lake Road on Upper Wolf Lake Road. Mature stand of Populus tremuloides, Abies balsamea and Picea glauca. Well developed ground flora. Glacial till. Fairly moist.

L2

89° 02'W 48° 53'N

June 19 1971.

N. side of Dorion Road. 10 km. E. of Spruce river Road. Near abandoned house. Young Betula papyrifera and Abies balsamea. Very tangled undergrowth with much dead fall. Fairly well drained but moist. Peaty soil over glacial till.

Continued:

Table 2

L4C

88° 57'W 48° 33'N

June 22 1970.

2 km. N. of MacKenzie Station.
Well developed stand of Populus balsamifera, Populus tremuloides, Betula papyrifera, Abies balsamea, Pinus bankslana and Picea spp. Very sandy soil, exposed sedimentary rock shelves. Well drained.

L5

88° 58'W 48° 32'N

June 3 1970.

400 m. S. of McKenzie Station.
Near old settlement. Some mature trees but generally young growth. Betula papyrifera, Populus balsamifera Larix laricina, Abies balsamea and Picea glauca. Thuja occidentalis and Picea mariana in swamp at bottom of hill. Sandy soil, probably a moraine. Well drained slope.

M2

88° 50'W 48° 55'N

June 19 1971.

S. Loop of Wolf Lake Road, 24 km. E. of Hwy 800.
Populus tremuloides, Betula papyrifera and Picea sp Thuja occidentalis seedlings and Acer spicatum. Mature. A swampy area with Salix spp. Area of red gravel soil, glacial till.

M3C

88° 43'W 48° 41'N

May 15 1971.

N. end of small lake. W. side of road, 800 m. S. of Amethyst Mine.
Thuja occidentalis swamp. Picea mariana and Betula papyrifera on drier ground. Peaty soil, exposed bed rock in area. Mature trees.

M4

88° 46'W 48° 38'N

May 7 1972.

1 km. W. of West Loon Station.
Mature Betula papyrifera, Abies balsamea, Picea mariana and Populus tremuloides. Well developed understorey which is mainly Acer spicatum. Exposed boulders in peaty soil. Moist but not swampy.

M4C

88° 45'W 48° 34'N

June 19 1970.

S. of Pass Lake Road, 400 m. W. of gate to Sibley Provincial Park.
Open stand with little ground flora. Well developed Picea glauca, Betula papyrifera, Prunus pennsylvanica and Acer spicatum. Small pond, near house. Peaty soil, no exposed rock. Fairly moist.

Continued:

Table 2

M5 — June 3 1970.

88^{o} 50'W 48^{o} 35'N

W. side of Birch Beach Road, near cottages. Open ground, stand with little ground flora. Mature Picea glauca, Betula papyrifera, Prunus pensylvanica and Acer spicatum. Noticeably behind inland areas in development for time of year. Peaty soil, no exposed rock. Fairly moist.

M5C — June 18 1970.

88^{o} 45'W 48^{o} 28'N

Near Lizard Lake, Sibley Park. Mature stand of Thuja occidentalis, Betula papyrifera, Populus tremuloides, Picea glauca and Abies balsamea. Thick undergrowth, swampy in places. Shale outcrops. Fairly moist.

M6 — June 18 1970.

88^{o} 50'W 48^{o} 23'N

N. end of Marie Louise Lake, Sibley. Mature open stand of Thuja occidentalis, Picea glauca, Abies balsamea, Populus spp. Betula papyrifera. Peaty soil, some rock outcrops, swampy area.

M7 — May 22 1971.

88^{o} 55'W 48^{o} 19'N

Tee Harbour, Sibley Park. Dry and rocky with rock slabs on shore. Abies balsamea, Betula papyrifera and Picea glauca. Mature.

N1C — September 5 1971.

88^{o} 37'W 48^{o} 56'N

3 km. W. of Armstrong road on Wolf Lake Road. Low swampy area with reddish sandy soil. Salix spp Picea glauca, Betula papyrifera and Alnus sp. Mature.

N2C — June 23 1970.

88^{o} 34'W 48^{o} 49'N

On Fish Hatchery road, 3 km. N. of Hwy 17. Well developed stand, mainly Populus sp. with some Picea glauca and young Abies balsamea. Very tangled undergrowth with deadfall. Well developed understorey of Alnus sp and Acer spicatum. Moist peaty soil, no rock outcrops.

Continued:

Table 2

N3

88° 35'W 48° 47'N June 23 1970.

N. side of road, 1 km. W. of Ouimet Canyon. Well developed stand of Populus tremuloides, Betula papyrifera, Picea glauca and Pinus banksiana. Understorey of Alnus sp, Sorbus decora and young Abies balsamea. Fairly well developed ground flora. Exposed rock slab. Small creek. Generally fairly moist.

N3C

88° 34'W 48° 42'N May 15 1971.

200 m. S. of gravel pit on track to Ancliff. S. of Hwy 11/17. Open stand of Pinus banksiana, Picea spp, Betula papyrifera, and Populus tremuloides. Understorey of Corylus sp. Acer spicatum and Alnus sp. Well drained gravel area. Mature trees.

N4

88° 38'W 48° 39'N June 22 1970.

Pearl Road, 2 km. W. of crossing with Pearl River. Vertical banks by road with Pearl River at foot. Well developed stand of Picea sp. Betula papyrifera and Populus tremuloides with thick understorey of Acer spicatum and Alnus sp. Well developed ground flora. Moraine. Rather moist but not swampy.

N5

88° 38'W 48° 31'N June 19 1970.

E. of Squaw Bay Road, near Moonlite Beach, Sibley Peninsula. Dense new growth except for some Populus tremuloides Abies balsamea and Betula papyrifera. Understorey mainly of Acer spicatum. Peaty soil, no exposed rock. Moist.

N6

88° 45'W 48° 25'N June 18 1970.

N. side of Silver Islet Road near Pickerel Lake and Addison Lake Trail. Very mature stand of Pinus strobus and Thuja occidentalis in hollow at top of steep rocky bank 100 m. above lake. Peaty soil, much deadfall. Moist but not swampy.

N7

88° 45'W 48° 21'N May 22 1971.

Edge of Middlebrun Bay, Sibley Peninsula. Picea mariana and Thuja occidentalis swamp. Very mature. Sand beach backed by swamp.

Continued:

Table 2

O1 88° 33'W 48° 39'N — September 5 1971.

17 km. N. of Hurkett on Armstrong Road.
Abandoned settlement with old track. Well drained and dry. Alnus sp. scrub and Pinus banksiana. Young stand. No rock outcrops.

O2 88° 33'W 48° 53'N — September 5 1971.

W. side of road at W. end of Stewart Lake.
Well developed stand of Betula papyrifera with Acer spicatum and Abies balsamea.
Steep sedimentary rock face, well shaded E. facing. Dry.

O3 88° 31'W 48° 48'N — September 11 1971.

W. end of Bonavista Camp site, 2 km. S. of Wolf River.
Batula papyrifera, Abies balsamea and Populus balsamifera. Well developed ground flora. Some parts of area cleared. Peaty soil, no rock outcrops. Well drained. Mature trees.

P1 88° 20'W 48° 54'N — September 11 1971.

Hwy 17, 1 km. E. of Beaver Valley Camp site at foot of Red Rock cuesta.
Open stand of Betula papyrifera and young P. tremuloides. Corylus sp. present with well developed ground flora. Well drained rocky slope.

P2 88° 22'W 48° 54'N — September 11 1971.

100 m. W. of Black Sturgeon River, N. side of road.
Mature open stand of Picea glauca, Populus tremuloides and Betula papyrifera. Moister area containing Picea mariana and Larix laricina. Peaty soil no rock outcrops.

APPENDIX II

ANNOTATED CHECK LIST

The phylogenetic arrangement and nomenclature used in this check list are according to Grolle (1972) for families and Schuster (1969, 1966, and 1953) for genera and species, with the exception of *Pellia endiviifolia* (*P. fabbroniana*) (Paton, 1965) and *Riccia cavernosa* (*R. crystallina*) (Paton, 1967). The names of authorities have been abbreviated according to Sayre, Bonner & Culberson (1964).

Numbers of collections and percentage of sites on which each species was found refer to collections made during this study only, although information is also drawn from other available collections, and the first record and first publication of each species from the study area are indicated.

In addition to the 94 species so far recorded in the study area the check list includes three species cited by Crowe & Barclay-Estrup (1971), *Scapania nemorosa*, *Odontoschisma denudatum* and *Odontoschisma macounii* which have been rcorded just outside the study area and which are considered likely to be found within the study area in future.

J U N G E R M A N N I A L E S

PSEUDOLEPICOLACEAE

1. Blepharostoma trichophyllum (L.) Dum.

189 collections, recorded on 70% of sites.

First record: Grass Lake, Silver Islet, Sibley Peninsula. September 1958. C.Garton 5541.

First published: Crowe & Barclay-Estrup (1971).

Arnell (1956) lists this species as arctic-alpine and MacVicar (1926) implies a similar distribution; but Paton (1965) shows a wide dispersal throughout Britain. Schuster (1953) suggests a more boreal range which fades out in the temperate zone except in microenvironments. A similar distribution is recorded in New York state (Schuster, 1949). B. trichophyllum is widely distributed in the study area, in both forest and tundra-type situations.
Circumpolar (Schuster, 1966).

Generally found as a member of a rotting log associule, most commonly associated with Jamesoniella autumnalis and Lophocolea heterophylla and also with Geocalyx graveolens and Cephalozia media. Lepidozia reptans and Nowellia curvifolia are often in the same associule. On rocks it is associated with Lophozia barbata and on soil with Calypogeia integristipula. A pure stand was collected once from talus in Ouimet Canyon. This species cannot tolerate exposed, xeric sites and is most prolific on permanently moist sites. Similar ecological requirements are recorded for other regions (MacVicar, 1926: Arnell, 1956: Schuster, 1966).

This common species is found at all distances from Lake Superior and at all elevations. Easily recognized by the characteristic feathery appearance of the deeply divided leaves. The single strand of cells in each leaf lobe is reminiscent of an algal filament. The colour and size vary but it is always comparatively small. Sporophytes are found.

PTILIDIACEAE

2. Ptilidium ciliare (L.) Hampe

8 collections, recorded on 7% of sites.

First record: Sleeping Giant, Sibley Peninsula.
August 2 1956. C.Garton 2940.

First published: Crowe & Barclay-Estrup (1971).

This bi-polar species is widespread in arctic-boreal regions and also occurs in Patagonia and New Zealand (Arnell, 1956). This seems to indicate an ancient origin (Darlington, 1965).Possibly, Ptilidium pulcherrimum, which is more vigorous and has a wider ecological amplitude (Schuster, 1966), has evolved from it. The scarcity of P.ciliare in the study area may be due to competition with P.pulcherrimum.
Arctic-boreal and circumpolar in the northern hemisphere (Schuster, 1966).

No special preference seems to be shown with respect to site factors but, with one exception, the records are from the eastern half of the area. Organic soil is a common substrate, both in black spruce swamps and on the dry forest floor, but it also occurs on rock. On one occasion it was found associated with Scapania irrigua in a rock crevice in a diabase sill on the very edge of Lake Superior. Schuster (1966) suggests that this species is basically epilithic, although rock may not actually be visible where specimens are found. Arnell (1956) notes its absence from calcareous ground and this may partially account for its rarity in the study area. P.ciliare was not recorded on wet sites, and Schuster (1953) implies that it tolerates more xeric conditions than P.pulcherrimum. The latter has, however, been observed on some very dry sites in the study area but not on sites which are both dry and exposed to light. P.ciliare seems more able to survive these conditions.

The fringed, bilobed leaves are completely characteristic of P.ciliare and P.pulcherrimum. P.ciliare differs from the latter as follows: The larger, antical lobe is 15 or more cells wide (MacVicar, 1926), the cilia are short and the colour tends to purplish red when exposed. Sporophytes have not been found in this area.

3. Ptilidium pulcherrimum (Web.) Hampe

240 collections, recorded on 93% of sites.

First record: Silver Mountain. June 8 1958. C.Garton 5492.

First published: Crowe & Barclay-Estrup (1971).

This ubiquitous species is the most common recorded during this study. The range of this species is sub-cosmopolitan covering a large part of the northern hemisphere but not extending into tropical regions.

P. pulcherrimum occurs on every type of site and substratum recorded in this study. This species is most often confined to the base of living trees, probably due to a high humidity requirement (Schuster, 1957). On one occasion it was collected 2 m up a live cedar but this was growing in what may have been a fog hollow at the top of a steep slope on Sibley Peninsula, where the average relative humidity was probably abnormally high. This species is very often a member of the *Jamesoniella-Lophocolea* associule on rotting logs but it also occurs with *Radula complanata* and *Frullania eboracensis* on living trees. Frequently found alone under conditions no other hepatic will tolerate.

P. pulcherrimum is almost always tinged with golden-brown, the antical leaf lobe is 10 cells or fewer wide. Generally a flat mat is formed but large tufts, reminiscent of *P.ciliare*, were found on talus blocks in Ouimet Canyon. Growth form, as suggested by Arnell (1956), does not appear to be a good separating character in the study area. Sporophytes are found frequently and spores are freely produced in early spring.

LEPIDOZIACEAE

4. *Lepidozia reptans* (L.) Dum.

146 collections, recorded on 61% of sites.

First record: Mount McKay. Oct. 14 1957. C.Garton 5456.

First published: Crowe & Barclay-Estrup (1971).

This boreal species is restricted to the Taiga in the north and only occurs in boreal microhabitats further south

Schuster (1969). It is common in this area but not universal. The local distribution does not suggest a relationship with any particular site conditions. Circumpolar.

L. reptans is found mostly on organic soil and rotting wood but it is also occasionally found on rock, usually on a thin humus layer. This species is often a member of the *Jamesoniella- Lophocolea* associule on rotting logs and is even more frequently associated with *Geocalyx graveolens* . Schuster (1947) suggests a loss of tolerance for lime in more temperate regions, possibly due to clinal variation or merely the interaction of habitat factors. In this respect, the area under consideration seems to be in a transition zone as this species occurs on both organic and inorganic substrates, but more commonly on the former than would be expected in more typical boreal regions (Schuster, 1969).

Characteristic of this species are the 3-4 finger-like lobes on the incubously arranged leaves. Underleaves are always clearly visible and similarly lobed. Capsules are frequently found.

5. *Bazzania trilobata* (L.) S.F.Gray

7 collections recorded on 6% of sites.

First record: S.W. corner of Whitefish Lake.
May 7 1960. C.Garton 7193.

First published: Crowe & Barclay-Estrup (1971).

Schuster (1953) refers to this species as widespread in the Taiga but in 1969 this is changed to essentially of temperate to warm-temperate range. B.trilobata is widely distributed in the northern hemisphere but is mainly sterile in Fennoscandia (Arnell, 1956). Its sterility in the study area may indicate that this is the edge of its range. Schuster (1969) postulates a sub-oceanic distribution. Williams (1960) found it on the Gaspé Peninsula and it was collected by the writer on Isle Royale in 1972. Noticeably absent from the central provinces of Canada (Bird, 1966), it appears again in British Columbia (Schofield, 1969). Leif Tibell of Uppsala University (Personal communication) commented on the similarity of the lichen flora in the study area to that in the oceanic regions of northwestern Europe. This similarity may account for the presence of B.trilobata in this area. With one exception, its distribution in southwest Thunder Bay District seems to be related to the presence of large bodies of water where a relatively high atmospheric humidity would be expected. However, this does not account for its comparative rarity as there are many other sites in the area which would fulfill these requirements. Boreal-temperate and circumpolar (Schuster, 1969).

This species is found only on stumps in an advanced state of decay or an organic soil, generally in a pure colony but an association with L.reptans has been recorded. The small number of collections showed no particular preference for any special site conditions but the well decayed organic substrates may indicate that this is a calciphobe species, although it will grow on humus over calcareous rocks (Schuster, 1969). Arnell (1956) specifies siliceous rocks.

This species is easily distinguished by the three small teeth at the leaf apex and the large, broadly oval, crenate underleaves. No sporophytes were observed.

CALYPOGEIACEAE

6. *Calypogeia integristipula* Steph.

81 collections, recorded on 33% of sites.

First record: Sturgeon Bay. June 4 1961. C.Garton 8478.

First published: Crowe & Barclay-Estrup (1971)

Before discussing the geographical distribution of this species it is necessary to make some comments on its distinction from two related species, *Calypogeia muelleriana* and *Calypogeia neesiana*. Aside from the differences in oil bodies, which can only be determined when fresh, *C.muelleriana* is said to have somewhat wider leaves and *C.neesiana* a clearly defined border of regular cells (Schuster, 1969). There has been considerable confusion between these two species, complicated by the fact that most European material has been determined as *C.meylanii* (Schuster, 1969). It is possible to find specimens approaching both *C.muelleriana* and *C.neesiana* in this area but they appear to the writer to be variations of a single species. Williams has not determined anything but *C.integristipula* from this area. Examination of Garton's collections, in which 6028 had been determined as *C.muelleriana* and 4410 as *C.neesiana* by Dr. Howard Crum some years ago, showed no substantial morphological differences from recent collections, although the oil bodies no longer exist so it is not possible for them to be re-determined accurately. Schuster (1969) specifically refers Garton's *C.neesiana* to *C.integristipula*. It has, therefore, been decided to drop these two doubtful species from the check list as they have not been found again recently. It seems likely that these three species occur in different geographical regions but are closely related. The species which occurs here corresponds very closely to the C.meylanii (now C.integristipula, Schuster, 1969) described by Schuster, (1953) in Minnesota. It is interesting that Dr. Norton Miller determined a species from Manitoba (Longton, 1972) as C.neesiana, although Schuster, (1969) states that it does not occur in mid-continental regions. Dr.Miller is accustomed to working in an area which Schuster (1969) describes as a stronghold of C.neesiana. This may be an indication that C.integristipula and C.neesiana are really one species. There seems to be somewhat better evidence for supposing that C.muelleriana is a separate species (Schuster, 1969) but it has not been found here during this study. It has, in fact, only been reported twice from Ontario (Schuster, 1969), the nearest station being Manitoulin Island. Certainly, all citations of these species in check lists should be regarded with scepticism. This is even more true of C.trichomannis (Schuster, 1953). Oil bodies have a tendency to look blue under the microscope and the variation in leaf width which occurs in other species can be confusing. Schuster (1969) suggests that most determinations of C.trichomannis in North America should be referred to C.muelleriana.

Undoubtedly this genus needs a thorough working over, especially from the cytological angle. C.integristipula is classed here as a boreal-temperate species but this would probably better describe the distribution of the Calypogeia neesiana-integristipula-muelleriana complex (Schuster, 1969). It is at least amphi-atlantic (Arnell, 1956) but because of the confusion in nomenclature there are some uncertainties about its overall distribution.

In this area it is moderately common and seems to be exhibiting no particular preference for general site conditions. It frequently occurs on rotting wood, especially in moist areas and also on organic soil. It will occasionally be found on a thin humus layer over rock. Schuster (1969) mentions a shade requirement and it is possible that this helps control its distribution here as it does not occur in exposed areas.

Leaving aside its doubtful distinction from C.neesiana, it is easily recognized in the field by its incubously arranged, entire leaves, bluish green in colour. It has large ovate under-leaves, which are usually notched. Frequently produces gemmae on shoots with reduced leaves but sporophytes were not found.

7. Calypogeia sphagnicola (Arn. & Perss.) Warnst. & Loeske

Not collected during the present survey.

First record: Silver Falls Road. October 13 1958. C.Garton 5854.

First published: Crowe & Barclay-Estrup (1971).

C.sphagnicola is a boreal species with an amphi-atlantic distribution (Schuster, 1969). As its name implies it is a species found associated with Sphagnum, usually in peat bogs. It has been collected twice in this area by Garton, on Sibley Peninsula and in a Sphagnum bog in the Kaministiquia valley. In spite of examining hundreds of handfuls of Sphagnum spp, it was not recorded by the writer in this area although it was collected on Isle Royale. True Sphagnum bogs are rare in the study area and this species apparently does not grow associated with the species of Sphagnum frequently found in Black Spruce swamps and on somewhat drier forest floors. Even so, a careful search at Middlebrun Bay, which is an open Sphagnum bog, did not produce a specimen. This may be an indication that it is really rare in this region and that there is some microclimate or edaphic factor which accounts for this.

The only species in the study area with which C.sphagnicola could be confused is Calypogeia suecica. Both species are small and of similar appearance, the underleaves are bilobed but in C.sphagnicola they tend to be longer than wide and in C.suecica wider than long. C.suecica has a chromosome number n=9, in C.sphagnicola n=18 (Schuster, 1969), suggesting that the latter is a diploid of C.suecica specially adapted to a close association with Sphagnum. Calypogeia integristipula, which may be found growing with Sphagnum is generally larger and has more rounded leaves and underleaves. Sporophytes have not been found in the study area.

8. Calypogeia suecica (Arn. & Perss.) K.Mull.

9 collections, recorded on 9% of sites.

First record: Near Cascades, Current River. May 19 1969. J.Crowe 174.

First published: Crowe & Barclay-Estrup (1971).

C.suecica is at least amphi-atlantic in distribution (Arnell, 1956), but also occurs in British Columbia (Schofield, 1969) so may be circumpolar. This is a true boreal species (Schuster, 1969) which Arnell (1956) says is rather rare in Scandinavia, and which does not seem to be common in the study area. This species is confined to the eastern half of the area (see distribution map) but there seems to be no clear reason for this.

In the study area it always occurs as a component of a rotting log associule. It is an obligate xylicole (Schuster, 1969) and Schuster quotes Buch (1936) as stating that it occurs almost invariably on spruce and fir logs. This is rather difficult to determine when the log is rotting, especially as Schuster (1969) states that it is not a true pioneer but occurs after the associule is established, but it could well be true in the study area. This could account for its sporadic occurrence. In addition its small size and habit of growing intermixed with other species may often cause it to be overlooked. Sporophytes have not been found.

JUNGERMANNIACEAE

9. Chandonanthus setiformis (Ehr.) Lindb.

1 collection, recorded on 1% of sites.

First record: Ouimet Canyon May 20 1957. C.Garton 4483.

First published: Williams & Cain (1959)

This extremely rare arctic species is imperfectly circumpolar in range (Schuster, 1969). It has only been found in Ouimet Canyon and only in a small area at the lower end. There are other canyons in the area and Garton is at present investigating one with a similar arctic flora at Cavern Lake. It is possible that it could be found there. Schuster (1969) describes C.setiformis as an old species, a relic of former geological ages. Like most of these it is a pronounced oxylophyte. The soil at the rim of the canyon (in a dry, not boggy, area) had a pH of 4.4 Acid rocks are unusual in this region and this may be an important factor in limiting this species to this one site.

This is an epipetric species and has been found growing on the sheltered north faces of the talus blocks which lie jumbled over the floor of the canyon.

It is easily recognized by its primitive 3-4 lobed and toothed leaves and large underleaves. It exhibits the golden colour of many of the bryophytes growing in Ouimet Canyon, which may be due to the north-south orientation, which exposes the floor to powerful insolation. Certainly, the collection of Anastrophyllum saxicola, which also occurs at Ouimet, from the less exposed Cavern Lake Canyon is much greener.
Only sterile specimens have been found.

10. Lophozia alpestris (Schleich.) Evans

Not collected during the present survey.
First record: Mount McKay June 1 1958. C.Garton 5447.
First published: Crowe & Barclay-Estrup (1971)

L.alpestris is essentially an arctic-boreal species of circumpolar distribution (Schuster, 1969). It may be true that this area represents its southern limit and this accounts for its rarity. Garton has collected it in the upper Kaministiquia valley, in Ouimet Canyon and near the Wolf River as well as on Mt. McKay, where it has also been collected by the writer on a sheltered north facing slope but this was not in the course of this study. In Minnesota its distribution is limited to arctic-boreal microhabitats (Schuster, 1953), this may also be true in in the study area.

An epipetric and pioneer species which Arnell (1956) suggests, avoids calcareous substrata. This also seems to be true in more southerly stations in the United States (Schuster, 1969) and may be another factor affecting distribution in the study area.

This small species can be distinguished from other small bilobed Lophozia spp by brownish pigmentation and the presence of reddish brown gemmae. Sporophytes have not been found in the study area.

11. Lophozia ascendens (Warnst.) Schust.

7 collections recorded on 6% of sites.

First record: Alpilla Road, I5. May 8 1970. J.Crowe 303. Unpublished.

This boreal species, at present shows an amphi-atlantic distribution. This may eventually prove to be circumpolar as it is a rather rare species (Arnell, 1956). Schuster (1969) mentions a recent report from Asia. In the present area the distribution parallels the lakeshore but some kilometres inland. In view of the small number of collections, it would be impractical to draw any conclusions from this, although it would be a very interesting distribution if further collecting confirmed this pattern.

It has been found mainly as a member of rotting log associules but one collection was made from organic soil on a path. This is very much the same as the ecological preferences cited in Schuster (1969) as well as in Arnell (1956).

This is a small species with bilobed, yellow green leaves and a tendency for the leaves to become reddish. It may be confused with L.longidens in which the immature gemmae are greenish and L.porphyroleuca, which is of similar size and colouring. However, L.longidens is always green, except for the gemmae and L.ascendens has a more erect habit than L.porphyroleuca. Sporophytes have not been found.

12. Lophozia attenuata (Mart) Dum.

2 collections, recorded on 1% of sites.

First record: Stewart Lake. 02. Sept.5 1971. J.Crowe 1190. Unpublished.

This is a boreal species. Muller regarded it as having circumpolar distribution, although Schuster (1969) is sceptical and there seems a possibility of confusion in some areas with L.binsteadii or L.atlantica. There seems little likelihood of such an error in this area, although Schuster reported a dubious specimen of L.atlantica from the Big Susie Islands (Minnesota) in 1953. L.atlantica is generally considered to be oceanic and L.binsteadii is arctic-alpine.

It was found on only one site; one collection was made from a crevice in the precambrian greywacke outcrop and one from bark which lay on the surface of the rock. It may be significant that this site was at the eastern end of the study area. It has been collected by Garton in the Wawa region approximately 350 km to the east. Although the site on which it was collected was unusually rich, similar conditions were met elsewhere in the area. Schuster (1969) regards it as a species with a wide tolerance and a nearly ubiquitous distribution in the spruce-fir zone. As it is not easily confused with any other species, except the two mentioned above, it appears that it is not ubiquitous in this area. A possible explanation would seem to be a slow post-glacial invasion. The distribution in Minnesota (Schuster, 1953) seems to correspond with the shore of Lake Superior and it may be that this continues into Ontario but it has not been found in the few sites covered in that part of the study area. It is conceivable that it could be moving in from the northeast. Future collecting should be of special interest with respect to this species.

Although Arnell (1956) classes this species as calciphobe it does not appear to be so in North America (Schuster, 1969) and the situation in which these specimens were found does not seem to indicate any such preference.

It is medium sized and easily recognized by the filiform, usually gemmiferous shoots, with scarcely bilobed leaves which innovate at the tip of mature shoots bearing clearly trilobed leaves. Sporophytes were not found.

13. Lophozia badensis (Gott. ex Gott. & Rabenh.) Schiffn.

Not collected during the present survey.

First record: Trowbridge Falls. Oct 19 1958. C.Garton 5893.

First published: Crowe & Barclay-Estrup (1971)

This species is circumpolar and widespread in the northern hemisphere, extending well into the tundra. It is found throughout the boreal forest and further south than any other member of the sub-genus Leiocolea (Schuster, 1969). It has only been reported once from the study area having been found on shale ledges near Current River. This is a typical habitat for this obligate calciphyte (Schuster, 1969; Arnell, 1956).

It seems likely that it is a matter of chance that it has not been picked up again. It possibly exists mainly on inaccessible rock ledges. A high humidity requirement is mentioned by Schuster, (1969). This area is not as foggy as regions to the east of Nipigon, where it has been collected by Williams (personal communication). This may be an important limiting factor in this area.

This is not an easy species to identify, especially if sterile. It is rather translucent and tends to grow as scattered stems among other bryophytes. It is rather similar to Lophocolea minor but the rhizoids are scattered along the stem and there are no underleaves, whereas in L.minor the rhizoids initiate at the base of distinct underleaves. L.minor also produces gemmae which L.badensis does not. When fertile the tubular, beaked perianths indicate that it is a species of Leiocolea.

14. <u>Lophozia barbata</u> (Schmid.) Dum.

61 collections, recorded on 26% of sites.

First record: Camp Bay, Silver Islet. April 4 1959. C.Garton 6005. First published: Crowe and Barclay-Estrup (1971).

Until recently, most reports showed that this species had an amphi-atlantic distribution but it has been found in Siberia and Japan (Schuster, 1969) so it is probably circumpolar. While it extends into temperate and arctic regions it is basically a boreal species (Schuster, 1969). It is widely distributed in this area and, until recently, was the second most common species in Lakehead University Herbarium (Crowe & Barclay-Estrup, 1971). This seems to have been largely due to its size and rather dark, dull green which enable the eye to distinguish it from mosses. The present percentage is probably a more realistic figure.

This is essentially an epipetric species, although it has been collected on rotting wood, soil and even from the base of a tree but, in all these cases, rock was to be found just below the surface. Very often it was a granite boulder but it has also been found on talus, quartz and limestone. Schuster (1969) describes it as having a wide ecological tolerance but Arnell (1956) indicates that it prefers siliceous rocks. It may be that it is able to tolerate more calcareous substrates when other conditions, such as moisture, are specially favourable or when there is an adequate layer of humus to act as a buffer.

It is the only large species with 4-lobed leaves recorded from the study area. Poorly developed specimens may have leaves which are only two or three lobed but these are always characteristically triangular and blunt. The underside of the stem is frequently reddish pigmented and is covered with a thick mat of rhizoids, but there are no noticeable underleaves. It has two close relatives; L.hatcheri (Evans) Steph. and L.lycopodioides (Wallr.) Cogn. The former has been found near Schreiber (east of Thunder Bay) and the writer found it common on Isle Royale. L.hatcheri usually has plentiful reddish brown gemmae; L.barbata is gemmae free. It is possible that L.hatcheri will be found in this area but Williams (personal communication) could not find it in likely habitats in 1972. L.barbata is considered by Schuster (1969) to have a wider ecological tolerance than L.hatcheri and it may be that there is some climatic limiting factor acting on this distribution. L.lycopodioides, which also has mucronate tips to the leaf lobes, is more specifically alpine (MacVicar, 1926) and it seems unlikely that it will be found in this area. The specimens of L.barbata which have been collected have been uniformly sterile.

15. Lophozia bicrenata (Schmid.) Dum.

3 collections, recorded on 3% of sites.

First record: East Bay, Dog Lake (J3). June 24 1970.
J. Crowe 777. Unpublished.

L.bicrenata is widely distributed in North America and is certainly amphi-atlantic. It may be circumpolar but it has not yet been reported from Eastern Siberia and Japan (Schuster, 1969).

It was only collected three times during this study but in every case it was found on leached, inorganic, sandy soil, on old logging roads. Schuster (1969) regards it as favouring sites where there is low organic content, low calcium content and low pH. These are rather specific requirements which do not occur in combination very often in this area. Low pH is usually accompanied by high organic content and sites with low calcium content are also rare. This may account for the small number of collections.

It can only be confused with L.excisa, which grows in somewhat similar habitats but has a wider range of tolerance for calcium (Schuster, 1969). L.bicrenata usually has reddish stellate gemmae and a very noticeable characteristic, at least in this area, is the presence of leaves with edges eroded by gemmae formation; this does not occur in L.excisa (Schuster, 1969). Sporophytes have not so far been found.

16. Lophozia capitata (Hook.) Boulay

1 collection, recorded on 1% of sites.

First record: Spruce River Road (Hwy 800) K3C. June 17 1970. J. Crowe 656. Unpublished.

Although L.capitata extends into boreal regions, it seems to be largely a temperate species and, as reported so far, has an amphi-atlantic distribution. (Schuster, 1969).

Schuster (1969) regards it as a species largely confined to old dune regions, or old lake beaches covered with peaty deposits. It is possible that the one site on which it was found conforms to this requirement as there are many traces of post-glacial lakes in the area. The collection was made from peaty ruts in an old logging road and included Pellia neesiana. Arnell (1956) regards this species as rare and Schuster (1969) refers to the distribution in eastern North America as 'peculiar'. An ecological requirement of continuous moisture on a well drained soil may be the determining factor in this case.

MacVicar (1926) confuses this species with L.excisa. L.capitata has smooth green gemmae and frequent 3-4 lobed leaves, whereas L.excisa has bilobed leaves and purplish gemmae. The latter is also found on drier, less organic substrates. The only specimen of L.capitata was sterile.

17. Lophozia excisa (Dicks.) Dum.

3 collections, recorded on 2% of sites.

First record: Mt. McKay. September 28 1969. J.Crowe 223.

First published: Crowe & Barclay-Estrup (1971).

L.excisa is a boreal species with a range extension both north and south (Arnell, 1956). The main distribution is amphi-atlantic, so far, although it occurs in British Columbia (Schofield, 1969). This bipolar, and probably ancient, species (Schuster, 1969) has a scattered distribution in the northern hemisphere. This may mean it is limited to sites inhospitable to most plants, by competition from more vigorous, newer species. The small number of collections here appear to fit this interpretation of its distribution; and it seems to be very similarly distributed in Minnesota (Schuster, 1953). This pioneer species was found with sporophytes in the original collection. The ability to produce spores would enable it to colonize suitable niches as they became available.

Found on thin soil over rock, often on the edge of rocky paths. The collections so far have been restricted to rocky elevations not far from Lake Superior.

This species can be confused with L. bicrenata or L. capitata as they are found in similar habitats. The distinguishing morphological features are listed under the former species.

18. Lophozia heterocolpa (Thed.) Howe

1 collection, recorded on 1% of sites.

First record: Sibley Peninsula. April 4 1959. C.Garton 6008

First published: Crowe & Barclay-Estrup (1971).

Although this species is found in the boreal zone, it appears to be restricted to arctic microhabitats. Thus, it may be classed as an arctic species. The distribution is amphi-atlantic and transcontinental in North America so it may be circumpolar, although it has not yet been reported from eastern Asia (Schuster, 1969). The sole collection in the course of this study was made on Mt. McRae. Garton has found specimens on Sibley Peninsula and in Ouimet Canyon. The writer also collected this species at the latter station in 1969.

The record for Ouimet Canyon is rather surprising (cf. C.setiformis) as both Arnell (1956) and Schuster (1969) regard it as a species of basic rocks. The pH of the soil on Mt. McRae was 5.5 which is not at all basic, although it is higher than on the site near Ouimet. Steere (1937) regarded it as a secondary species and it seems likely that it does not actually grow on basic rocks but requires the presence of a modifying layer of humus.

This is the only species of Lophozia with bilobed leaves and erect gemmiparous shoots, occurring in the study area. L.attenuata has 3-lobed leaves and Anastrophyllum hellerianum is much smaller with filiform shoots and scarlet gemmae, not brownish as in L.heterocolpa. Sporophytes were not found.

19. Lophozia incisa (Schrad.) Dum.

34 collections, recorded on 18% of sites.

First record: Silver Mountain. June 8 1958. C.Garton 5477

First published: Crowe & Barclay-Estrup (1971).

Lophozia incisa seems to be essentially boreal and circumpolar in distribution (Schuster, 1969). It is interesting that, in this area, it appears to be restricted to the region of late precambrian rocks, It is difficult to see the reason for this as it is a humicolous species and it seems unlikely that it would be dependent on the bed rock in any way.

In the study area it is only found on organic substrates in an advanced state of decomposition, commonly on rotting stumps which are just on the point of disintegrating. It may be that its present distribution is associated with the period at which logging took place in the area, so that the zone in which it was found contains logs and stumps at the right stage of decomposition. Its habitat requirements cause it to be found associated with other rotting log species, such as Jamesoniella autumnalis, Lepidozia reptans and Blepharostoma trichophyllum. It cannot really be said to be a member of these associules as it is not found when the log or stump is not in a suitably advanced state of disintegration. It seems more likely that, when found with these species, it is in the process of invading a log which is progressing beyond the stage of decay where it is a suitable habitat for the associule. On very disintegrated stumps it is frequently found in pure patches, where its bright jewel-like green makes it easy to pick out with the naked eye. It had not been found frequently before this study, probably because of the bias towards rocky sites. The present percentage is probably a more realistic estimate of its importance in the local hepatic flora.

This species is easily recognized by its opaque blue green colour and the production of 'cabbage-like' heads composed of wavy toothed leaves packed tightly together, forming a tight turf. Capsules were found occasionally, also pale green gemmae.

20. Lophozia longidens (Lindb.) Macoun

28 collections, recorded on 16% of sites.

First record: Silver Mountain. June 8 1958. C.Garton 5484.

First published: Crowe & Barclay-Estrup (1971).

L.longidens is basically a boreal species, at least amphi-atlantic and probably circumpolar, as it is transcontinental in North America (Schuster, 1969). Its occurrence in this region is sporadic and seems unconnected with any recorded site factor. It is possible that this is an obligate shade species (Schuster, 1957) but it is impossible to tell from one brief visit to a site the precise light regime on a particular log or rock (Warren-Wilson, 1965). Strong light for even one portion of the day might be sufficient to exclude an obligate shade species. This would account for a species which otherwise seemed to have a wide habitat tolerance, not being evenly distributed through a given area. It is noticeable that Lorenz (1910, ex Schuster, 1969) found it most common on the east and north side of living trees, which suggests that light or humidity was controlling distribution.

In the study area it is rare on live trees, having been found only once on a live cedar. It is mainly found on rotting logs, where it may be associated with the Jamesoniella-Lophocolea associule, or on humus layers over various types of rock. Schuster (1969) and Arnell (1956) agree that this species avoids basic sites.

The rather rectangular bilobed leaves and bright red (when mature) gemmae, distinguish this species from any other member of the genus found in the study area. Specimens with immature gemmae might be confused with L.ascendens but it is usually possible to find some gemmae which show reddish colouration. Sporophytes occur occasionally.

21. Lophozia marchica (Nees) Steph.

1 collection, recorded on 1% of sites.

First record: Silver Falls Road. October 13 1958. C.Garton 5857

First published: Crowe & Barclay-Estrup (1971).

L.marchica is found from the boreal region into the tundra (Schuster, 1969). As recorded at present, it has an amphi-atlantic distribution, but it does also occur in British Columbia (Schofield, 1969).

This is an obligate bog species. It was collected by Garton in the bog in the upper Kaministiquia valley and by the writer at Middlebrun Bay. Schuster (1969) describes it as being found in open bogs and this is true of the locations where it has been found in the study area. It does not appear to grow among the species of Sphagnum growing in densely shaded areas, such as Black Spruce swamps.

It is a small species, usually with trilobed leaves and, in view of its habitat requirement, is not likely to be confused with any other species. It is related to L.capitata and has been considered conspecific to it in the past (Schuster, 1969) but L.marchica can usually be distinguished by its tendency to develop reddish pigmentation. Sporophytes were not found.

22. Lophozia porphyroleuca (Nees) Schiffn.

4 collections, recorded on 4% of sites.

First record: Devon township. 6 km S. of Jackpine. G9.

June 15 1970. J. Crowe 638.

Unpublished.

L.porphyroleuca is a boreal species which appears to be circumpolar (Schuster, 1969). *L. ventricosa* is closely related and there has been confusion with *L.ascendens* (Schuster, 1969). There seems to be some doubt as to which of this group are good species and which merely varieties. This confusion has led to some uncertainty as to the world distribution of *L.porphyroleuca*. Schuster (1969) regards it as a disjunct in the Great Lakes region, the main range seems to be in the oceanic northeast.

Specimens have only been collected from rotting wood. Arnell (1956) specifies fallen trunks of conifers, this may be true here. Collections have only been made from sites with a pH between 5.2 and 5.7 but, in view of the small number of collections, this may not be significant.

Carmine pigmentation is the distinguishing feature of *L.porphyroleuca*. Gemmae are absent. In *L.ascendens*, which may develop reddish pigmentation, gemmae are always abundant (Schuster, 1969). Sporophytes were not found in the study area.

23. *Lophozia rutheana* (Limpr.)Howe

2 collections recorded on 1% of sites.

First record: Middlebrun Bay. September 21 1969.
P.Barclay-Estrup 2119.

First published: Crowe & Barclay-Estrup (1971).

L.rutheana, as recorded at present, has a clear amphi-atlantic distribution, but extends into Sibera (Arnell, 1956). Schuster regards it as an arctic species but it is found well into the United States (1969). Dr.Norton Miller (personal communication) suggests that its distribution is more allied to its ecological requirements. It is always found in rich wet fens or calcareous cedar swamps and bogs (Schuster, 1969).

The single site in the study area on which this species was found is one which provides arctic conditions. The edge of the swamp is within 5 m. of the Lake Superior shore on the exposed eastern side of Sibley Peninsula. Ice was present just under the surface of the Sphagnum on May 22 1971. At the same time this is undoubtedly a calcareous site. The sand beach registered an average pH of 7.0 with a field pH meter. Water running off the swamp averaged 7.5 in pH, although readings taken in the surface of the Sphagnum averaged 4.4.

This rather large, lax species has large leaf cells and is very similar in superficial appearance to Chiloscyphus pallescens except that it has bilobed leaves. Sporophytes were not found.

24. Lophozia ventricosa (Dicks.) Dum.

50 collections, recorded on 23% of sites.

First record: Ouimet Canyon. September 13 1958. C.Garton 5613.

First published: Crowe & Barclay-Estrup (1971).

L.ventricosa is considered by Schuster (1969) to be circumpolar but he does not give any supporting evidence for this statement. However, it is recorded from right across Canada (Bird 1966; Schofield, 1969). While it appears basically boreal (Arnell, 1956), it also extends into the arctic and south as far as Tennessee (Schuster, 1969). It is fairly well distributed throughout the study region but it is by no means universal.

It has quite a wide ecological tolerance as it is found on rotting logs, moist organic soil and on a humus layer on various types of rock. On rotting logs it is frequently found associated with *Jamesoniella autumnalis*, *Lepidozia reptans* and *Anastrophyllum hellerianum*. It is rarely found with *Ptilidium* spp and never with *Lophocolea heterophylla*. The latter species are probably able to tolerate a larger amount of desiccation, and moisture may well be a limiting factor for *L.ventricosa* on some sites.

This is an easy species to recognize. Its bilobed leaves are as long as wide and they are quite concave, this enables it to be differentiated from *L.ascendens* which also has yellow green gemmae but has rectangular leaves like *L.longidens*. Sporophytes are found occasionally.

25. *Tritomaria exsectiformis* (Breidl.) Schiffn.

17 collections, recorded on 13% of sites.

First record: Silver Mountain. June 8 1958. C.Garton 5477.

First published: Crowe & Barclay-Estrup (1971).

T.exsectiformis is a boreal species with an amphi-atlantic distribution (Schuster, 1969). There has been some confusion in the past with *T.exsecta* from which it can only be distinguished under the microscope (Schuster, 1969). It has now been established that *T.exsecta* has a chromosome number n=9, whereas in *T.exsectiformis* n=18. It thus appears that the latter is diploid (Schuster,1969).Only *T.exsectiformis* has so far been found in this area, possibly this is because of the vigour usually associated with polyploidy which may have enabled the species to colonize this area within comparatively recent times. Where both species occur, as in Minnesota (Schuster, 1953), *T.exsectiformis* is the more common. In the study area it is not a common species but it is widespread.

It has been found in this area on rotting logs and on humus over rocks. This corresponds with the ecological requirements listed by Schuster (1969) who regards it as having a fairly wide range of tolerance for a number of habitat factors.

The leaves, in this area, are more often bilobed rather than trilobed, but the unequal lobing and the masses of reddish brown, angular gemmae make it easy to distinguish from *Lophozia* spp. *T.exsectiformis* differs from *T.exsecta* in having larger cells which tend to develop trigones, and larger, angular gemmae as opposed to the small smooth ones found in *T.exsecta*. The specimens found in the study area consistently have gemmae but sporophytes have not been found.

26. *Tritomaria quinquedentata* (Huds.) Buch

8 collections, recorded on 6% of sites.

First record: Ouimet Canyon. May 20 1957. C.Garton 4473.
First published: Crowe & Barclay-Estrup (1971).

T.quinquedentata is a widespread, essentially circumpolar species found in both boreal and arctic regions (Schuster, 1969). It has been found in a number of scattered localities in this area. It is entirely an epipetric species which automatically limits its distribution.

Schuster (1969) specifies basic rocks but Arnell (1956) states that it is found on both acid and basic rocks. As it is found both in and around Ouimet Canyon, where a pH of 4.4 has been recorded, and where mildly calciphobe species such as Anastrophyllum saxicola and C.setiformis are found, it seems likely that Arnell's observations hold true in this area.

It appeared to be rather common in the first check list (Crowe & Barclay-Estrup, 1971) but this would seem to be due to the high proportion of rocky sites visited. It is an easy species to recognize. The very broad leaves are always clearly trilobed and the lobes are very unequal. It is also quite large and easy to see with the naked eye. Sporophytes have not been found.

27. Tritomaria scitula (Tayl.) Joerg.

Not collected during the present survey.

First record: Ouimet Canyon. July 10 1972. H.Williams 3292.
Unpublished.

T.scitula is amphi-atlantic in distribution and is considered by Schuster (1969) to be of low arctic-alpine range. He regards the scattered sites away from the tundra as relict. It has been found in a number of places around the shore of Lake Superior but in the study area it has only been found in Ouimet and Cavern Lake canyons. In both cases the stands could be relict.

Schuster (1969) suggests that it is an obligate calciphyte, at least in North America. Again, as with *T.quinquedentata*, it grows in Ouimet canyon where obligate calciphobes also occur. On the other hand, Garton (personal communication) regards the Cavern Lake canyon as calcareous.

T.scitula is the only member of the genus to have almost equally trilobed leaves, which are also longer than broad. It is most like *T.exsectiformis* with which it was considered conspecific at one time. The latter always has clearly asymmetrical leaves. Sporophytes have not been found.

28. *Anastrophyllum hellerianum* (Nees) Schust.

35 collections, recorded on 20% of sites.

First record: Mountain Lake. October 4 1958. C.Garton 5777.

First published: Crowe & Barclay-Estrup (1971).

A.hellerianum is a boreal species of circumpolar distribution (Schuster, 1969) and has been found quite widely distributed over the study area. Curiously enough it has not been collected closer than 15 km to the built up area of Thunder Bay, although collections have been made over most of the rest of the study area.

It is an obligate log species, which limits its distribution, especially as it is not a pioneer and neither will it grow on completely disintegrating logs (Schuster, 1969). It is possible that its distribution pattern, like that of *Lophozia incisa* is connected with the periods at which logging has taken place in relation to the settlement. Occasionally it formed pure carpets (Gimingham & Smith, 1971) on decorticated logs, but it was usually associated with the *Jamesoniella-Lophocolea* associule and was collected at least once with all the typical rotting log species.

A.hellerianum is very easy to identify, although it is extremely small, as it always produces erect, filiform shoots with reduced leaves, which bear masses of scarlet gemmae on their tips. Three other species produce gemmiparous shoots of this type but *A.hellerianum* is the only one in which the leaves are so markedly reduced. *Scapania apiculata* is closest in this respect but typically unequal bilobed leaves can always be found and in this species as well as in *S.glaucocephala*, which also produces gemmae tipped shoots, the gemmae are ovoid, not angular as in *A.hellerianum*. *Lophozia longidens* also produces erect shoots with scarlet gemmae but they are much larger and not filiform. Sporophytes have not been found.

29. *Anastrophyllum michauxii* (Web.) Buch

1 collection, recorded on 1% of sites.

First record: East Bay, Dog Lake. May 21 1961. C.Garton 8459.

First published: Crowe & Barclay-Estrup (1971).

A.michauxii is a circumpolar boreal species (Schuster, 1969). It was collected once during this study, in Ouimet Canyon, but it has been collected by Garton on the Wolf River and at Dog Lake.

Its preference for moist rock walls (Schuster, 1969) may not often be met in this area. It was collected from a cedar log in Ouimet Canyon but otherwise from rocks.

It is a medium sized species, larger than A.hellerianum but smaller than A.saxicola. It is brownish olive pigmented and the leaves stand out from the stem in a very distinctive way. Sporophytes have not been found.

30. Anastrophyllum minutum (Schreb. ex Cranz) Schust.

1 collection, recorded on 1% of sites.

First record: Ouimet Canyon. July 10 1972. J.Crowe 1522. Unpublished.

Schuster (1969) regards this species as widely distributed in arctic and boreal regions but Arnell (1956) suggests a more arctic distribution. It is circumpolar (Schuster, 1969) in range. It has only been found once in the study area growing on a talus block on the canyon floor. It has been collected east of here by Williams at Heron Bay in 1957 (personal communication) and by Garton at Wawa in 1971. It also occurs frequently in Minnesota (Schuster, 1953). Its apparent restriction to Ouimet Canyon may be a function of the microclimate in this area rather than a restriction to arctic habitats. This could possibly be the need for a higher average humidity than is usual in this area.

This appears to be an epipetric species in the south although it grows on peaty soil in more northern regions (Schuster, 1969). It also has a fairly high moisture requirement on rocky sites (Schuster, 1969).

This species is intermediate in size between A.michauxii and A.hellerianum. It produces gemmiparous shoots which somewhat resemble A.hellerianum but they are much less reduced and the difference in habitat preference make it unlikely that the two species would be confused. Sporophytes have not been found.

31. Anastrophyllum saxicola (Schrad.) Schust.

1 collection, recorded on 1% of sites.

First record: Ouimet Canyon. May 20 1957. C.Garton 4476.

First published: Williams & Cain (1959).

A.saxicola is essentially arctic-alpine and circumpolar (Schuster, 1969). It has been collected a number of times from Ouimet Canyon where it is quite flourishing and widespread, unlike C.setiformis. It has also recently been collected from the Cavern Lake Canyon by Garton. It seems likely, therefore, that it is an arctic relic. It is an epipetric species and was found growing in mats on the surface of talus blocks on the floor of the canyon, not on rock walls as suggested by Schuster (1969). Both Schuster (1969) and Arnell (1956) regard it as a species of siliceous rocks of low to moderate pH.

This species is distinguished by its cupped, bilobed leaves, both overlapping and decurrent. From Ouimet Canyon it is always a clear golden-brown but Garton's collections from Cavern Lake

Canyon are greener. All specimens found so far are sterile.

32. Gymnocoles inflata (Huds.) Dum.

Not collected during the present survey.

First record: Slate River Gorge. September 28 1958. C.Garton 5743.

First published: Crowe & Barclay-Estrup (1971)

G.inflata is an arctic-boreal circumpolar species (Schuster, 1969). It has been collected once only in this area in the Kaministiquia Valley, at its confluence with the Slate River, by Garton. Williams has collected it further east on the Lake Superior shore. It apparently requires non-calcareous rocks, which are both wet and insolated. This is an unlikely combination in the study area where exposed rock surfaces are usually dry and inhabited by lichens if they are well insolated.

The obtuse lobes of the bilobed leaves distinguish it from all species except Cladopodiella fluitans. Their ecological requirements are quite different and G.inflata has smaller cells, smaller underleaves and leaves with a very open sinus. When fertile which was not so in this specimen, the terminal inflated perianths of G.inflata are diagnostic. C.fluitans has trigonous perianths borne on short postical branches (Schuster, 1969).

33. Jamesoniella autumnalis (D.C.) Steph.

204 collections, recorded on 73% of sites.

First record: Ouimet Canyon. September 13 1958. C.Garton 5608.

First published: Crowe & Barclay-Estrup (1971).

J.autumnalis is a circumpolar, boreal species but it does not extend into the temperate zone (Schuster, 1969). This is the third commonest species in the study area and is widely distributed throughout.

While essentially a rotting wood species in this area, it also occurs on organic soil and occasionally on rock surfaces. On rotting logs it is usually found in an associule, of which it is often a dominant member. Occasionally, large pure patches are found.

The decurrent, round, entire leaves, often reddish tinged, make this species easy to recognize. It is dioecious and frequently fertile. The capsules are fringed and the antheridia borne each enclosed by a bract on an imbricate shoot. It can only be confused with Jungermannia lanceolata, in which the leaves are somewhat longer than wide and not so clearly decurrent. J.lanceolata is paroecious (Schuster, 1969) and the perianths are cylindrical with a short beak set in an indentation at the top. Sporophytes are frequently found in J.autumnalis.

34. Jungermannia lanceolata (L.emend.) Schrad.

18 collections, recorded on 15% of sites.

First record: Slate River Gorge. June 5 1955. C.Garton 2564.

First published: Crowe & Barclay-Estrup (1971).

J.lanceolata is boreal and amphi-atlantic (Schuster, 1969). It is moderately common in the study area but seems to be confined to the eastern half of the region.

Its habitat requirements are similar to *J.autumnalis*. It was found most often on rotting wood, once on organic soil and once on granite. It was found on sites with average soil pH of between 5 and 6.9. It appears to have a somewhat higher moisture requirement than *J.autumnalis* (Schuster, 1969). It is probable that it has a narrower ecological amplitude than *J.autumnalis* which would limit its distribution. Sporophytes are frequently found.

35. *Mylia anomala* (Hook.)S.F.Gray

2 collections, recorded on 1% of sites.

First record: Middlebrun Bay. September 7 1958. C.Garton 5595.

First published: Crowe & Barclay-Estrup (1971).

M.anomala is an arctic-boreal species and is probably circumpolar in distribution, although it has been little collected in eastern Asia (Schuster, 1969). It is probable that it has been overlooked throughout this study and that it is actually commoner than the distribution map would suggest. The older collections were made by Garton in *Sphagnum* bogs. Schuster (1953) was used as a reference in the earlier part of this study and it does not point out, unlike Schuster (1969), that this species forms short turfs over peaty soil. At first sight these turfs look like small mosses. They were pointed out by Harry Williams to the writer growing on fairly dry hummocks at the base of trees in a black spruce swamp.

Once seen, this species is easily identified by its dimorphic leaves, there is no other species in the study area which exhibits these characteristics. Sporophytes were not found.

SCAPANIACEAE

36. Diplophyllum taxifolium (Wahl.) Dum.

2 collections, recorded on 1% of sites.

First record: Silver Mountain. June 8 1958. C.Garton 5486.

First published: Crowe & Barclay-Estrup (1971).

D.taxifolium is a circumpolar species described by Arnell (1956) as largely alpine, but Schuster (1953) suggests a more arctic-boreal distribution. It was found, in this study, on rock surfaces on a talus slope at the foot of a cliff on Mt McRae, and was collected by Garton from rock ledges in the Kaministiquia valley and at Silver Mountain.

Arnell(1956) and Schuster (1953) agree that it is found on rather acid rocks. The recorded soil pH from the Mt McRae site was 5.5 which is not specially low for the study region and it is unlikely that the rocks in the area where it was collected by Garton would have a low pH.

Easily distinguished by the complicate bilobed leaves common to this family in which, unlike Scapania spp, the lobes are at right angles to each other, elongate and toothed. The habit is stiff and glossy not lax, as in Scapania. Sporophytes were not found.

37. Scapania apiculata Spruce.

Not collected during the present survey.

First record: Ouimet Canyon on cedar log. July 10 1972.
H.Williams 3293.

Unpublished.

S.apiculata is a rather rare circumpolar and boreal species (Arnell, 1956). It is found exclusively on decaying wood. It is very small and produces slender gemmiparous shoots, but the gemmae are ovoid, brownish and, unlike S.glaucocephala, all one-celled. The cells also have bulging trigones which separate it from all other species with which it might be confused (Schuster, 1953). Sporophytes were not found.

38. Scapania cuspiduligera (Nees) K.Mull.

Not collected during the present survey.

First record: Trowbridge Falls. October 19 1958. C.Garton 5890.

First published: Crowe & Barclay-Estrup (1971).

S.cuspiduligera is at least amphi-atlantic (Arnell, 1956). Its distribution is arctic-boreal. It has only been found once in this area by Garton, growing on shale ledges near Trowbridge Falls on Current River.

According to Schuster (1953), this is a calciphyte which requires moist rock crevices. That particular set of circumstances was not encountered on any of the sites visited, but it seems likely that this species could be found again if deliberately searched for.

This very small species is chiefly distinguished from other Scapania spp with reddish brown two-celled gemmae by its blunt leaf lobes and lack of keel. The dorsal lobe almost sheaths the stem (Schuster, 1953). Sporophytes were not found.

39. Scapania glaucocephala (Tayl.) Evans

15 collections, recorded on 12% of sites.

First record: Near Cascades, Current River, Port Arthur. May 19 1969. J.Crowe 174.

First published: Crowe & Barclay-Estrup (1971).

This appears to be a rare species, although the small size may cause it to be overlooked. This boreal species (Schuster, 1953), has recently been discovered in Fennoscandia (Arnell, 1956) thus giving a probable amphi-atlantic distribution. Although not common, there is quite a wide distribution throughout the study area.

This species has only been found on rotting logs, occasionally as a member of the Jamesoniella-Lophocolea associule. This corresponds closely to Schuster's (1953) description of its ecological preferences.

Confusion with Anastrophyllum hellerianum, Tritomaria exsectiformis or Scapania apiculata is possible but these species lack the robust gemmiparous shoots with oval two-celled gemmae which always occur in S.glaucocephala. Sporophytes have not been found in the study area.

40. Scapania gymnostophila Kaal.

Not collected during the present survey.

First record: Trowbridge Falls. October 19 1958. C.Garton 5893.

First published: Crowe & Barclay-Estrup (1971).

S.gymnostophila is regarded by Schuster (1953) as arctic alpine. The distribution, as recorded at present, is amphi-atlantic (Arnell, 1956). It has been found once in this area by Garton on the same site as S.cuspiduligera. It is a pronounced calciphyte (Schuster, 1953; Arnell, 1956) and the rocks on which it was found are most probably calcareous. It has also been found by Williams (personal communication) to the east of this area and has been found in Minnesota (Schuster, 1953).

It is most like S.glaucocephala as it is small with sharply keeled leaves and two-celled reddish brown gemmae. However, the leaves in S.glaucocephala have a border of regular thick walled cells which is absent in S.gymnostophila and their ecological preferences are different. The specimen found did not have sporophytes.

41. Scapania irrigua (Nees) Dum.

21 collections, recorded on 13% of sites.

First record: Sibley Peninsula. October 25 1958. C.Garton 5924.

First published: Crowe & Barclay-Estrup (1971).

S.irrigua is considered to be a boreal species (Schuster, 1953) and has an amphi-atlantic distribution (Arnell, 1956). It has been found on a number of sites scattered over the study area although it is not really common.

The chief factor limiting its distribution would seem to be that it is restricted to permanently moist sites. It has been found on rotting wood on the ground, bare rock and organic soil.

It has been found on densely shaded sites and in crevices in bare rock on the very edge of Lake Superior. Schuster (1953) suggests that S.irrigua is a calciphile but collections were made during this study only on sites with a range of soil pH below 5.7.

This moderately large species has typical scapanoid complicate bilobed leaves, which are rather broad. It can only be confused with Scapania paludicola, which is almost identical except that it has keels so arched that they are almost circular; the keels in S.irrigua are much less clearly marked. No sporophytes have been observed.

42. Scapania microphylla* Warnst.

Not collected during the present survey.

First record: Silver Mountain. June 8 1958. C.Garton 5486.

First published: Crowe & Barclay-Estrup (1971).

S.microphylla appears to be arctic-boreal with an amphi-atlantic distribution (Schuster, 1953). However, there seems to be some confusion with respect to the taxonomy of this species. There are two common synonyms: S.buchii and S.lingulata. It also has similarities with S.mucronata although in S.microphylla the leaves have small scattered teeth. Williams (personal communication) casts some doubt as to whether the North American species is really the same as the European. There is obviously a need for critical examination and it is possible that this will be clarified in the next volume of Schuster's series.

*Now: Scapania lingulata Buch (Schuster, 1974). S.lingulata var microphylla is known only from Greenland. The typical variety is distributed as above except that it is imperfectly circumpolar (Schuster, 1974).

It has been collected by Garton in the Kaministiquia Valley and more recently by Williams in Ouimet Canyon on the same cedar log as S.apiculata. Garton collected it on shale, although both Schuster (1953) and Arnell (1956) specify siliceous rocks. Schuster (1953) also states that it is not found on organic substrates, while Arnell (1956) limits himself to saying it is rare on decaying wood and soil. More collections are needed before it will be possible to be able to make any definite statements about its preferences in this area. Sporophytes have not been found.

43. Scapania mucronata Buch

12 collections, recorded on 10% of sites.

First record: Silver Mountain. June 8 1958. C.Garton 5476.

First published: Crowe & Barclay-Estrup (1971).

S.mucronata is a circumpolar species (Arnell, 1956) of mainly boreal distribution but extending into both tundra and deciduous forest regions (Schuster, 1953). It seems to be quite evenly distributed throughout the study area.

It has been found mostly on decaying wood but it also occurs on rock surfaces and on organic soil. This corresponds to the ecological preferences described by both Schuster (1953) and Arnell (1956).

On rotting logs it may be quite small and could be confused with S.glaucocephala but the two-celled gemmae in S.mucronata are always greenish. On rocks it is unlikely to be confused with any other Scapania spp as it is larger with dorsal leaf lobes equal to half the ventral lobe, unlike S.gymnostophila. The lobes are pointed, unlike S.cuspiduligera, and both of these latter species have reddish-brown gemmae. Sporophytes have not been found.

44. Scapania nemorosa (L.) Dum.

Not yet collected in the study area but considered likely to occur

S.nemorosa is an amphi-atlantic species which is widely distributed but centres on the boreal zone (Schuster, 1953). The first local record is from St.Ignace Island and was made by C.Garton on October 25 1957, 5308 (Crowe & Barclay-Estrup 1971). It has also been found on Perley Island which is on the edge of the study area.

Arnell(1956) states that it is mostly found on shady cliffs inundated with water. On Perley Island it was found under these conditions on the very edge of Lake Superior, in what can only be regarded as an arctic habitat. There seems little doubt that its large size would make it unlikely to have been overlooked. Thus, it seems probable that it is a rare species in this region.

The large,oval leaf lobes are clearly denticulate, this distinguishes it from all other species of Scapania in the study area. Brownish, one-celled gemmae are produced. Sporophytes were not found.

45. Scapania paludicola Loeske & K.Mull.

4 collections recorded on 2% of sites.

First record: Silver Falls Road. October 13 1958. C.Garton 5855.

First published: Crowe & Barclay-Estrup (1971).

S.paludicola is considered by Schuster (1953) to be mainly arctic-boreal. It is circumpolar (Arnell, 1956). It was only collected on two sites; roughly at the same latitude but at extreme ends of the study area. However, both these sites have early felsic igneous bedrock. In one case it was collected from granite and in the other from twigs in swamp pools. In fact, the two sites were very strongly contrasted as one was extremely wet and the other very well drained. Wet sites are a more typical habitat according to Schuster (1953), who also states that it is confined to at least slightly calcareous sites. In contrast, however, Arnell (1956) says clearly that it avoids calcareous sites! It appears that a critical examination of this species and the allied S.paludosa, which occurs in Michigan (Schuster, 1953) would be desirable.

Its differentiation from S.irrigua which is the only species with which it could be confused is dealt with under that species. Sporophytes have not been found.

46. Scapania undulata (L.) Dum.

Not collected during the present survey.

First record: Black Bay Bridge, Current River. September 20 1958.
C.Garton 5667.

First published: Crowe & Barclay-Estrup (1971)

S.undulata is an arctic-boreal species (Schuster, 1953), showing, thus far, an amphi-atlantic distribution (Arnell, 1956). It was not recorded during this study but it has been collected on shale in the Kaministiquia and Current River Valleys by Garton and, submerged, in the Black Sturgeon area just north of the study region.

It is restricted to 'rocky places in the vicinity of water' (Schuster, 1953). It is large and somewhat like Scapania nemorosa but in this area, at least, it does not have strongly denticulate leaf margins. It is pure green and does not develop purplish pigmentation like S.nemorosa (Schuster, 1953). Sporophytes have not been found.

LOPHOCOLEACEAE

47. Lophocolea heterophylla (Schrad.) Dum.

274 collections recorded on 80% of sites.

First report: Ouimet Canyon. June 15 1958. C.Garton 5503.

First published: Crowe & Barclay-Estrup (1971)

L.heterophylla is a boreal-temperate species (Schuster, 1953) and circumpolar in distribution (Arnell, 1956). It is an almost ubiquitous species in the study area and has the distinction of having the highest total number of collections although it was not found on as many sites as P.pulcherrimum. It is inclined to be variable in size and colour which makes it collected more frequently than P.pulcherrimum which is easier to recognize in the field. It has several times been the sole species collected on specially inhospitable sites.

It is commonest on rotting wood and inorganic soil but it also occurs at the base of living trees. It has a wide ecological amplitude but does not grow on inorganic substrates. This species is a dominant member of rotting log associules with Jamesoniella autumnalis.

The rectangular leaves with thin-walled cells and bifid underleaves differ from all other species except the smaller Lophocolea minor. The latter has large disc shaped gemmae on the eroded edges of the leaves, which are absent in L.heterophylla. This species is frequently fertile and the trigonous perianths are a further diagnostic feature.

48. Lophocolea minor Nees.

11 collections, recorded on 8% of sites.

First record: Silver Mountain. June 8 1958. C.Garton 5488.

First published:Crowe & Barclay-Estrup (1971)

L.minor, a circumpolar, boreal-temperate species (Arnell, 1956) is fairly widely distributed in the central part of the study area but not common. The absence of this species from the northern and western parts of the area may be significant but the number of collections is too small to be certain.

Classified by Schuster (1953) as a calciphyte which only grows on mineral substrates; it was first found in this study in deep crevices at the base of an old balsam poplar. Later, it was collected from rotting wood, a moss mat and organic soil. Williams (personal communication) says it is common on organic substrates in Canada, this agrees with Arnell (1956). This species was found growing more freely on rock on Isle Royale, than it appears to do in this area. It is found loosely associated with other rotting wood species and, quite frequently, Lophozia barbata when found on rock. It could be confused with small bilobed Lophozia spp but none of these have underleaves or disc shaped gemmae. Sporophytes have not been found.

49. Chiloscyphus pallescens (Ehr.) Dum.

12 collections, recorded on 10% of sites.

First record: Oliver Creek. May 15 1955. C.Garton 2515.

First published: Crowe & Barclay-Estrup (1971).

C.pallescens is a boreal-temperate species with circumpolar distribution (Arnell, 1956). Its local distribution as recorded at present suggests that it may be more temperate than boreal.

It is found in wetter than average sites, mostly in bog pools or on wet wood. Schuster (1953) suggests that it needs sites rich in minerals. A number of collections in the past have been identified as var. fragilis. However, examination of these has shown that they have larger leaf cells than those from drier areas, not smaller, as stated in Schuster (1953), although they do not have underleaves. There seems to be some confusion so, for the time being, all collections of this species have been lumped together.

This is an easy species to recognize; being quite large and flaccid, with whitish green, incubously arranged leaves. It is unlikely to be confused with any other species except C.polyanthu which has much smaller cells, not at all hyaline, and is pure green to brownish green. Sporophytes have been found.

50. Chiloscyphus polyanthus (L) Corda.

1 collection, recorded on 1% of sites.

First report: Mt.McKay (J6C) July 22 1970. J.Crowe 861. Unpublished.

C.polyanthus has a similar world distribution to C.pallescens (Arnell, 1956). The sole collection in the study area was made from organic soil on a rocky shelf, shady and moist but not wet. Schuster (1953) suggests that its ecological requirements are similar to those of C.pallescens but the site on which it was found was much drier than any on which C.pallescens occurred. Sporophytes were not found.

GEOCALYCACEAE

51. Harpanthus scutatus (Web. & Mohr) Spruce

10 collections, recorded on 10% of sites.

First record: Sibley Peninsula. October 25 1958. C.Garton 5918.

First published: Crowe & Barclay-Estrup (1971).

H.scutatus is a boreal-temperate species (Schuster, 1953) with an amphi-atlantic and amphi-pacific distribution (Arnell, 1956). Its distribution in the study area appears to follow the lake shore; in addition it is conspicuously absent from the more built up area of Thunder Bay.

It has been found exclusively on rotting wood or organic soil during this study, although, according to Schuster (1953) and Arnell (1956) it is also found on rocks in other areas.

Geocalyx graveolens is the only species it is likely to be confused with, as L.heterophylla is much more translucent.

G.graveolens is yellow green and has very distinct cell walls with a deeply chlorophyllose interior which gives a characteristic mottled appearance under low magnification. H.scutatus is a clear green. In addition, both L.heterophylla and G.graveolens have bilobed underleaves while H.scutatus has large, ovate underleaves fused on one side with the leaves. Sporophytes have not been found.

52. Geocalyx graveolens (Schrad.) Nees

130 collections, recorded on 60% of sites.

First record: Grass Lake, Sibley. September 1 1958
C.Garton 5541.

First published: Crowe & Barclay-Estrup (1971)

G.graveolens is a boreal-temperate species of circum-polar distribution (Arnell, 1956), occurring widely through the study area wherever a suitable substrate is found.

Most frequently found on rotting wood; this species forms an associule with Cephalozia media, Blepharostoma trichophyllum, Jamesoniella autumnalis and other species typical of rotting wood. Collections have been made from organic soil, where it is often associated with Calypogeia integristipula. Very occasionally found on rock. In spite of a wide ecological amplitude, it is rarely associated with Lophocolea heterophylla and the limiting factors for Geocalyx graveolens may be atmospheric moisture and light.

Frequently found with sporophytes which produce a very characteristic long, cylindrical, brown capsule which emerges on a slender, white seta from the perigynium on the ventral side of the stem.

PLAGIOCHILACEAE

53. Plagiochila asplenioides (L.) Dum.

27 collections, recorded on 25% of sites.

First record: Sawyer's Bay, Sibley. July 18 1956. C.Garton 2887.

First published: Crowe & Barclay-Estrup (1971).

P.asplenioides is widespread throughout the northern hemisphere (Arnell, 1956). It was found quite evenly distributed throughout the study area but it was by no means universal.

It is most often found in pure stands, usually on a thin humus layer on rock or on soil, occasionally being found on rotting wood or at the base of a tree or stump. It did not occur at all on exposed sites, either wet or dry, and this may give a clue to its somewhat sporadic distribution. Schuster (1957) suggests that it is a species capable of growing at low light intensities. As far as moisture is concerned, it appears to have a wide range of tolerance and grows very luxuriantly on wet or dry sites.

The only species with which it could be confused is J.autumnalis but it very quickly becomes recognizable from its dark green, very decurrent leaves, which roll back, hiding the dorsal margin. Teeth on the margins of the leaves are completely diagnostic of P.asplenioides but they are usually lacking in the study area. It was never found with sex organs or sporophytes in this area and appeared to have no means of asexual dispersal.

This would seem likely to limit its distribution locally.

ARNELLIACEAE

54. Arnellia fennica (Gottsche) Lindb.

Not collected during the present survey.

First record: Ouimet Canyon. August 12 1970. H.Williams 2934. Unpublished.

A.fennica is a circumpolar, arctic species (Arnell, 1956). It was predicted by the present writer (Crowe, 1970) that this species might be found here and H.Williams did discover an isolated strand matted in the sod of a mixed collection from Ouimet Canyon. Unfortunately, attempts to collect it again have been unsuccessful. It is almost certainly an arctic relic and may be very close to extinction.

According to Arnell (1956) it is found on calcareous rocks. As a number of calciphobe species are found in the canyon it would also be desirable if more collections were made to obtain information with regard to the substrate on which it grows.

The almost circular, closely imbricate, blue-green leaves of this fairly small species make it quite distinct from any other found in this area. Sporophytes were not found.

CEPHALOZIACEAE

55. Cephalozia affinis Lindb.

1 collection, recorded on 1% of sites.

First record: Near Black Sturgeon River (P2) September 11 1971. J.Crowe 1221. Unpublished.

C.affinis is a boreal species occurring in Western Europe and North America (Schuster, 1953). It was found growing on *Sphagnum* sp in a mature, shady, white spruce stand. It was identified by its autoecious inflorescence (Schuster, 1953) as well as vegetative characteristics. Sporophytes were present.

56. *Cephalozia bicuspidata* (L.) Dum.

3 collections, recorded on 3% of sites.

First record: Spruce River Road, 7 km. N. of Dorion Road. June 19 1971. J.Crowe 1100. Unpublished.

C.bicuspidata is basically a boreal species, though of wide amplitude (Schuster, 1953) and circumpolar in distribution (Arnell, 1956). It was only found a few times in this area so it is impossible to generalize about its local distribution. It is also somewhat rare in Minnesota (Schuster, 1953).

It was found in rock crevices and on organic soil. The somewhat divergent leaf lobes with a deep sinus separate this species from other large *Cephalozia* spp. It also tends to develop golden brown pigmentation. Sporophytes were not found.

57. *Cephalozia connivens* (Dicks.) Spruce

20 collections, recorded on 14% of sites.

First record: Sibley Peninsula. October 25 1959. C.Garton 5921.

First published: Crowe & Barclay-Estrup (1971).

C.connivens is circumpolar (Arnell, 1956) and boreal (Schuster, 1953). Although not common it is quite widespread over the study area.

It has been found on rotting wood and on organic soil. It tends to appear in wetter sites and this is probably the limiting factor in its distribution.

C.connivens may be separated from other Cephalozia spp with connivent lobes, by the insertion of the leaf (see key). The perianth, when present, is distinctly ciliate at the mouth and has numerous linear bracts. They are found quite frequently.

58. Cephalozia media *Lindb.

184 collections, recorded on 74% of sites.

First record: Mt.McKay. October 4 1969. J.Crowe 262.

First published: Crowe & Barclay-Estrup (1971).

C.media is so widely distributed throughout the northern hemisphere it is classed as sub-cosmopolitan (Schuster, 1953). It is extremely widespread but rather small so it had probably been overlooked in the study area prior to 1969.

It was found first associated with Calypogeia integristipula but it is more commonly a member of rotting log associules and seems to be specially associated with Geocalyx graveolens. These species fade out on drier logs but Lophocolea heterophylla and Jamesoniella autumnalis persist. It also occurs occasionally on rock and organic soil and was once collected at the base of a live birch.

The small number of large cells in the leaf are distinctive there is also a small notched sinus. Cephalozia lacinulata also has very few cells in the leaf but the cells are hyaline and the lobes more divergent. Sporophytes are frequently found.

* Now: Cephalozia lacinulata (Dum.) Dum. (Schuster, 1974).

59. Cephalozia lacinulata (Jack.) Spruce

5 collections, recorded on 4% of sites.

First record: Near Little Dog Lake (I4) June 25 1970.
J.Crowe 823. Unpublished.

C.lacinulata has a boreal, amphi-atlantic distribution (Arnell, 1956) but it is probably frequently overlooked in mixed collections as it is very small.

It has been found as small isolated strands among associules of other hepatics growing on organic substrates. It is considered to be a rotting wood species by Schuster (1953) and Arnell (1956).

Its colour is a distinctive, whitish green due to the very few hyaline cells. Sporophytes have not been found.

60. Cephalozia pleniceps (Aust.) Lindb.

4 collections, recorded on 2% of sites.

First record: Current River, Port Arthur. September 20 1958.
C.Garton 5672.

First published: Crowe & Barclay-Estrup (1971).

C.pleniceps is an arctic-boreal species (Schuster, 1953) with a circumpolar distribution (Arnell, 1956). The small number of collections is due to the very specific ecological requirements of this species. It seems to be found exclusively in Sphagnum bogs in this area, as in Minnesota (Schuster, 1953), although, according to Arnell (1956) it has a somewhat wider ecological amplitude in Fennoscandia as it is also found there on rotting wood.

C.pleniceps is characterized by the much larger number of leaf cells than is usual among other *Cephalozia* spp in the study area. The leaf lobes are 8-9 cells wide at the base, whereas in most other species they are 6 cells wide or less. Sporophytes were found.

61. *Nowellia curvifolia* (Dicks.) Mitt.

43 collections, recorded on 21% of sites.

First record: Ouimet Canyon. September 13 1958. C.Garton 5608.

First published: Crowe & Barclay-Estrup (1971).

This is a boreal-temperate species (Schuster, 1953) with an amphi-atlantic, amphi-beringian distribution at present. The apparent absence from Sibley Peninsula in this area is rather surprising. Possibly this area may be a little too cool in summer for a species with temperate affinities, although it has been collected by Garton on St.Ignace Island near Nipigon.

It is found exclusively on rotting logs or stumps and is a member of associules, although it could not be described as a basic member of an associule in the study area, in the way in which it was used by Schuster (1957). It is by no means always present.

N.curvifolia is probably one of the easiest rotting log species to recognize. It can often be seen with the naked eye by its bright reddish colouration. Under low magnification, the long ciliate leaf lobes and saccate leaf are quite distinctive. Sporophytes are sometimes found.

62. Cladopodiella fluitans (Nees) Buch

Not collected during the present survey.

First record: Silver Falls Road. October 13 1958. C.Garton 5854.

First published: Crowe & Barclay-Estrup (1971).

C.fluitans is a boreal species and is probably circumpolar (Arnell, 1956). It has been collected by Garton in three localities in the study area and appears to be confined to Sphagnum bogs in all areas (Schuster, 1953; Arnell, 1956). It is one of the two species in this area with obtuse lobed leaves (see Gymnocolea inflata). Sporophytes have not been found.

CEPHALOZIELLACEAE

63. Cephaloziella elachista (Jack.) Schiffn.

Not collected during the present survey.

First record: Silver Falls Road. October 13 1958. C.Garton 5854.

First published: Crowe & Barclay-Estrup (1971).

C.elachista is listed by Schuster (1953) as a boreal species but Arnell (1956) quotes Douin as stating that it is temperate. It is at least amphi-atlantic (Bonner, 1963) but, as with Cephalozia spp, the small size and difficulty in determining members of the Cephaloziellaceae makes all their distributions somewhat doubtful as they must frequently be overlooked.

This species has only been collected once by Garton from the bog on the Silver Falls Road. It is an obligate Sphagnum bog species.

This species is the largest of the Cephaloziellaceae found in the study area and may be recognized by the presence of accessory teeth on the bilobed leaves. Sporophytes were not found.

64. *Cephaloziella hampeana* (Nees) Buch

12 collections, recorded on 10% of sites.

First record: Ouimet Canyon. September 13 1958. C.Garton 5624.

First published: Crowe & Barclay-Estrup (1971).

C.hampeana is a sub-cosmopolitan species which occurs in the arctic (Polunin, 1940; Schuster, 1951) and also in boreal and temperate zones (Schuster, 1953). From present records the longitudinal distribution seems somewhat dissected (Arnell, 1956).

This species has a wide ecological amplitude and has been found on a number of different substrates including rotting logs, soil and rocks. Frequently associated with such species as *Lophozia barbata* and *L.ventricosa*. Distinction from *Cephaloziella rubella* is most difficult but the leaf lobes in *C.hampeana* tend to diverge more, the lobes are flatter and the leaf cells more numerous. Quite often found with sporophytes.

65. *Cephaloziella rubella* (Nees) Douin

20 collections, recorded on 13% of sites.

First record: Near Walmsley (I8). May 20 1970. J.Crowe 375.

Unpublished.

C.rubella is mainly a boreal species (Schuster, 1953) and it is circumpolar (Arnell, 1956).

This species has been found fairly widely distributed in the study area. It always occurs on rotting wood in an associule. For this reason it may be referable to var. sullivanti as the type variety grows on rock (Schuster, 1953). As it is infrequently fertile it is difficult to be sure of this.

The leaves are very obviously transverse and imbricate. It is quite stiff and erect, unlike the procumbent and translucent Cephalozia spp with which it might be confused on account of its size.

66. Cephaloziella starkei (Funk) Schiffn.

2 collections, recorded on 2% of sites.

First record: High Falls, Pigeon River. May 26 1970.
J. Crowe 433. Unpublished.

C.starkei is a boreal-temperate species (Schuster, 1953) and circumpolar in distribution (Arnell, 1956). It was found only twice during this study, in both cases on high rocky places, in rather moist areas.

It is considered by Schuster (1953) to be an oxylophyte and this might account for its rarity in this area. Arnell (1956) indicates a somewhat wider ecological amplitude in Fennoscandia.

This the easiest of the Cephaloziellaceae found in the study area to distinguish. In colour it is very dark, almost black; there are distinct underleaves; the leaf cells bear papillae which are very clear under moderate magnification. Sporophytes were not found.

ADELANTHACEAE

67. Odontoschisma denudatum (Mart.) Dum.

Not yet collected in the study area but considered likely to occur.

Schuster (1953) regards this species as widely distributed in the boreal forest, not at all arctic but extending well into southern regions. It is circumpolar (Arnell, 1956). It has been collected on St.Ignace Island, the first record being on August 5 1959, C.Garton 6715 (Crowe & Barclay-Estrup 1971). More recently, it was found on Perley Island which is on the edge of the study area. Williams has collected this species at Heron Bay to the east (personal communication) and it is found in Minnesota to the west (Schuster, 1953).

It is usually found on organic substrates (Schuster, 1953). Garton's collections have been made from Sphagnum growing over rock but Williams found it growing directly on rock.

Odontoschisma spp are distinguished from all other round-leaved species found in the study area by the presence of stolons (Schuster, 1953). O.denudatum is differentiated from O.macounii by reddish to blackish colouration and only slightly concave leaves. O.macounii is green to whitish green with extremely concave leaves.

68. _Odontoschisma macounii_ (Aust.) Evans

Not yet collected in the study area but considered likely to occur.

O.macounii is strictly a circumpolar, arctic species (Arnell, 1956; Schuster, 1953). In common with _O. denudatum_, it has been found on St.Ignace Island by Garton and to the east and west of the study area by Williams and Schuster. The first local record was made by Garton, 7017, on August 18 1959 (Crowe & Barclay-Estrup, 1971). There seems to be a strong possibility that it could be found somewhere along the Lake Superior shore line within the study area if a thorough search was made for it. Collections have only been made from what may be termed the tundra zone (Soper & Maycock, 1963) in adjacent areas. It always occurs on mineral substrates and _O.denudatum_ has always been found in the same zone even though the latter is not considered to be an arctic species.

RADULACAE

69. _Radula complanata_ (L.) Dum.

58 collections recorded on 40% of sites.

First record: Sibley Peninsula. August 15 1956. C.Garton 4292.

First published: Crowe & Barclay-Estrup (1971).

R.complanata is a sub-cosmopolitan species and is widespread, although not universal, in the study area.

This species is most often found on the lowest 50cm of a variety of living trees, usually those with smooth bark. It is also found on dead trees, usually still vertical, or on the side of stumps. It was never collected from a rotting log.

R.complanata is occasionally found on rock surfaces. These habitats seem to be similar to those colonized by this species in other areas (Schuster, 1953; Arnell, 1956).

The bright yellow green of the circular dorsal leaf lobe and the ventral lobe about one quarter the size of the dorsal distinguishes this from other species in the study area except Cololejeunea biddlecomiae. The latter is always very much smaller. R.complanata frequently bears the distinctive, flat purse shaped perianths which are characteristic of this species.

PORELLACEAE

70. Porella platyphylla (L.) Lindb.

2 collections, recorded on 2% of sites.

First record: Sibley Peninsula. April 15 1956. C.Garton 2734.

First published: Crowe & Barclay-Estrup (1971).

P.platyphylla is a sub-cosmopolitan species which does not extend into the tundra. It occurs across North America (Schofield, 1969) and in Europe and North Africa (Arnell, 1956). The related species Porella platyphylloidea has a similar range except that it is absent from Scandinavia (Arnell, 1956). Schuster (1953) speaks of intergrades between the two species and it seems there may be some slight difference in environmental conditions which may cause one to be more common than the other in a given area. Schuster (1953) regards P.platyphylloidea as the most frequent in Minnesota but this is not borne out by his citation of Conklin's collections nor, even, of his own. These show an excess of P.platyphylla over P.platyphylloidea.

Certainly, in the study area, P.platyphylla appears to be most common as it has been collected twelve times recently by six collectors, while P.platyphylloidea was collected four times by Garton about fifteen years ago and has not been reported since.

Both species appear to have similar ecological requirements. They are found on dry sites, very often on organic litter over rock. Occasionally, they are found at the base of a tree. During this study P.platyphylla was found once at the base of an elm.

P.platyphylla is distinguished by the oval dorsal leaf lobes, narrowly oval ventral lobes and broad underleaves. P.platyphylloidea has ventral leaf lobes as wide as the underleaves and more rounded dorsal lobes. When fertile, which is seldom, P.platyphylloidea has a densely ciliate perianth whereas P.platyphylla has only a few scattered cilia.

71. Porella platyphylloidea (Schwein.) Lindb.

Not recorded during the present survey.

First record: Trowbridge Falls. October 19 1958. C.Garton 5683.

First published: Crowe & Barclay-Estrup (1971).

The range of this species is similar to that of Porella platyphylla (see previous page). Arnell (1956) classes P.platyphylloidea as continental, regarding P.platyphylla as more oceanic. This might have some significance with respect to their relative distribution in the study area.

JUBULACEAE

72. Frullania asagrayana Mont.

1 collection, recorded on 1% of sites.

First record: Cedar swamp, near Amethyst Mine (M3C) May 15 1971.

Observed by: P.Barclay-Estrup. J.Crowe 945.

F.asagrayana is considered by Schuster (1953) to be a boreal species although in some places it occurs in the temperate zone. It is North American but it is very similar to F.tamarisci (found in Asia, Europe and North America - Arnell, 1956 -). Schuster (1947) suggests that the F.tamarisci found in New York is different from the European form. It seems quite probable that this is a distribution dissected by glaciation, which has resulted in speciation due to isolation. It is significant that Frullania spp are generally associated with living trees, which would mean that they would be confined to more temperate refugia longer than species with a wider range of habitat. A secondary substrate seems to be rock in many cases. Glaciation would favour ecotypes able to exploit this substrate. The saccate ventral lobes would pre-adapt them to life on a vertical rock face, they are also adapted to periods of desiccation associated with life on a tree trunk.

The specimen collected during this study was found on the bark of a mature cedar growing in a very moist area. Williams (personal communication) expressed surprise at its habitat, as he has collected it from dry rock at Heron Bay. Schuster (1953) describes it as a pioneer on dry rock and occasional on birch bark. Its presence on this particular site and habitat alone in the study area seems completely inexplicable. It is possible that it is present elsewhere in that particular region, as it was found on one of the most inaccessible sites. It may also be significant that it was also one of the highest, although less than 25 km from Lake Superior. This was unusual as it was a heavily forested area, not a tundra zone such as is found at the top of a mesa. It also seemed to be a rather humid area with fog clinging to the tops of the trees in the early morning, more so than in the region immediately surrounding the Lakehead cities.

This is one of the most attractive species of hepatics, it is quite distinct from any other local Frullania species because of its glossy red colour, almost purple. The leaves have clear lines of ocelli and it is much the largest Frullania to be found in the area. No sporophytes were found.

73. Frullania bolanderi Aust.

8 collections, recorded on 8% of sites.

First record: Mount McRae. June 17 1961. C.Garton 8491.

First published: Crowe & Barclay-Estrup (1971).

Schuster (1953) regards this species as boreal-temperate. Steere (1937), from the pattern of collecting as it then was, thought that it was a cordilleran relict, but it is now known to be quite widely distributed. For example, Williams (1960) collected it in Gaspé. Schuster (1958) suggests that it survived glaciation in the forested, driftless area of Wisconsin. It is curious that it is confined to North America and unlike other American species of Frullania appears to have no close relations in Europe. Of course, there are many tropical species to which it might be related (Clark & Svihla 1948; Svihla, 1956). The possibility that the flagelliform shoots might be some kind of deformity produced by some parasitic organism should be investigated. It is difficult to see a selective advantage in leafless shoots unless they are propagules.

Generally found on live trees with fairly smooth bark, for instance, sugar maple, cedar and ash, and has been collected once from rock by Barclay-Estrup. It shows similar ecological preferences in Minnesota (Schuster, 1953). The collections were confined to the more temperate part of the study area.

The diagnostic character for this species is the presence of slender, leafless shoots which look like small caterpillars. Sporophytes are found.

74. Frullania brittoniae Evans

3 collections, recorded on 3% of sites.

First record: Black Bay Bridge, Current River. September 20 1958.
C.Garton 5656.

F.brittoniae is a boreal-temperate species (Schuster, 1953) which is only found in North America (Bonner, 1965), although it corresponds very closely to the common European species F.dilatata. (Schuster, 1953) regards it as closely related to Frullania eboracensis. It may be that the vigorous and more widespread North American species, F.eboracensis, arose when the original Tertiary distribution of the ancestral species was fragmented by glaciation. The distribution of F.brittoniae in the study area seems to be similar to that of F.bolanderi, but it is even less common.

It has been found on live ash, balsam poplar and balsam fir. Schuster (1953) states that it is not usually found on rock.

F.brittoniae is easily recognized, when fertile, by the tuberculate perianths with supplementary keels in addition to the three keels seen in F.eboracensis. The perianth also has a longer beak than the latter. When sterile or male it would most likely be overlooked as it can then only be distinguished by the rather wide underleaves which bear supplementary teeth. The lobules are also compressed at the mouth. It is frequently fertile.

75. Frullania eboracensis Gott.

89 collections, recorded on 56% of sites.

First record: Middlebrun Bay, Sibley. September 7 1958.
C.Garton 5584.

First published: Crowe & Barclay-Estrup (1971).

F.eboracensis has a similar distribution to F.brittoniae as it is boreal-temperate and North American. (Schuster, 1953). It has been found almost throughout the study area, except in the Lac des Mille Lacs region where the climate is, perhaps, a little more extreme.

Like most common species *F.eboracensis* has a wide ecological amplitude, much wider than the other *Frullania* spp found in the study area. The commonest substrate is live trees and it has been collected from every species of tree encountered during this survey, except pin cherry and alder. Most often the trees are mature, at least 15 to 20 cm in diameter and this may account for its absence from alder which is usually little more than a shrub in the study area. This species generally occurs at eye level, rarely at the base of a tree. It is occasionally found on dead trees but this seems to be the perpetuation of a colony growing while the tree was still alive, collections were never made from old logs or rotting wood. It has been found twice on rock. Sometimes other species of *Frullania* grow with *F.eboracensis*, also *Radula complanata* and, more often, *Ptilidium pulcherrimum*.

This species is very variable in colour, from bright green to deep brown, almost black. It is usually fertile and the smooth, three keeled, beaked perianths or pendulant androecial shoots are characteristic. The dorsal leaf lobes are auriculate. Every other species of *Frullania* in the study area has at least one marked vegetative characteristic which distinguishes it from *F.eboracensis*.

76. *Frullania inflata* Gott.

2 collections, recorded on 2% of sites.

First record: Corbett Creek (I6). May 13 1970. J.Crowe 311. Unpublished.

F.inflata is a very widespread species in North America but with a rather more southerly distribution so that it is classed as a temperate species (Schuster, 1953). The two collections made in the study area come from the more southerly and temperate part. It is possible that it is at the extreme northern limit of its range in the study area.

It was collected from ash in a flood plain area similar to that mentioned in Schuster, (1953) and it was also found on balsam poplar bark.

It is most difficult to distinguish from F.eboracensis but F.inflata is always green. The ventral lobules may not be inflated, especially near the apex of the shoot. The dorsal lobes are truncate. If fertile it may be distinguished by its autoecious inflorescence but the specimens found were not fertile.

77. Frullania oakesiana Aust.

2 collections, recorded on 2% of sites.

First record: Near Mud Lake. October 13 1958. C.Garton 5846.

First published: Crowe & Barclay-Estrup (1971).

F.oakesiana is described by Schuster (1953) as boreal. Comparing its distribution here with that of F.inflata, for instance, it does seem to have been found further inland in a more typically boreal part of this area. It is supposedly found in Europe (Arnell, 1956) but the description does not correspond well with that of the north American material.

It was found on live cedar and birch. Garton has also collected it from Balsam poplar. Schuster (1953) mentions similar habitats.

It is identified by the very large, inflated, ventral lobules, which are almost equal in size to the dorsal lobes. Sporophytes have been found.

78. *Frullania selwyniana* Pears.

2 collections, recorded on 2% of sites.

First record: Sibley Peninsula. October 25 1958. C.Garton 5904.

First published: Crowe & Barclay-Estrup (1971).

F.selwyniana is also classified by Schuster (1953) as a boreal species and it is only found in North America. Its distribution in this area seems to bear out its boreal affinities.

It has only been collected from live cedar bark, on which it also occurs in Minnesota (Schuster, 1953). He suggests that it requires a high relative humidity; this may be a limiting factor in this area and may help account for its distribution.

This is the only *Frullania* from the study area, apart from *Frullania asagrayana*, which has ocelli. However, it is very small and orange brown in colour, unlike the purplish red, large *F.asagrayana*. Sporophytes have been found.

79. *Lejeunea cavifolia* (Ehr.) Lindb.

3 collections, recorded on 2% of sites.

First record: S.W.corner of Whitefish Lake. October 4 1958. C.Garton 5751.

First published: Crowe & Barclay-Estrup (1971).

L.cavifolia is a very widespread circumpolar species (Arnell, 1956), mainly centred on the temperate zone (Schuster, 1953). However, the few collections made of it in this area are widely distributed and show no particularly temperate pattern.

Schuster (1953) suggests that it may be somewhat calciphilic whereas Arnell (1956) specifies siliceous rocks. It was found here, as in Minnesota, on live cedar bark and on rocks.

The hyaline borders of the cells on the leaf edge (see key), refract light when under moderate magnification and give the surface a 'sparkling' appearance. The only species with which it is at all likely to be confused in the study area is *Cololejeunea biddlecomiae*. *L.cavifolia* is larger and has large bilobed underleaves, (absent in *C.biddlecomiae*) and very small, slightly inflated ventral lobules. Sporophytes were found.

80. *Cololejeunea biddlecomiae* (Aust.) Evans.

3 collections, recorded on 3% of sites.

First record: S.W. corner of Whitefish Lake. October 4 1958. C.Garton 5764.

First published: Crowe & Barclay-Estrup (1971).

C.biddlecomiae is a North American species (Bonner, 1963) with a boreal-temperate distribution (Schuster, 1953). Only a few collections have been made in the study area but Williams (personal communication) is of the opinion that it is frequently overlooked. It is very small and has a similar yellow green colour to *Radula complanata*, with which it is often associated.

It was only found growing on cedar in the course of this study but it has been collected by Garton from a rock wall and from birch on St.Ignace Island. These substrates are similar to those listed for Minnesota (Schuster, 1953). Sporophytes were not found.

M E T Z G E R I A L E S

CODONIACEAE

81. *Fossombronia foveolata* Lindb.

1 collection, recorded on 1% of sites.

First record: Inwood Park, Upsala. September 27 1958.
C.Garton, 5711.

First published: Crowe & Barclay-Estrup (1971).

F.foveolata is a widely distributed species with a temperate range (Schuster, 1953). It is found in northwest and central Europe and in North America (Arnell, 1956). It was only collected once during this study and, curiously, within a few kilometres of the site of the collection made by Garton. However, it was also collected by Barclay-Estrup in 1971, in the centre of the study area on Current River.

Garton's collection came from the bank of a stream and it also was collected by Barclay-Estrup on silt just above the water line of the river. During this study it was collected from a disused gravel road in a rather swampy area. Schuster (1953) describes it as a pioneer species which does not resist desiccation well and is confined to damp areas. The collections made in this area were from wet sites which were, however, fully exposed to sunlight and might thus rapidly become desiccated during dry periods.

This species cannot be confused with any other found in the study area. The wings of the prostrate thallus are dissected into 'leaves', giving it a ruffled appearance. Thus it is neither typically thallose nor truly leafy. The rhizoids are deep violet and the involucre is campanulate. The ridges on the spores form polygonal markings. In Fossombronia wondraczekii the ridges do not meet so polygons do not form, in this way these two species may be distinguished. Sporophytes were collected.

BLASIACEAE

82: Blasia pusilla L.

18 collections, recorded on 18% of sites.
First record: Chippewa Park Road. July 26 1958. C.Garton 5535.
First published: Crowe & Barclay-Estrup (1971).

This circumpolar species (Bonner, 1963) is centred on the temperate zone (Schuster, 1953). It is fairly common throughout the study area but not ubiquitous.

The occurrence of this species depends mainly on the presence of disturbed inorganic soil, frequently on roadside banks and in ditches. Very wet sites are not favourable and it appears to prefer sites of moderate pH. This correlates well with the ecological requirements outlined by Schuster (1953).

It is easy to detect with the naked eye as the thalli are fairly large and usually grow in widespread colonies. Examination with the lens reveals large black spots along the edge of the thallus. These are colonies of the blue-green alga, Nostoc sp. This is unique, in the study area, to this species. B. pusilla frequently has either stellate gemmae or gemmae flasks but sporophytes have not been found.

PELLIACEAE

83. Pellia endiviifolia (Dicks.) Dum.

4 collections, recorded on 4% of sites.

First record: McIntyre River. November 9 1969. P.Barclay-Estrup 2176.

First published: Crowe & Barclay-Estrup (1971).

P.endiviifolia is a temperate, circumpolar species (Arnell, 1956). It has only been found a few times in the study area, always on soil in moist areas. It is considered by Arnell (1956) to be a calciphyte but this should not be a limiting factor on its distribution here.

It can only be confused with the other two species of Pellia found in the study area, P.neesiana and P.epiphylla. They are difficult to separate if they are not fertile but it is usually possible to find old involucres even if the capsules have disappeared P.epiphylla is paroecious and the antheridia can be seen as small lumps on the thallus behind the involucre which is a simple flap. The other two are dioecious with a tubular involucre, which in P.endiviifolia is erect, in P.neesiana low and inconspicuous. In section, P.neesiana and P.epiphylla have bands of spiral thickening in the cell walls in the middle of the thallus. *P.endiviifolia* has no spiral thickenings. Sporophytes have not been found but old involucres or antheridial papillae are usually present.

84. *Pellia epiphylla* (L) Corda.

6 collections, recorded on 6% of sites.

First record: Kaministiquia River, Neebing. September 28 1958. C.Garton 5740.

First published: Crowe & Barclay-Estrup (1971).

P.epiphylla is widely distributed throughout the Northern Hemisphere (Arnell, 1956). It has been collected a number of times but it is not particularly common. It has similar substrate requirements to *P.endiviifolia*. Sporophytes were collected.

85. *Pellia neesiana* (Gott.) Limpr.

8 collections, recorded on 7% of sites.

First record: Mile 17, Spruce River Road (K3C). June 17 1970. J.Crowe 656. Unpublished.

P.neesiana is boreal and circumpolar (Arnell, 1956). The collections made in this area seem to be distributed well away from Lake Superior which seems to confirm its boreal affinities. Its habitat requirements are similar to those of the other *Pellia* spp. Sporophytes have not been found but old involucres or antheridial papillae are usually present.

86. *Moerckia hibernica* (Hook.) Gott.

Not collected during the present survey.

First record: Middlebrun Bay. September 7 1958. C.Garton 5604.

First published: Crowe & Barclay-Estrup (1971).

M.hibernica is a boreal, amphi-atlantic species (Arnell, 1956). It is considered by Schuster (1953) to be an obligate calciphyte and is generally associated with cedar swamps. Middlebrun Bay fulfills these requirements.

It is often found on the edge of open grassy pools in cedar swamps (personal communication, Dr. Norton Miller).

The only species with which it could be confused are in the genus Pellia. Unlike these, it has a distinct midrib through the middle of the thallus and, in plants of both sexes, scales are present on the dorsal surface of the thallus. Sporophytes have not been found.

ANEURACEAE

87. Riccardia latifrons (Lindb.) Lindb.

34 collections, recorded on 24% of sites.

First record: Near Current River School. (now Claude Garton School)
September 20 1958. C.Garton 5671.

First published: Crowe & Barclay-Estrup (1971).

R.latifrons is a circumpolar, boreal-temperate species (Arnell, 1956). It is quite common and has been found throughout the study area.

It is found in bog pools and also frequently on rotting logs where it is associated with other rotting log species.

There are three species of Riccardia which are rather similar, R.latifrons, R.palmata and R.multifida. They all tend to be found in similar habitats, although Schuster, (1953) considers R.multifida to be confined to calcareous regions and R.palmata is somewhat less dependent on shade than the other two. They are distinguished as follows; R.multifida is pinnately branched and has a clear border of hyaline cells round the thallus which can be seen with a hand lens: both R.palmata and R.latifrons are palmately branched and not clearly bordered, but R.palmata is more xeromorphic, the cells have thicker walls and it is dark green to brownish. R.palmata is dioecious and R.latifrons is monoecious. R.latifrons frequently has sporophytes.

88. R.multifida (L.) S.F.Gray.

2 collections, recorded on 2% of sites.

First record: Middlebrun Bay. September 7 1958. C.Garton 5601.

First published: Crowe & Barclay-Estrup (1971).

R.multifida is confined to boreal regions (Schuster, 1953) and is circumpolar (Arnell, 1956). It seems likely that the situations in which it has been found in the study area do provide the calcareous conditions which it requires (Schuster, 1953). It is always found in bogs. Sporophytes were not collected.

89. Riccardia palmata (Hedw.) Carruth.

1 collection, recorded on 1% of sites.

First record: Drift Lake Road (F4). May 20 1972. J.Crowe 1368.

Unpublished.

R.palmata is a widespread, circumpolar species found at many latitudes (Arnell, 1956). It also extends into the West Indies and Mexico. It is interesting that it has a chromosome number n = 10, whereas R.latifrons, with which it has many features in common has n = 20 (Arnell, 1956). Sporophytes were not found.

90. Riccardia pinguis (L.) S.F.Gray

32 collections, recorded on 24% of sites.

First record: Provincial Paper Mill, Port Arthur.
May 2 1959. C.Garton 6041.

First published: Crowe & Barclay-Estrup (1971).

R.pinguis is a sub-cosmopolitan species found throughout the world (Arnell, 1956). It is apparently well adapted to life in the study area.

It has a similar ecological amplitude to R.latifrons but it is less often found on rotting wood and more often on organic soil and, occasionally, even on inorganic soil. It was never collected from living trees or rocks, although Garton has made one collection of it from a rock crevice; it is probable that this contained some soil. It is not found consistently with any other hepatic but it does sometimes grow over others found on the same substrate.

It is much larger than the other species of Riccardia and has a characteristic greasy, yellow-green colour. It is very little branched. Sporophytes have not been found.

M A R C H A N T I A L E S

CLEVEACEAE

91. *Asterella ludwigii* (Schwaegr.) Underw.

Not collected during present survey.

First record: Mount McKay. 1955. C.Garton (number not available)

First published: Crum (1956).

A.ludwigii is regarded as arctic-alpine by Schuster (1953). It is circumpolar but not common anywhere (Arnell, 1956). This has only been found in the study area on Mt.McKay, although it has been collected several times and by several collectors, including the writer. It was mentioned by Conklin (1927) as a possible find in the Pigeon River area but it has not, so far, been found on the Canadian side.

It grows on dry, inorganic soil on a south facing slope although not in direct sunlight. It was found originally in association with a species determined by Schuster as *Mannia sibirica*. This led to some speculation (Crum, 1956) as to whether other Cordilleran relicts might be found here. *M.sibirica* has not been found again and it seems possible that it was a xeromorphic form of *M.pilosa* (which has been collected recently) as Schuster (1953) himself suggests. Arnell (1956) also regards *M.sibirica* as a variety not a species. It is probable that this site more nearly approaches an alpine situation than most places in the study area. It could certainly not be regarded as arctic as it is just above one of the few stands of Sugar Maples in the study area.

This species is difficult to separate from M.pilosa unless it is fertile, when it can be recognized by the pseudoperianth, a fringe of linear scales surrounding the involucre. Unfortunately, the specimens found have been sterile but the thallus is very distinctly heart-shaped, unlike M.pilosa, which is more linear.

92. Mannia pilosa (Hornem.) Frye & Clark

Not collected during present survey.

First record: Kaministiquia River, near Kakabeka.
April 8 1970. C.Garton 11386.

First published: Crowe & Barclay-Estrup (1971).

M.pilosa is a circumpolar species (Arnell, 1956), considered by Schuster (1953) to be arctic-alpine. Although this species was not collected during the study period it had been found previously, growing on shale ledges in the Kaministiquia Valley, just below Kakabeka Falls. This was a much more sheltered site than that on which A.ludwigii has been found. It had no particular arctic or alpine characteristics, although it was a pioneer site. It is also said to be found at Pigeon River and Grande Portage in Minnesota (Schuster, 1953).

Neither this nor the previous species have been found in sites which could be regarded as arctic-alpine refugia but they do have in common a dry, unstable substrate which would be inhospitable to the establishment of a vascular flora. It seems probable that these are true pioneer species which like so many arctic and alpine species are unable to survive competition from higher plants (Tallis, 1958) and that this accounts for their rarity. Sporophytes were found.

CONOCEPHALACEAE

93. Conocephalum conicum (L.) Dum.

25 collections recorded on 25% of sites.

First record: Oliver Creek. May 15 1955. C.Garton 2516.

First published: Crowe & Barclay-Estrup (1971).

C.conicum is circumpolar (Bonner, 1963) and temperate (Schuster, 1953). The distribution in this area shows clearly its temperate affinities, and gives the impression that it is moving in from the southwest. Schuster (1953) postulated that it would not be found north of Grande Portage, but it is common within the limits indicated on the distribution map.

It is almost always found on moist organic soil, especially in swamp pools. However, at the south end of Ouimet Canyon it was found growing on moist, sheltered rock walls, in very much the same situation that the writer had observed it in Cassino, Italy, although in a vastly different climate. It is considered by Schuster (1953) to have a wide ecological amplitude, although calcareous sites seem to favour it and it is certainly not found in dry areas.

It is large and bright yellow green, with very clear polygonal markings on the thallus. Marchantia polymorpha is similar in size but darker green and not so clearly marked. C.conicum is supposedly recognizable from its smell, which

Arnell (1956) likens to turpentine. It is somewhat aromatic in the study area but the scent is rather earthy and not very distinctive. Sporophytes have not been found.

CLEVEACEAE

94. _Clevea hyalina_ (Sommert.) Lindb.

Not collected during present survey.

First record: Bat Cave, Cavern Lake, near Dorion.
C.Garton (number not available).

First published: Crowe & Barclay-Estrup (1971).

C.hyalina is a circumpolar, arctic species (Schuster, 1953) which has been found in only one place in the study area. The plant grows at the mouth of a large, sandstone cave in a heavily shaded situation. Unfortunately, the original collection has been lost but further collections have been made recently by Garton (not yet processed). The latter specimens were found by the writer to have distinct antheridial papillae; female plants have not been seen.

The Bat Cave is a collapsed cave and it seems highly probable that it was inundated in post-glacial times as the present water level of Cavern Lake is quite near the entrance. The rocks are probably calcareous and the situation is certainly xeric, this would agree with the ecological prefererences cited by Schuster (1953).

C.hyalina is intermediate in size among thallose species. The pores, few in number, are stellate and the ventral scales have hyaline appendages which protrude under the edge of the thallus making it appear fringed.

MARCHANTIACEAE

95. <u>Preissia quadrata</u> (Scop.) Nees

3 collections, recorded on 3% of sites.

First record: Trowbridge Falls. June 12 1956. Bailey 857.

First published: Crowe & Barclay-Estrup (1971).

P.quadrata is widely distributed in the northern hemisphere (Schuster, 1953). Surprisingly it was only collected three times during this study, although there were previously nineteen collections of it in Lakehead University Herbarium. However, eight of these were found on shale ledges near two rivers in the immediate vicinity of Port Arthur and six were just outside the study area.

None of the collections made during this study came from shale: one was from a stream bank, one from a swamp and one from a roadside ditch. Barclay-Estrup has also collected it from a lake shore. Schuster (1953) regarded it as a calciphyte, which the shale collections would tend to support. The local collections seem to indicate that it has a wide amplitude with respect to moisture and tolerates exposure well. It seems to be confined to the more temperate part of the study area.

P.quadrata is also intermediate in size among the members of the Marchantiaceae found in the study area. It is recognized by the crisped reddish purple edges of the thallus. Sporophytes have not been found.

96. *Marchantia polymorpha* L.

7 collections, recorded on 7% of sites.

First record: Pearl Road, Sibley. August 1 1955. C.Garton 2637.

First published: Crowe & Barclay-Estrup (1971).

First published: Crowe & Barclay-Estrup (1971)

M.polymorpha is a sub-cosmopolitan species occurring throughout the northern hemisphere (Arnell, 1956). It has been collected in the arctic (Polunin, 1940; Schuster, 1951) and is common all over Minnesota (Schuster, 1953). It is surprising that it has not been collected more often in the course of this study. However, about half the earlier collections were taken from a very small, rich, flush area on Mt.McKay (Hess, 1970). The others were all found within a few kilometres of Lake Superior except for one on Oliver Lake, an area much affected by cottage development.

In other parts of the world, M.polymorpha is often associated with recently burned areas (Benson & Blackwell, 1926; Skutch, 1929). Arnell (1956) regards it as a species of cultivated ground. No newly burned areas were visited here but the collections made were generally on the site of some kind of soil disturbance, such as roadside banks. It does not seem to be associated with natural forest areas at all, nor even with areas of natural erosion on which B.pusilla may be found.

This large species is often fertile, male and female plants are usually found in close proximity, but the antheridiophores disappear fairly quickly, while the archegoniophores persist and bear the sporophytes. Gemmae cups are also frequently found.

RICCIACEAE

97. Riccia cavernosa Hoffm.

Not collected during the present survey.

First report: S.W. end of Whitefish Lake. September 1972.
C.Garton. Unpublished.

R.cavernosa is a circumpolar, temperate species (Paton, 1967). It was identified by the writer as Riccia crystallina, and this was confirmed by Carol Woodfin of the University of Texas at Austin (personal communication). However, it was pointed out by Williams (personal communication) that it was actually R.cavernosa as described by Paton (1967). The two species are distinguished by their spores, R.crystallina has not been found in North America. Schuster (personal communication via Carol Woodfin) expressed surprise that this species should have been found so far north.

Dr.Woodfin cultured the original sample sent to her and a second, different species cropped out, which she identified as R.beyrichiana. However, Dr.Schuster has recently cast some doubt on this. He is at present engaged on a revision of the genus in which Dr.Woodfin is assisting. This should be of considerable interest as Riccia spp are probably far more common than they appear but are overlooked because of their small size. They also frequently occur in cultivated areas which do not attract collectors. It seems likely also that their appearance is very ephemeral, their spores only germinating when conditions are exactly right. The thalli in this collection produced spores within a few days of being brought indoors.

The plants were found on silt from a creek bank, the presence of spores from another species seems to suggest that these spores are being borne into the area by the atmosphere. The nearest recorded station for R.crystallina (R.cavernosa) (Schuster, 1953) is in the region of Minneapolis.

This is an extremely small species but it can be seen with the naked eye as tiny bright green spots. Under low magnification these appear spongy and eroded. The capsules are embedded in the thallus, which ruptures to release the spores. It could only be confused with another Riccia sp. It is quite closely related to R.fluitans, which is quite likely to be found in the study area. However, the latter species has a linear thallus, which is not eroded. It is never fertile and is usually found floating. R.fluitans has been included in the artificial key so as to avoid confusion should specimens be found at some future date.

APPENDIX III

ARTIFICIAL KEY TO THE HEPATICS OF SOUTH WEST THUNDER BAY DISTRICT

This key has been devised in the hope that it would prove useful to local collectors. For this reason, it has been kept simple and technicalities avoided as far as possible. It is based mainly on material collected in the study area but, where this was inadequate, taxonomic information has been gleaned from the following works: MacVicar (1926), Arnell (1956), Schuster (1953, 1966, 1969).

In general, ecological information has been confined to the check list. If these factors are used too freely in a key, valid determinations may be rejected if the species is found in an unusual type of habitat.

Appended to the key is a guide to the relative size of the leafy Jungermanniales, the terms large, small etc as used in the key refer directly to this list. This is subjective and is only intended as a rough guide because most species exhibit variability, especially under less than optimum conditions.

KEY

Plant thallose 1
Plant with distinct stem and leaves 17
(Jungermanniales and Fossombronia)

1a Thallus with air spaces and, in most cases, distinct pores. (Marchantiales) 2
1b Thallus with no air spaces or pores. (Metzgeriales) 9

2a Air pores large, may be visible to the naked eye when fresh, surface reticulate. Thallus 6-10 mm or more wide. 3
2b Air pores only visible under x10 magnification or absent. Surface not reticulate. Thallus 6 mm or less in width. 5

3a Pores of thallus simple. Thallus bright yellow green with strongly reticulated surface. Aromatic when bruised. Conocephalum conicum
3b Pores of thallus compound, with inner cruciate opening. Dark green thallus with faint reticulations. No odour. 4

4a Large thallus, 7-20 mm wide. Uniformly green. Gemmae often present in cups on thallus surface. Frequently fertile, dioecious, with erect stalked archegoniophores or antheridiophores. Marchantia polymorpha

4b Thallus smaller, 6-10 mm wide. Dull green with reddish purple crisped edges. No gemmae. Not so far found fertile in southwest Thunder Bay District. Preissia quadrata

5a Pores sparse, stellate when present, thallus fringed with violet scales. Colourless fringe like projections on male thallus. Clevea hyalina
5b Pores simple or none. Thallus not fringed, without colourless fringe like projections. 6

6a Pores simple. 7
6b Pores none. 8

Continued: KEY

7a Thallus somewhat elongate and clearly bifid, fringed at notch where archegoniophore is inserted. No pseudoperianth. Has been found fertile in S.W. Thunder Bay District. Mannia pilosa

7b Thallus heart-shaped, not clearly bifid, only slightly notched, not fringed at insertion of archegoniophore. Whitish fringe of pseudoperianth hangs below receptacles on sporophyte. Has not been found fertile in S.W. Thunder Bay District. Asterella ludwigii

8a Thallus 1-2 mm wide, heart-shaped, spongy, dorsal epidermis breaking down. When fertile, black sessile sporangia enclosed in thallus. Riccia cavernosa

8b Thallus 1 mm wide, linear, dichotomously branched, translucent, epidermis entire. Always sterile. Riccia fluitans *

9a Thallus linear, often branched, several cells thick in cross section. No midrib. (Riccardiaceae) 10

9b Thallus broader, little branched, one cell thick on wings. Midrib present, may not be visible externally. 13

10a Thallus large, 4-10 mm wide, sparingly branched, bright green, greasy appearance, 10-15 cells thick. May be confused with Pellia spp but turgid, not thin, especially on wings. May form rosettes but not broad sheets. Riccardia pinguis

10b Thallus smaller, less than 2 mm wide, dull green 4-9 cells thick. 11

11a Thallus regularly 3-pinnately branched. Hyaline thallus border, 2-3 cells wide (clear cells visible with hand lens). Riccardia multifida

11b Thallus not regularly pinnate, without a hyaline border. 12

12a Cells of mature portion of thallus thin walled but not hyaline. Appressed to substrate. Monoecious. Riccardia latifrons

12b Cells of mature portion of thallus thick walled and brownish. Linear, ultimate segments somewhat erect. Dioecious. Riccardia palmata

* Not yet recorded from study area.

Continued: KEY

13a Clearly defined midrib present. Cells differentiated in cross section. Scales on dorsal surface of thallus. Moerckia hibernica

13b Midrib not clearly defined. Cells not differentiated in cross section. No scales on dorsal surface. 14

14a Black spots round edge of bright green, opaque thallus. Narrow white lines sometimes found on dorsal surface. Forms rosettes or patches. Blasia pusilla

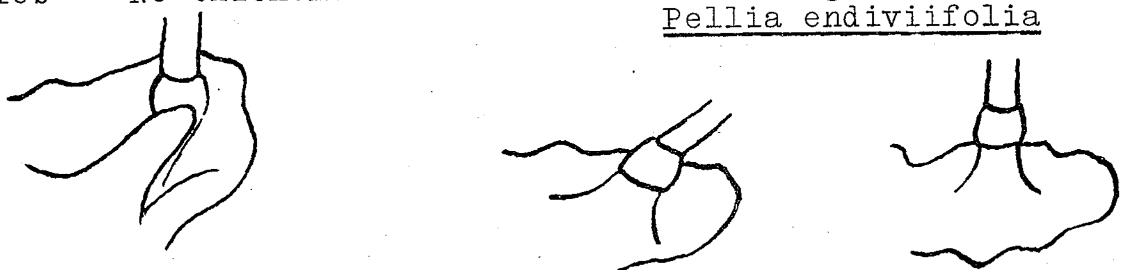
14b No black spots or white lines. Thallus dull green, thin. Widespread patches, no rosettes. (Pelliaceae) 15

15a Paroecious species with flap-like involucre. Thickened bands seen in cross section. Pellia epiphylla

15b Dioecious species with tubular involucre. May or may not have thickened bands. 16

16a Thickened bands in thallus. Tinged with red on midrib. Pellia neesiana

16b No thickened bands. No red colouring. Pellia endiviifolia



P.epiphylla P.neesiana P.endiviifolia

17a Sporangia borne dorsally in goblet-shaped cups. Large undulate leaves. Purplish rhizoids. Fossombronia foveolata

17b Sporangia borne terminally. Clearly defined stems and leaves. (Jungermanniales) 18

18a Leaves deeply divided and fringed into narrow filaments. 19

18b Leaves not so divided, they may be toothed, lobed or entire. 21

19a Leaves divided to the base in 3 or 4 linear segments each one cell wide. Blepharostoma trichophyllum

19b Leaves divided into two main lobes, each fringed with filaments. 20

Continued: KEY

20a Dorsal (larger) lobe 6-10 cells wide at base. Green to golden brown. Usually creeping over surface. Ptilidium pulcherrimum

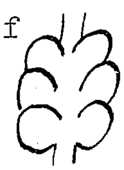
20b Dorsal lobe 15-20 cells wide. Purplish red. More often erect in growth form. Ptilidium ciliare

21a Leaves incubous. Entire or variously lobed or toothed. 22

21b Leaves succubous or transverse. 38

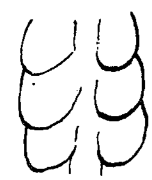
Incubous

apex of shoot



Dorsal view

Succubous



apex of shoot

22a Leaf lobed or toothed. 23

22b Leaf entire or with a conduplicate ventral lobe. 24

23a Leaf with 3 or 4 finger like lobes. Underleaves similarly lobed, easily seen. Leaves tightly curled when dry. Pinnate branching. Medium size. Lepidozia reptans

23b Leaf 3-lobed at apex. Underleaves wider than long, irregularly lobed. Forked branching, large. Bazzania trilobata

24a Leaf entire, bluish or whitish green. Underleaf rounded, bilobed or nearly entire. (Calypogeiaceae) 25

24b Leaf has conduplicate ventral lobe hidden by the dorsal lobe. (Porellinae) 27

25a Medium size. Rounded leaves, growing on organic soil in noticeable patches distinguished by their light colour. Calypogeia integristipula

25b Small species. Pointed leaves. Growing on various substrates, not found in patches but as isolated strands among other bryophytes. 26

26a Underleaves as long as wide, seldom toothed. Found on Sphagnum. Calypogeia sphagnicola

26b Underleaves wider than long, often with lateral teeth. Found on rotting logs. Calypogeia suecica

Continued: KEY

27a Underleaves absent. 28
27b Underleaves present. 29

28a Plants very small. Ventral lobule inflated. Rhizoids clustered on stem. Papillose cuticle. Pointed leaves. Not so far found fertile in study area. No gemmae. Cololejeunea biddlecomiae

28b Medium size. Ventral lobule little inflated. Rhizoids, if present, on ventral lobule. Smooth cuticle. Rounded leaves. Flattened 'purse shaped' perianths frequent. Discoid gemmae common. Radula complanata

29a Underleaves entire. Lobules not inflated. Long axis of lobule parallel to stem. Large. (Porellaceae) 30

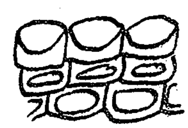
29b Underleaves bilobed. Lobules inflated, not necessarily parallel to stem. Size variable. 31

30a Ventral lobules as wide as underleaves. Dorsal lobes as wide as long. Perianth mouth densely ciliate. Irregular pinnate branching. Porella platyphylloidea

30b Ventral lobule tapering.* Dorsal lobes ovate. Perianth mouth with scattered cilia. Regularly bipinnate. Porella platyphylla

31a Ventral lobe not stalked, lying at an angle with stem but parallel to the posterior leaf margin. Somewhat inflated. Yellow green, rather 'sparkling' under microscope due to hyaline edges of leaf cells. Perianth 5-angled. Lejeunea cavifolia

Cell structure of leaf edge.



31b Ventral lobe stalked, parallel to stem. Generally inflated and helmet shaped. Reddish brown to deep green. Perianth 3-angled, sometimes with supplementary ridges. (Frullaniaceae) 32

32a Dorsal lobe with ocelli-oblique lines of coloured cells in the leaf. 33
32b Dorsal lobes lacking ocelli 34

*Narrower than underleaves.

Continued: KEY

33a Rather large, dark reddish brown, glossy, imbricate. Frullania asagrayana

33b Very small, orange brown, leaves not noticeably shiny, overlapping but not closely imbricate. Frullania selwyniana

34a Erect 'worm-like' branches with deciduous leaves and persistent underleaves. Frullania bolanderi

34b Without erect worm-like branches, although shoots with deciduous leaves may sometimes occur. 35

35a Dorsal lobes truncate. Autoecious. 36

35b Auriculate dorsal lobes. Dioecious. 37

36a Ventral lobes inflated. Very large, nearly as big as dorsal lobes. Brownish green. Frullania oakesiana

36b Many ventral lobules not inflated, less than half the size of dorsal lobes. Bright green. Frullania inflata

37a Ventral lobules inflated throughout. Underleaves bilobed, not toothed. 3 keels on perianth, not tuberculate. Frullania eboracensis

37b Ventral lobules pinched at opening, underleaves toothed. Supplementary keels on perianths, also tuberculate. Frullania brittoniae

38a Leaves entire. 39

38b Leaves lobed. 47

39a Stems with thread-like branchlets from main stem, distinct underleaves with slime papillae. 40
Leaves rather rigid and concave. (Odontoschismaceae)

39b Stems without flagellae. Underleaves various but not distinctly concave. 41

40a Plants reddish, blackish or brownish, cuticle papillose. Leaves moderately concave. Odontoschisma denudatum*

40b Plants green to whitish green. Cuticle smooth, leaves strongly concave. Odontoschisma macounii*

* Not yet recorded from the study area.

Continued: KEY

41a Leaves pressed closely together. Leaf insertions markedly overlapping, running down stem, decurrent. Leaves rather square, often reddish tinged. Trigones small, perianth fringed.
Jamesoniella autumnalis

41b Plant not having all the above characteristics. 42

42a Rhizoids restricted to the base of bilobed underleaves. 3 lobed perianths. 43

42b Underleaves absent or hidden by rhizoids. 44

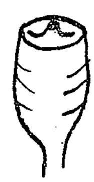
43a Leaves whitish green. Somewhat rectangular and lax. Cells hyaline. *Chiloscyphus pallescens*

43b Leaves deeper green and somewhat rounded. Cells not hyaline. *Chiloscyphus polyanthus*

44a Leaves two different shapes, upper lanceolate, lower orbicular. Plants erect, may form tufts 3-8 cm high. Often with yellow green gemmae.
Mylia anomala

44b Leaves on individual plants all same shape. Not erect or tuft forming. No gemmae. 45

45a Leaves rather elongate, rectangular, bulging trigones. Perianth with small beak set in indentation. Often fertile in this area.
Jungermannia lanceolata



Perianth

45b Leaves circular or broadly ovate. Perianth not as above. 46

46a Leaves broadly ovate, may have minute teeth, pleated at insertion. Alternate, overlapping but spreading. Large. Sterile in this area.
Plagiochila asplenioides

46b Leaves circular, no teeth, opposite, tightly imbricate. Small. *Arnellia fennica*

47a At least some leaves 3-4 lobes. 48

47b Leaves uniformly bilobed. 57

Continued: KEY

48a Large teeth on margins of lobes. Golden yellow.
Chandonanthus setiformis
48b No teeth on lobes except for terminal point.
Colour various. 49

49a Lobes equal, most 4 lobed. 50
49b Leaves unequally 3 lobed or variable some leaves
2 lobed some 3. 52

50a Plant erect. Always bearing slender flagellae,
often tipped with gemmae.
Lophozia attenuata
50b Plant prostrate, no flagellae. 51

51a Plant with underleaves, reddish brown gemmae.
Leaf may have mucronate tips. (Not found in study
area so far). *Lophozia hatcheri*
51b No underleaves or gemmae. Stem often reddish.
Tips of leaves always blunt.
Lophozia barbata

52a Lobes equal, somewhat irregular in number, mostly
2 or 3, sometimes with supplementary teeth. 53
52b Leaves 3-lobed, on poor specimens may be 2, always
unequal. Gemmae, if present, angular, opaque. 55

53a Bright, bluish green. Densely chlorophyllose cells,
thick trigones, appears mottled under x40
magnification. Compressed 'cabbage-like' heads
formed from densely crowded leaves with supplementary
teeth. *Lophozia incisa*
53b Pure green or reddish brown or black. Cells thin
walled, pellucid. No compact heads. 54

54a Leaves reddish brown to black. Stem pale green.
Leaves 2 to 3 lobed, irregular in outline.
Lophozia capitata
54b Leaves pure green. Stem brownish red. Leaves
2 to 4 lobed. Regular in outline.
Lophozia marchica

55a Lobes not strongly unequal. Leaves rather
rectangular in shape.
Tritomaria scitula
55b Lobes strongly unequal. Leaves less rectangular,
may be wider than long. 56

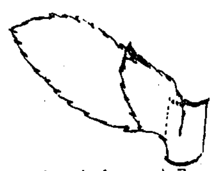
Continued: KEY

56a Rather large, leaves concave, broader than long.
No gemmae. Tritomaria quinquedentata
56b Leaves not markedly concave, as broad as long.
Small, lobes often reduced to 2. Reddish brown
angular gemmae. Tritomaria exsectiformis

57a Leaves bilobed with extremely long points. Very
concave. Reddish brown pigmentation.
Nowellia curvifolia
57b Leaves variously bilobed but points subequal half
leaf length. Not so markedly concave. Pigmentation
various. 58

58a Leaves bilobed, lobes pressed together to form 59
a keel. Dorsal lobe smaller than ventral
(Scapaniaceae)
58b Leaves bilobed but not keeled. 69

59a Leaf lobes narrow, oval, their axes at right angles.
Leaf margins at least partly denticulate.
Diplophyllum taxifolium



59b Leaf lobes not distinctly oval. If narrow, not 60
denticulate (Scapania spp).

60a Plants very small, under 8mm long, oval, reddish 61
brown gemmae.
60b Plants larger, over 8mm long. 63

61a Gemmae 1 celled. Leaves of gemmiparous shoots
reduced. Scapania apiculata
61b Gemmae 2 celled. No shoots with reduced leaves. 62

62a Plant green except for reddish brown gemmae. Dorsal
lobe clearly smaller than ventral. Lobes pointed.
Scapania glaucocephala
62b Plant pure green to blackish. Dorsal lobe almost
equal to ventral. Lobes rounded.
Scapania cuspiduligera

63a Ventral lobe narrow, longer than wide, pointed but 64
not mucronate.
63b Ventral lobe broad as wide as long. 66

Continued: KEY

64a 2 celled reddish brown gemmae. Dorsal lobes one quarter size of ventral.
Scapania gymnostophila

64b 2 celled greenish yellow gemmae. Dorsal lobes half size of ventral. 65

65a Leaf margins entire. Less than 6 oil bodies per cell in leaf edge. 6 to 12 in leaf middle.
Scapania mucronata

65b Occasional teeth on leaf margin. 6 or more oil bodies per cell in leaf edge, 9 or more in leaf middle. Scapania microphylla

66a Large species with broad, oval lobes, margin clearly toothed. Scapania nemorosa *

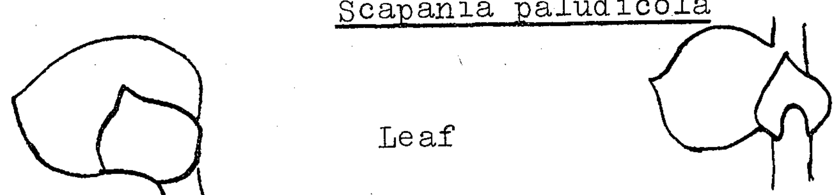
66b Leaves with no marginal teeth. 67

67a Ventral lobule decurrent, leaves bordered, in or near moving water. Scapania undulata

67b Ventral lobule not decurrent, leaves not bordered. 68
Plants sometimes found in wet areas but not submerged.

68a Leaves rather lax. Keel weakly arched.
Scapania irrigua

68b Leaves firmer, keel very markedly arched.
Scapania paludicola



Leaf

S. irrigua S. paludicola

69a Plants very small to minute. Leaves either clearly transverse or stem translucent with a darker central strand. 70

69b Plants various in size but generally larger and not having the above characters. 81

70a Minute plants with transverse bilobed leaves with spreading, deeply cleft lobes. (Cephaloziellaceae) 71

70b Plants generally somewhat larger with translucent stems having a central strand. Leaf cells large and few OR leaves with obtuse lobes. 74

* Not yet collected in the study area

Continued: KEY

71a Elongate leaf lobes, cleft nearly to base. Small linear or bilobed underleaves on sterile shoots.
Cephaloziella elachista

71b Triangular leaf lobes less than half length of leaf. Underleaves may be present. 72

72a Linear underleaves. Very deeply brownish to blackish pigmented. *Cephaloziella starkei*

72b Underleaves usually absent. Green or slightly brown or reddish pigmented. 73

73a Leaf lobes 6 to 9 cells wide. No underleaves. Leaves spreading. Green or brownish green.
Cephaloziella hampeana

73b Leaf lobes 3 to 5 cells wide. Underleaves rare. Leaves very concave. Reddish brown.
Cephaloziella rubella

74a Very small plants with translucent stems. 75

74b Leaves with obtuse lobes. 80

75a Leaf lobes non-connivent, half leaf length, whitish green or hyaline. 76

75b Leaf lobes connivent, clear green. 77

76a Leaves with very few large hyaline cells. Lobes 2 cells wide. *Cephalozia lacinulata*

76b Leaves with denser, more numerous cells. Lobes 3 or 4 cells wide. Whitish green.
Cephalozia bicuspidata

77a Cells few and large. Lobes 3 to 4 cells wide. Leaves slightly decurrent, symmetrically inserted.
Cephalozia media

77b Cells smaller and more numerous, lobes 4 or more cells wide. Leaves decurrent. 78

Continued: KEY

78a Leaves asymmetrically inserted. Lobes strongly connivent. Perianth mouth ciliate.
Cephalozia connivens

C. connivens

78b Leaves not so asymmetrically inserted. Lobes not strongly connivent. Perianth mouth with small teeth. 79

79a Whitish green. Perianth mouth tightly pleated.
Cephalozia pleniceps

79b Yellowish green. Perianth mouth dentate.
Cephalozia affinis

80a Stems with flagellae. Leaves distant, flat.
Cladopodiella fluitans

80b No flagellae. Leaves overlapping. Slightly concave.
Gymnocolea inflata

81a Leaves equally bilobed. Underleaves distinctly bilobed. 82

81b Leaves equally bilobed. Underleaves either absent, or not bilobed, or minute. 84

82a Leaves dense, bright green. Underleaves with parallel lobes pressed close to stem.
Geocalyx graveolens

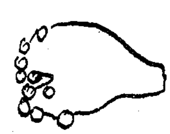
82b Leaves rather transparent. Lobes of underleaves diverging and with supplementary teeth. Lophocolea spp. 83

Underleaf
G. graveolens

Underleaf
L. heterophylla

83a Plants small. Discoid gemmae on edge of leaf, giving ragged appearance. No means of sexual reproduction.
Lophocolea minor

Leaf
L. minor



83b Plants variable in size but generally medium. Yellow green to whitish green. Usually fertile with a trigonous perianth. Never gemmiparous.
Lophocolea heterophylla

Continued: KEY

84a Plants with large lanceolate underleaves fused to one side with the lateral leaves. Small
Harpanthus scutatus
84b Plants with or without underleaves. Never as above. (*Lophoziacaeae*) 85

85a Plants with underleaves. 86
85b Plants with no underleaves. 87

86a Large lax leaves with 2-3 bifid underleaves. Similar, superficially, to *C.pallescens* except for bilobed leaves. *Lophozia rutheana*
86b Medium size. Brownish gemmiparous shoots with appressed leaves. Linear underleaves.
Lophozia heterocolpa

87a Plants with relatively flat leaves. (*Lophozia* spp) 88
87b Plants with transverse, very concave leaves, clearly channelled. (*Anastrophyllum* spp) 95

88a Plants with reddish gemmae. 89
88b Plants with greenish gemmae or none. 92

89a Plants with orbicular leaves with a shallow sinus. 90
89b Plants with more rectangular leaves and a clear sinus. 91

90a Few purplish gemmae. Thin walled polygonal cells. Somewhat ascending. Crenulate perianth mouth.
Lophozia excisa
90b Reddish brown gemmae. Cells with small trigones. Prostrate. Perianth mouth with short teeth.
Lophozia alpestris

91a Crimson gemmae on erect shoots (not with reduced leaves). Leaves almost transverse, spreading.
Lophozia longidens
91b Rusty brown gemmae. Gemmiparous shoots with eroded leaves. Leaves succubous, not spreading.
Lophozia bicrenata

92a Gemmae none. Small. Yellow green.
Lophozia badensis
92b Gemmae green or greenish yellow. Plants various 93

Continued: KEY

93a Plants medium. Leaves wider than long. Insertions overlap. Masses of yellow green gemmae.
Lophozia ventricosa

93b Plants small. Leaves longer than wide, distant. 94

94a Plants erect. Leaves similar to *L.longidens* but with green gemmae. Trigones small.
Lophozia ascendens

94b Plants sub-erect. Leaves similar to *L.ventricosa* Rarely with greenish gemmae. Trigones large. Reddish pigmented. *Lophozia porphyroleuca*

95a Plants large. Green to golden yellow with closely imbricate leaves. Leaf lobes concave and cupped together. *Anastrophyllum saxicola*

95b Plants small to minute. Leaves less concave and less imbricate. 96

96a Plants small, dorsal lobe squarrose to decurrent. Purplish brown gemmae, no filiform shoots.
Anastrophyllum michauxii

96b Plants small to minute. Red gemmae borne on filiform shoots.

97a Plants small forming brownish black mats. Filiform shoots but leaves on them not reduced. Gemmae yellow to red. *Anastrophyllum minutum*

97b Plants minute often forming velvety carpets on rotting logs. Filiform shoots with extremely reduced leaves and tipped with scarlet gemmae.
Anastrophyllum hellerianum

GUIDE TO RELATIVE SIZE
JUNGERMANNIALES

LARGE over 3 cm long

Anastrophyllum saxicola
Bazzania trilobata
Chandonanthus setiformis
Chiloscyphus pallescens
Lophozia barbata
L.Hatcheri L.rutheana
Plagiochila asplenioides
Porella platyphylla
P.platyphylloidea
Scapania nemorosa
S.undulata
Tritomaria quinquedentata

MEDIUM 1.5 to 3 cm

Anastrophyllum michauxii
Calypogeia integristipula
Chiloscyphus polyanthus
Cladopodiella fluitans
Diplophyllum taxifolium
Geocalyx graveolens
Gymnocolea inflata
Frullania asagrayana
Jamesoniella autumnalis
Jungermannia lanceolata
Lepidozia reptans
Lophocolea heterophylla
Lophozia attenuata
Lophozia heterocolpa
Lophozia ventricosa
Mylia anomala
Nowellia curvifolia
Ptilidium pulcherrimum
Ptilidium ciliare
Radula complanata
Scapania irrigua
S.paludicola

SMALL approx 1-2 cm

Arnellia fennica
Blepharostoma trichophyllum
Calypogeia sphagnicola
C.suecica
Frullania bolanderi
Frullania brittoniae
F.eboracensis
F.inflata
Harpanthus scutatus
Lejeunea cavifolia
Lophocolea minor
Lophozia badensis L.ascendens
L.bicrenata
L.capitata
L.excisa
L.alpestris
L.incisa
L.longidens
L.marchica
L.porphyroleuca
Odontoschisma denudatum
O.macounii
Scapania gymnostophila
S.microphylla
S.mucronata
Tritomaria exsectiformis
T.scitula

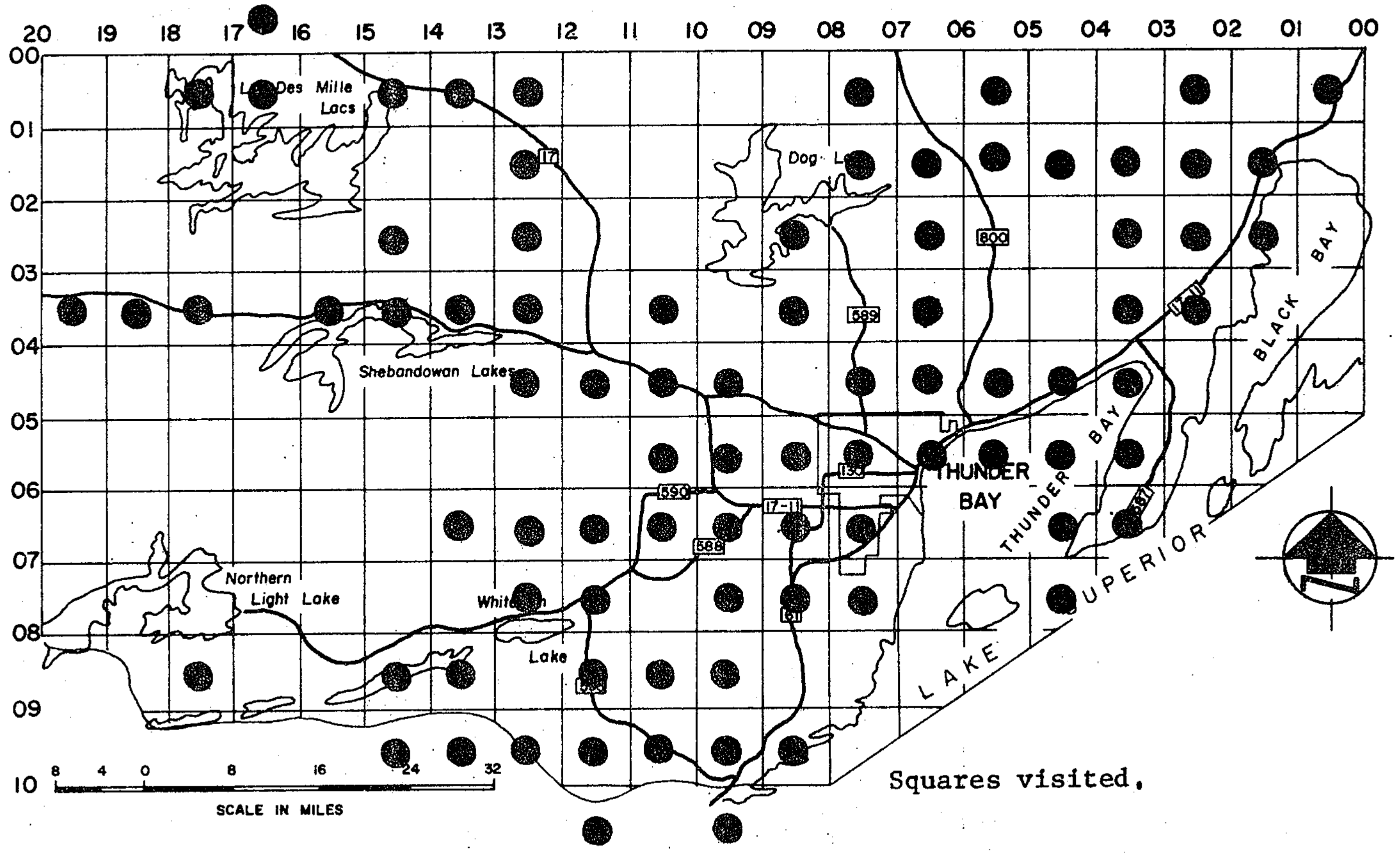
VERY SMALL under 15 mm long

Anastrophyllum hellerianum
Cephalozia affinis
C.bicuspidata
C.connivens
C.lacinulata
C.media
C.pleniceps
Cephaloziella elachista
C.hampeana
C.rubella
C.starkii
Cololejeunea biddlecomiae
Frullania oakesiana
F.selwyniana
Scapania apiculata
S.cuspiduligera
S.glaucocephala

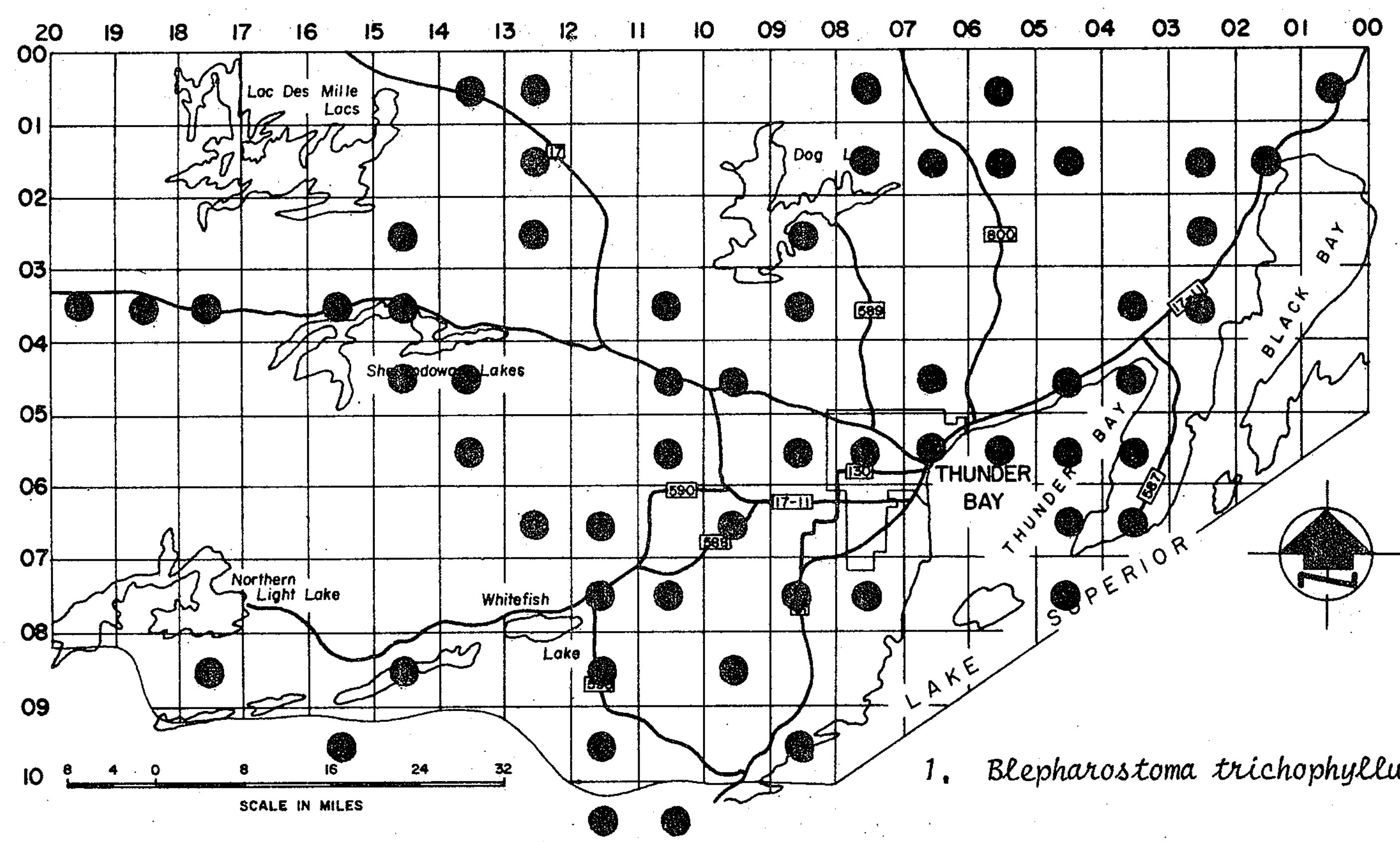
APPENDIX IV

DISTRIBUTION MAPS

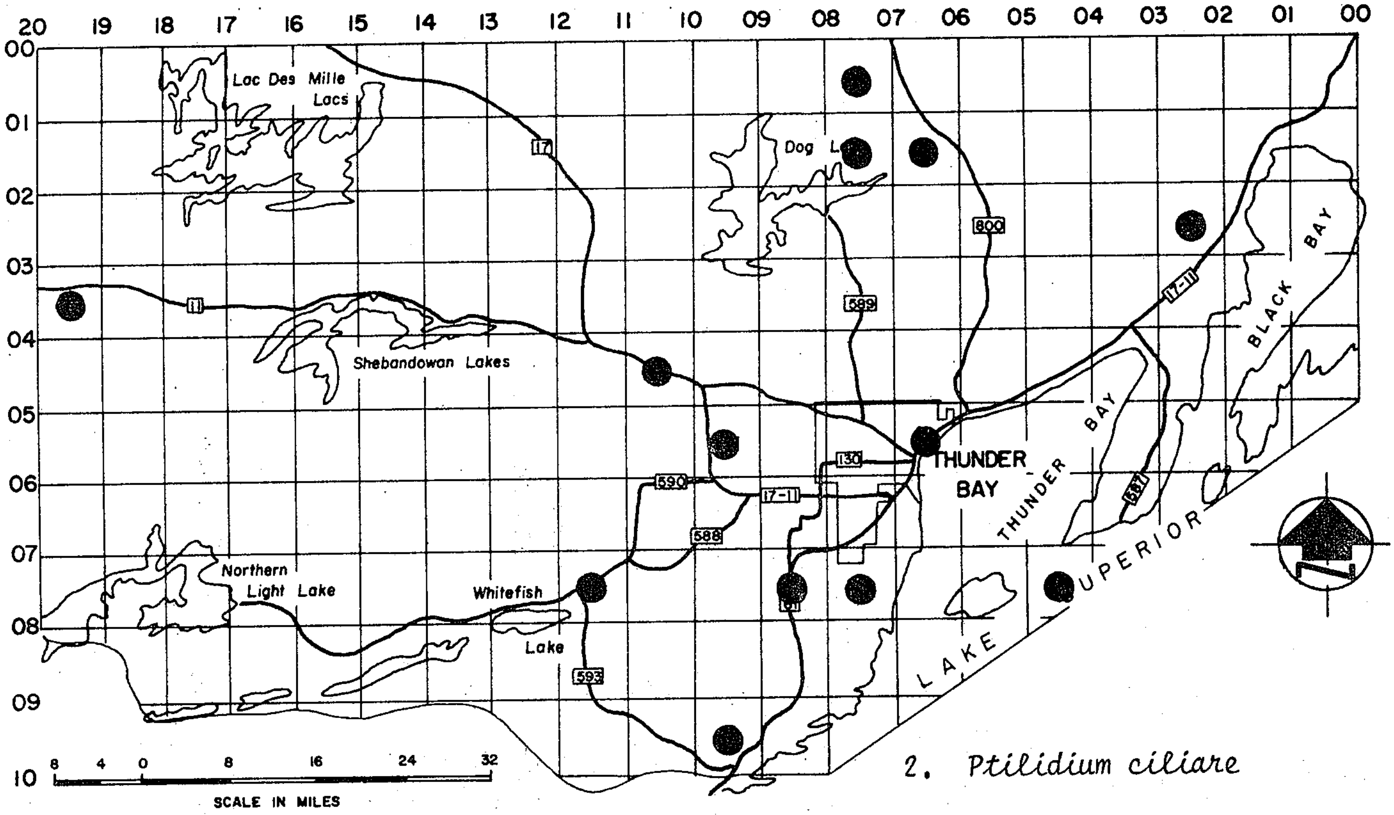
One map is provided for each species. Each map is divided into 10 kilometre squares on the international Mercator grid. A single spot in a square indicates that the species has been collected somewhere within that square at least once. All available records have been used to prepare these maps.



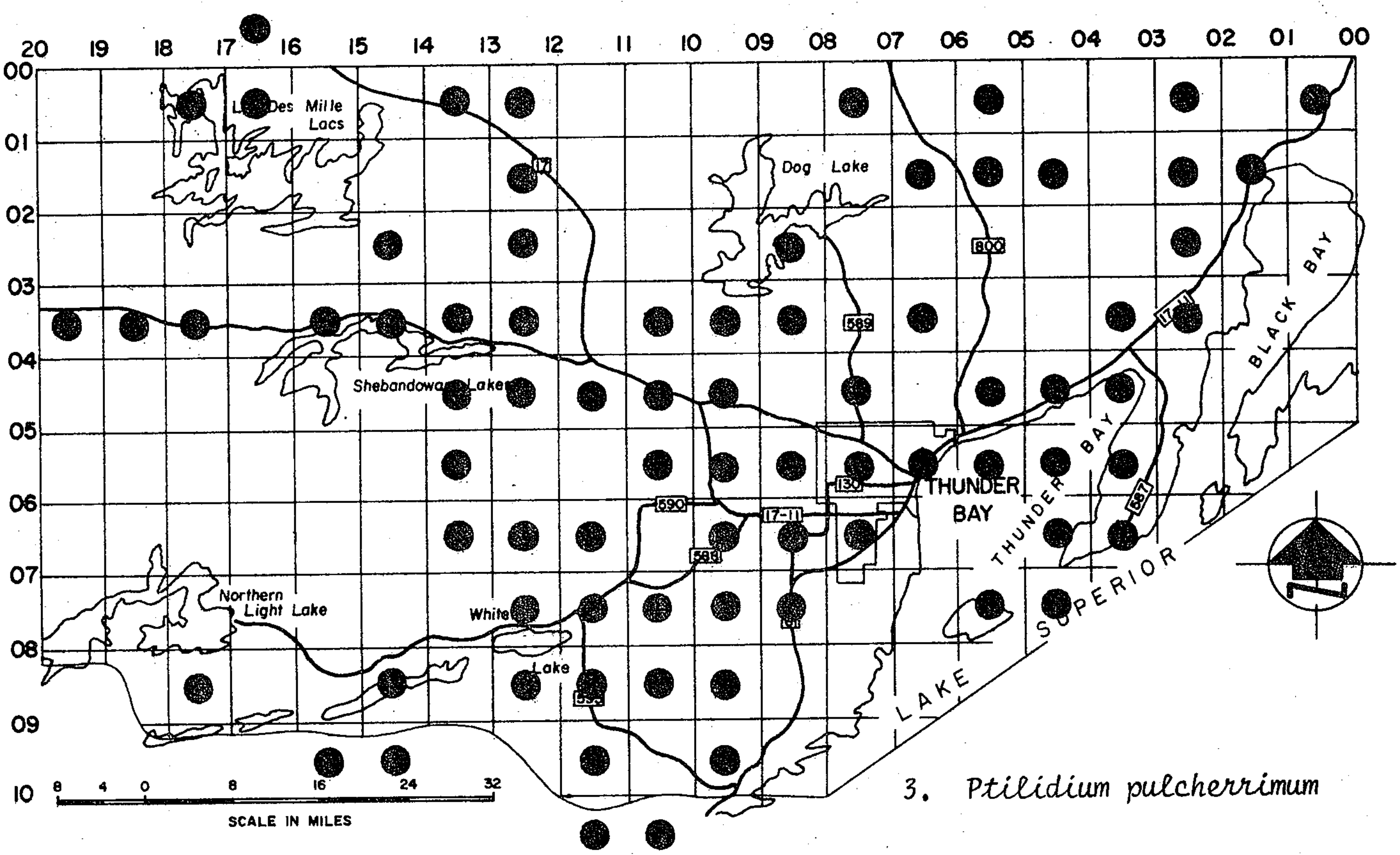
Squares visited.



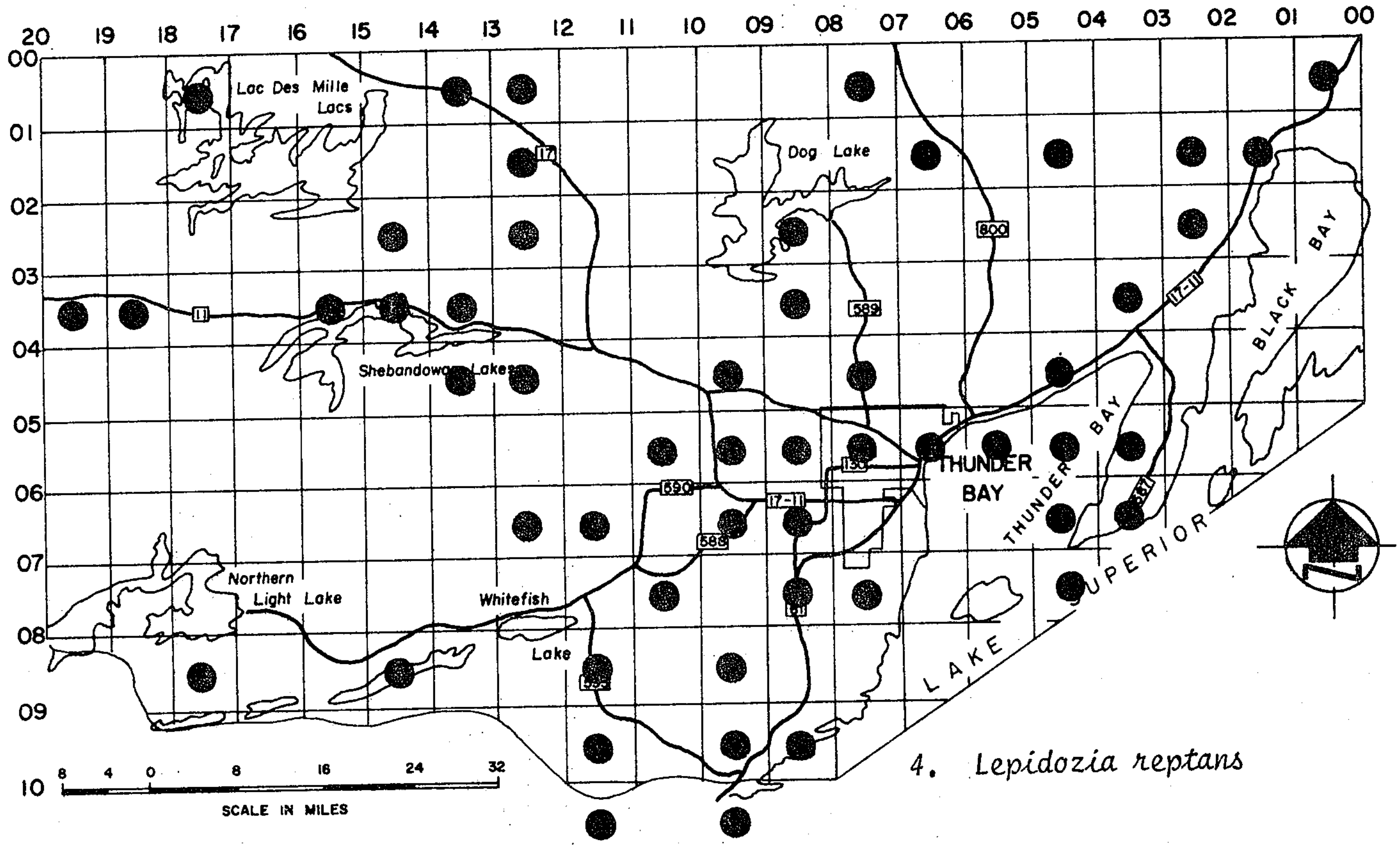
1. *Blepharostoma trichophyllum*



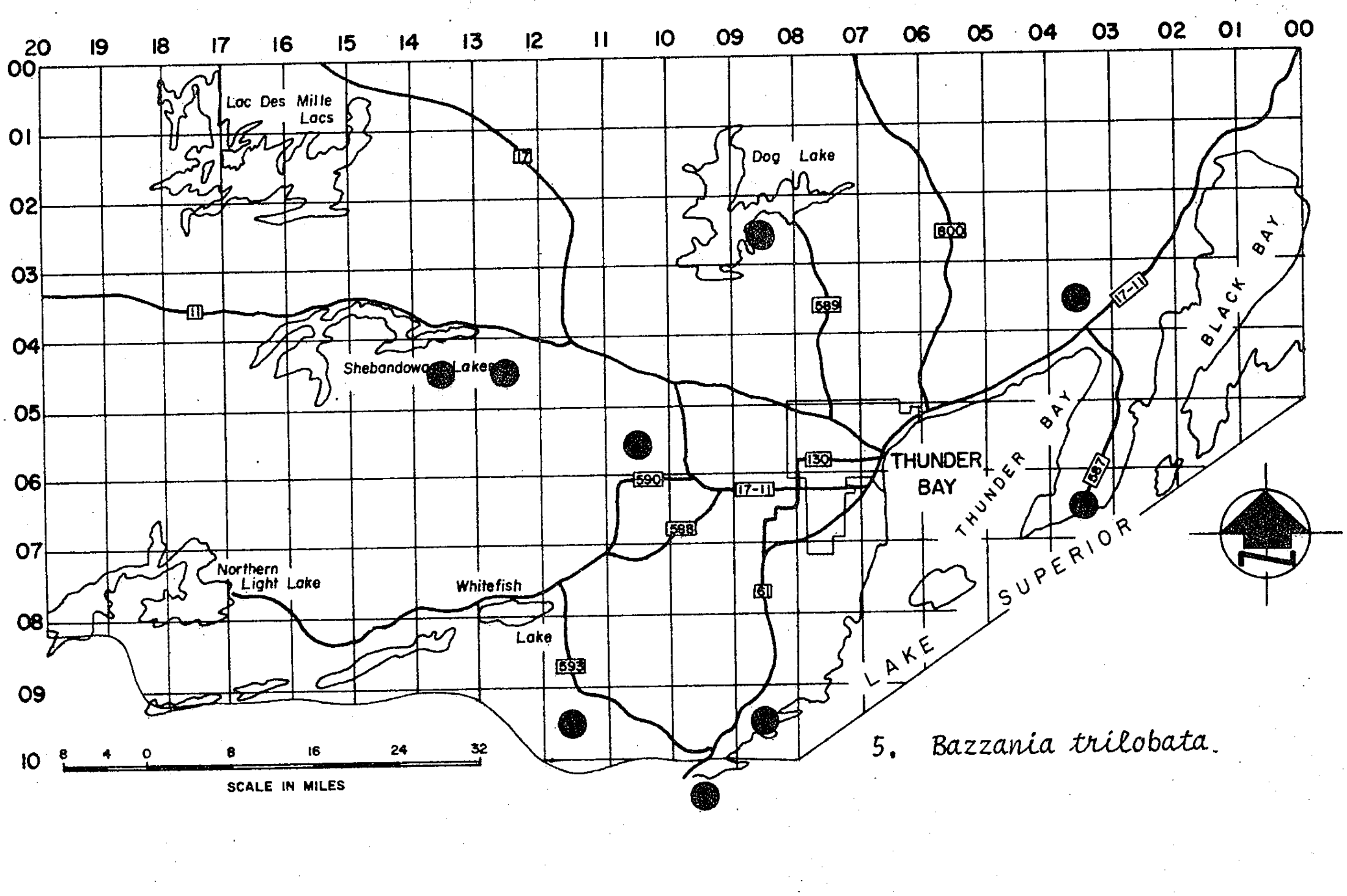
2. *Ptilidium ciliare*



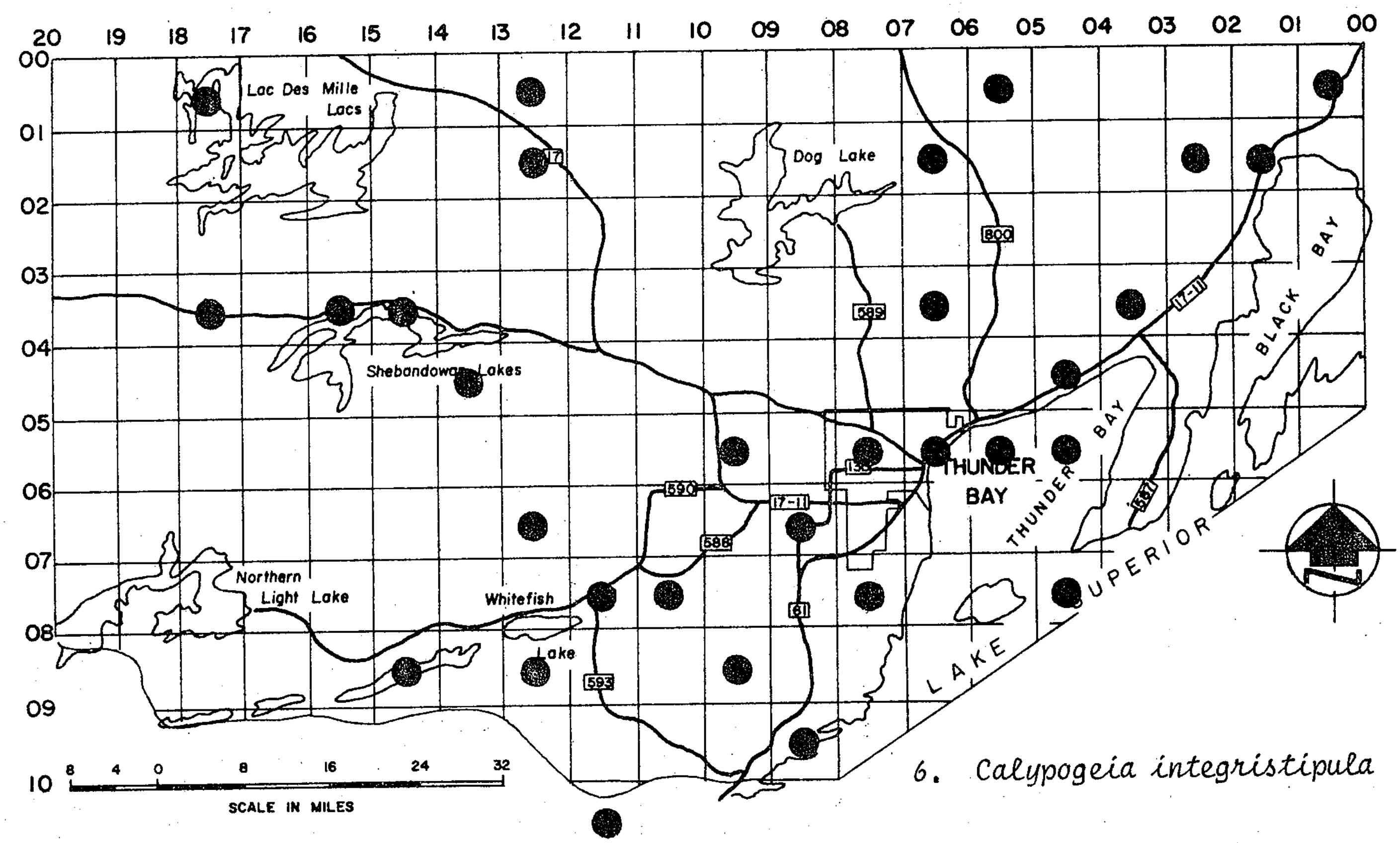
3. *Ptilidium pulcherrimum*



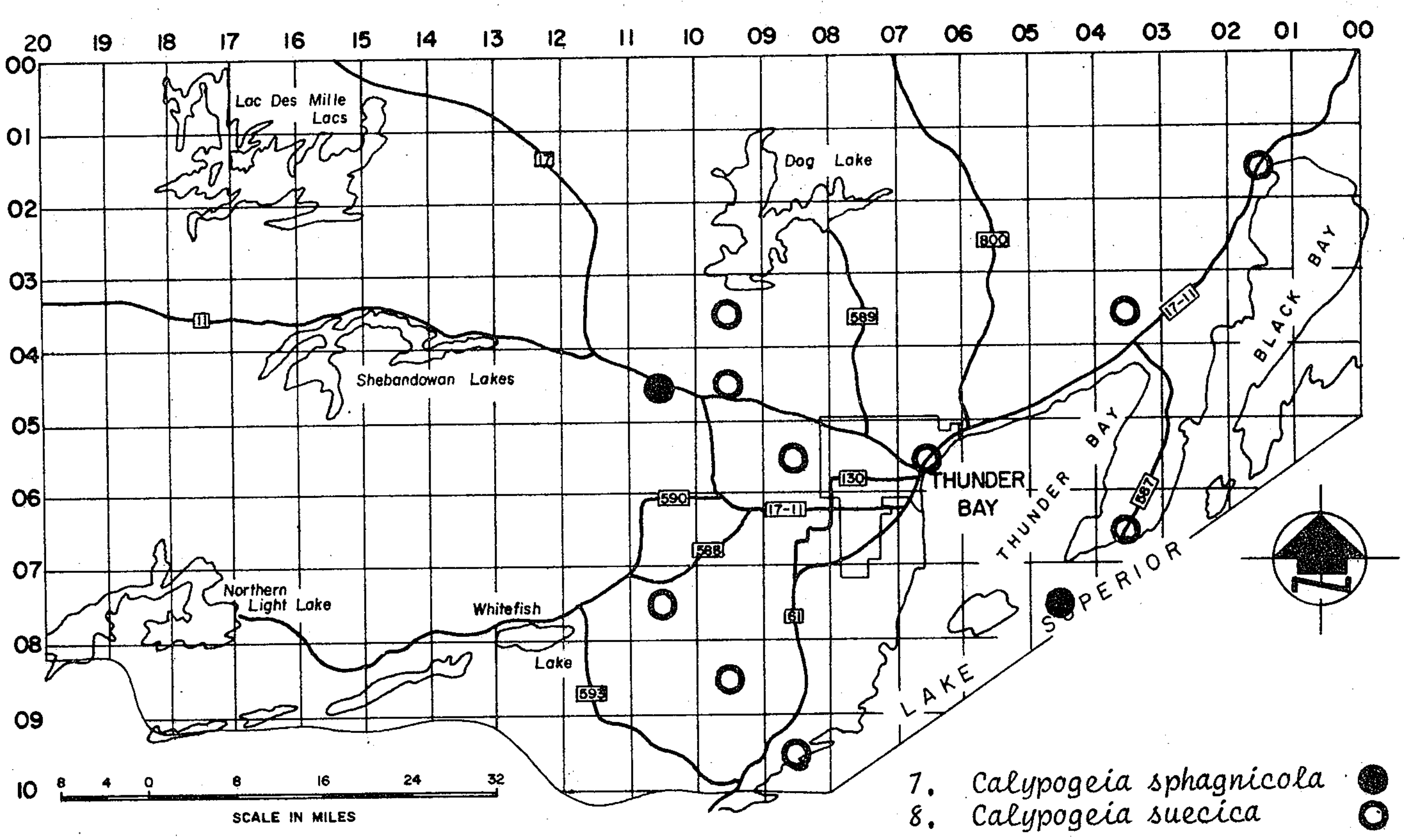
4. *Lepidozia reptans*



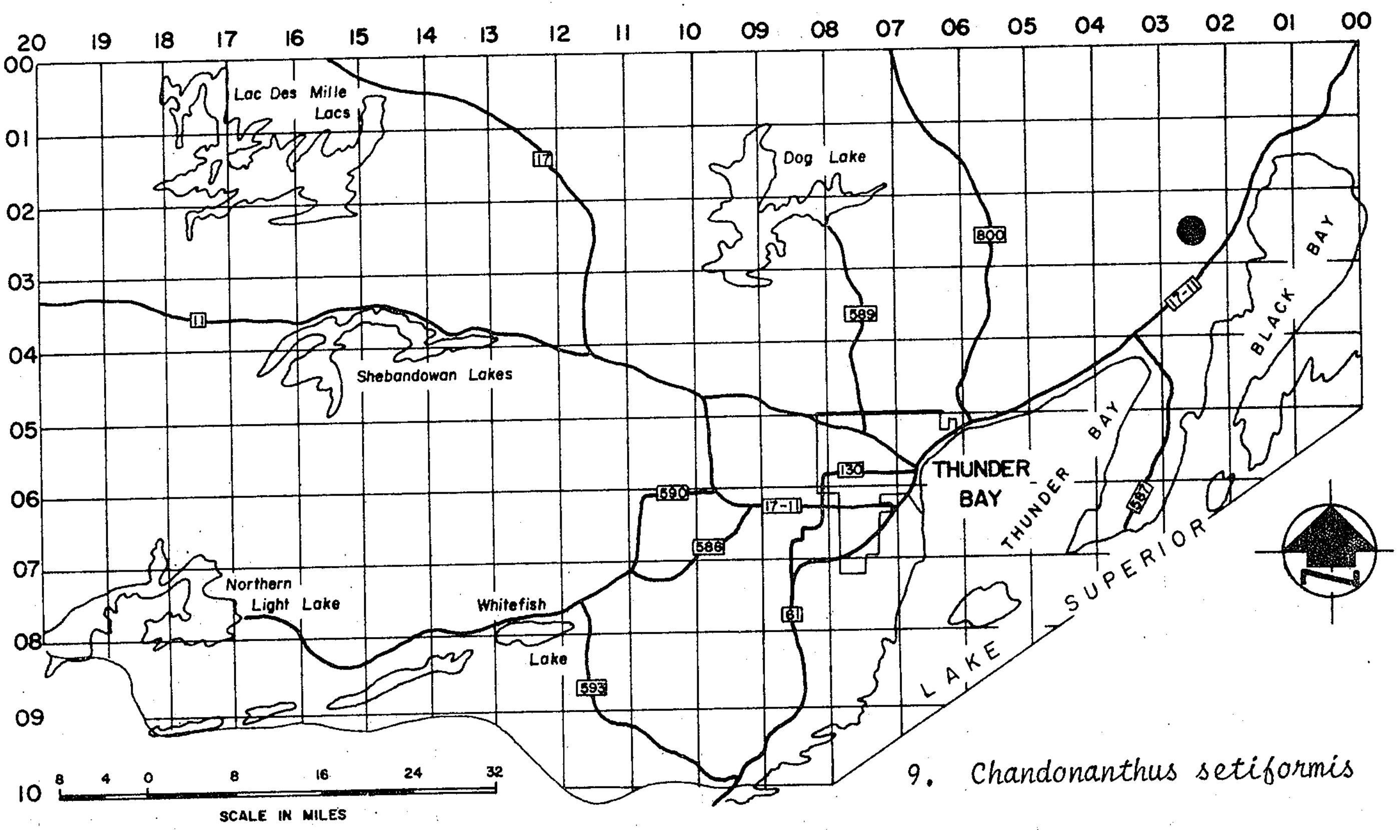
5. *Bazzania trilobata*.



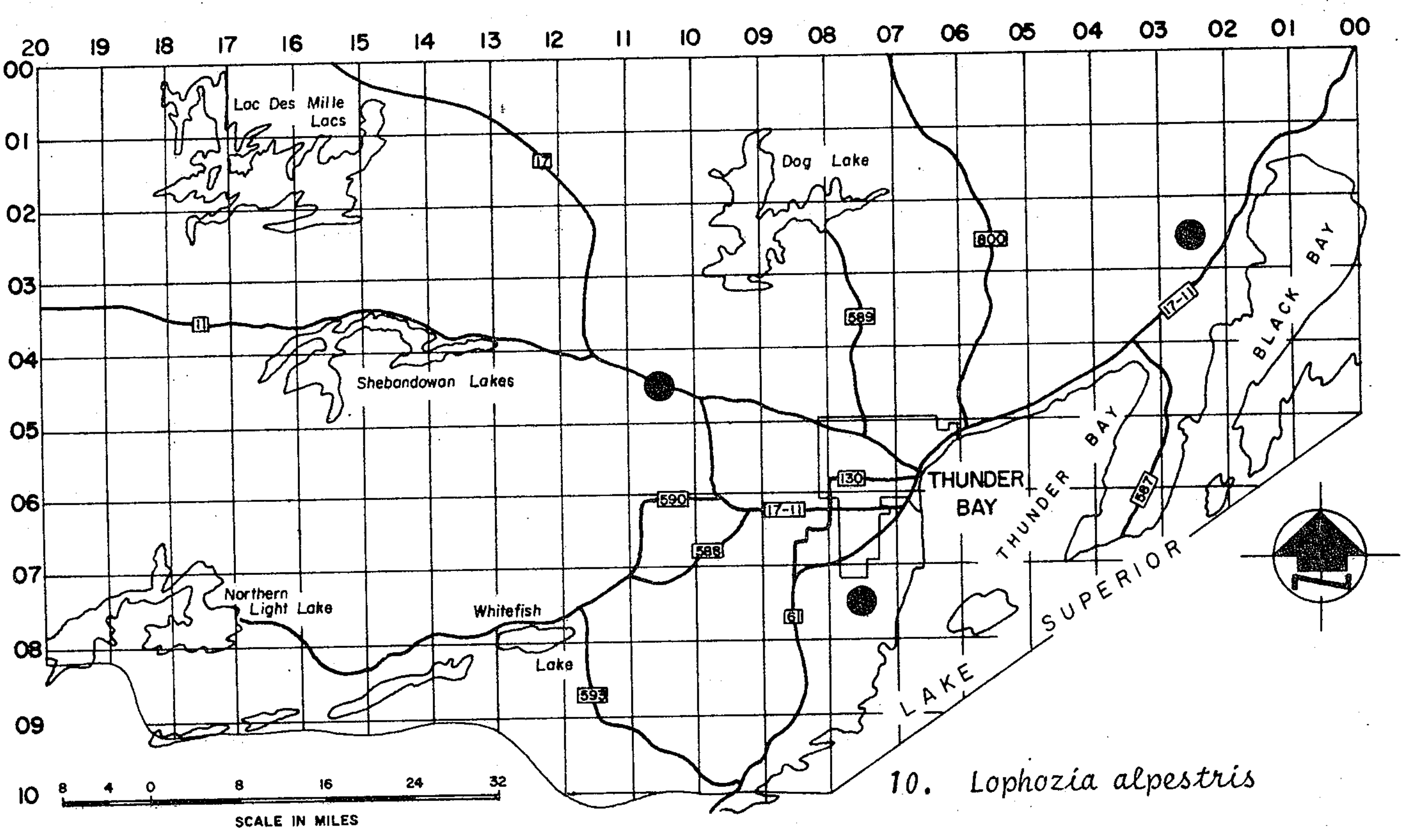
6. *Calypogeia integristipula*



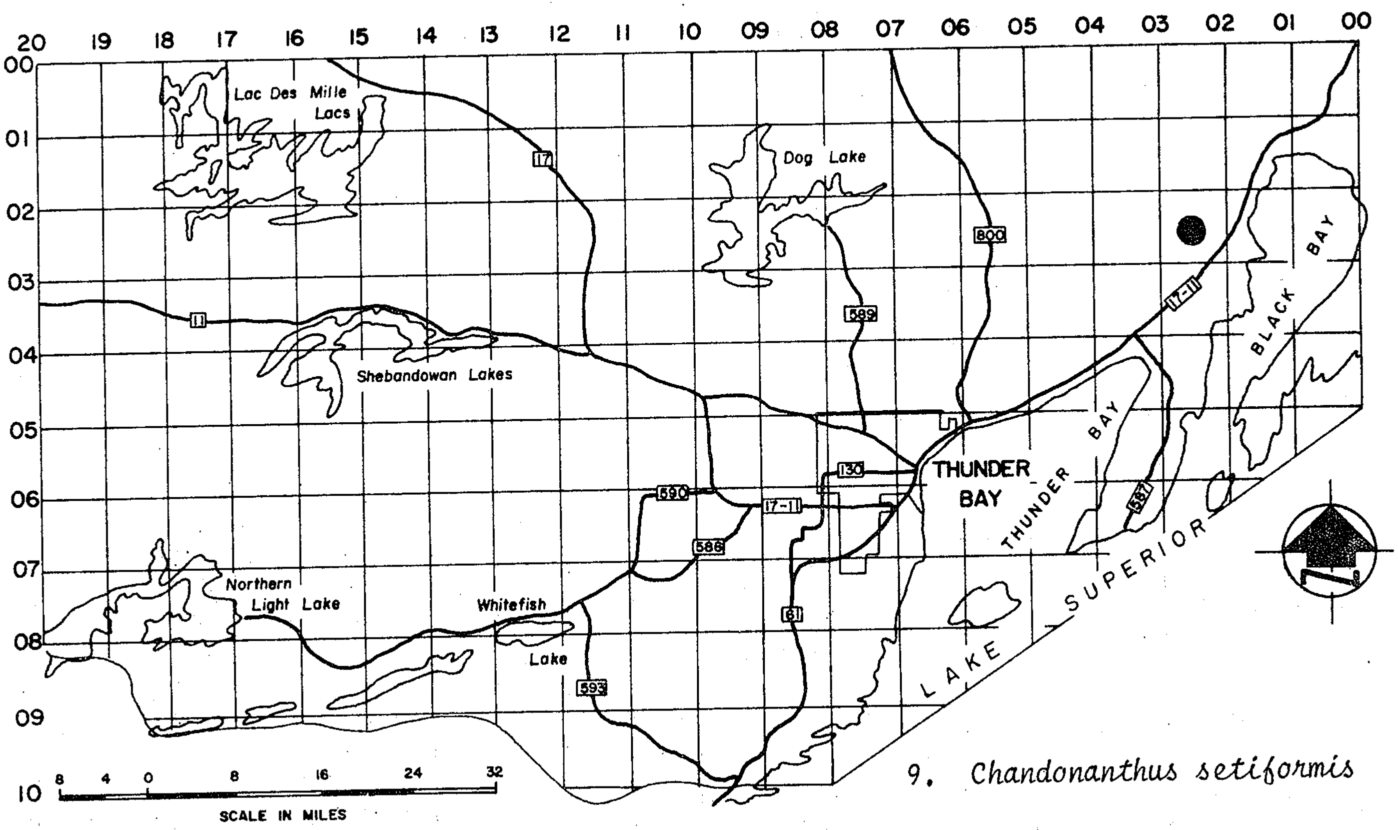
7. *Calypogeia sphagnicola* ●
8. *Calypogeia suecica* ○



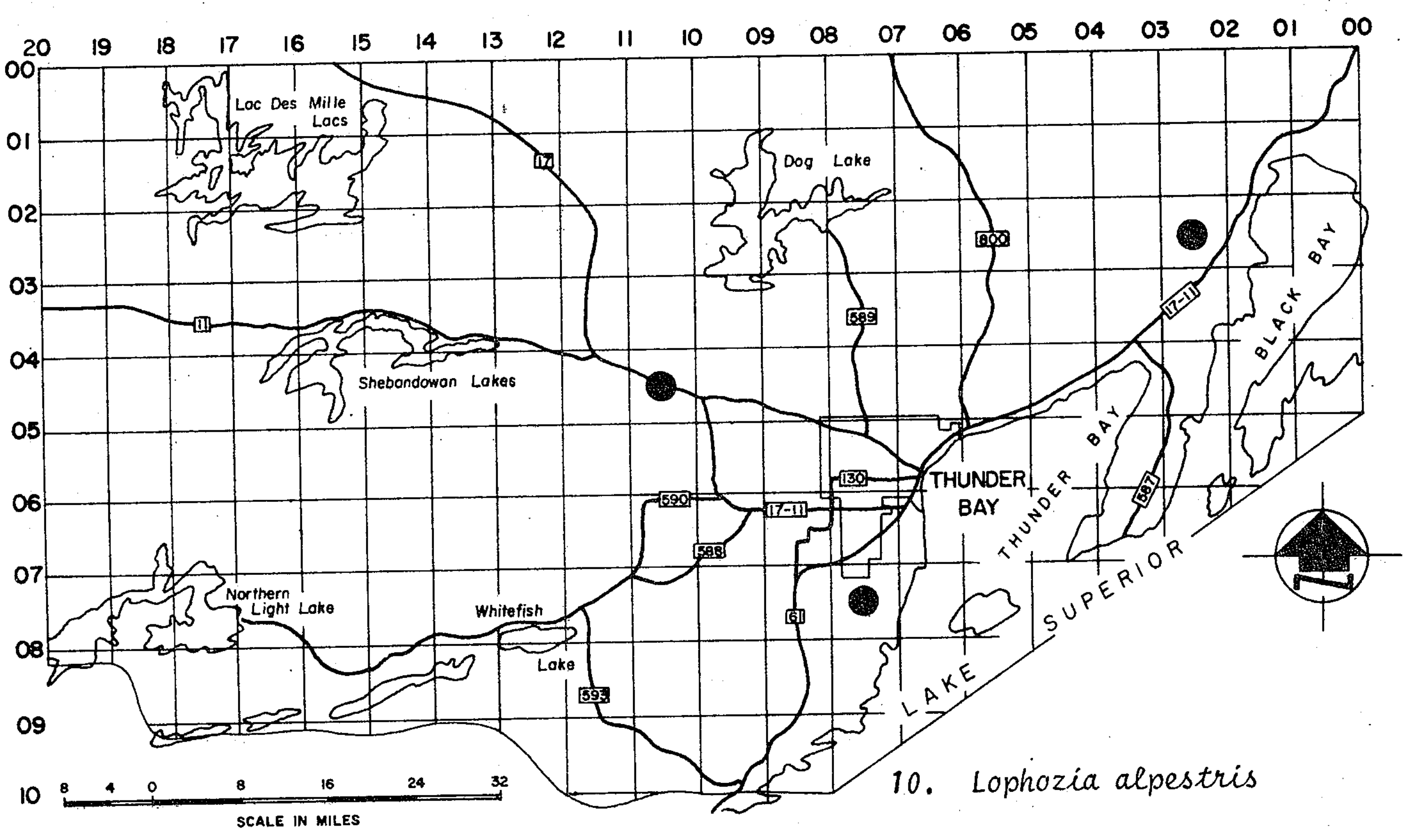
9. *Chandonanthus setiformis*



10. *Lophozia alpestris*



9. *Chandonanthus setiformis*



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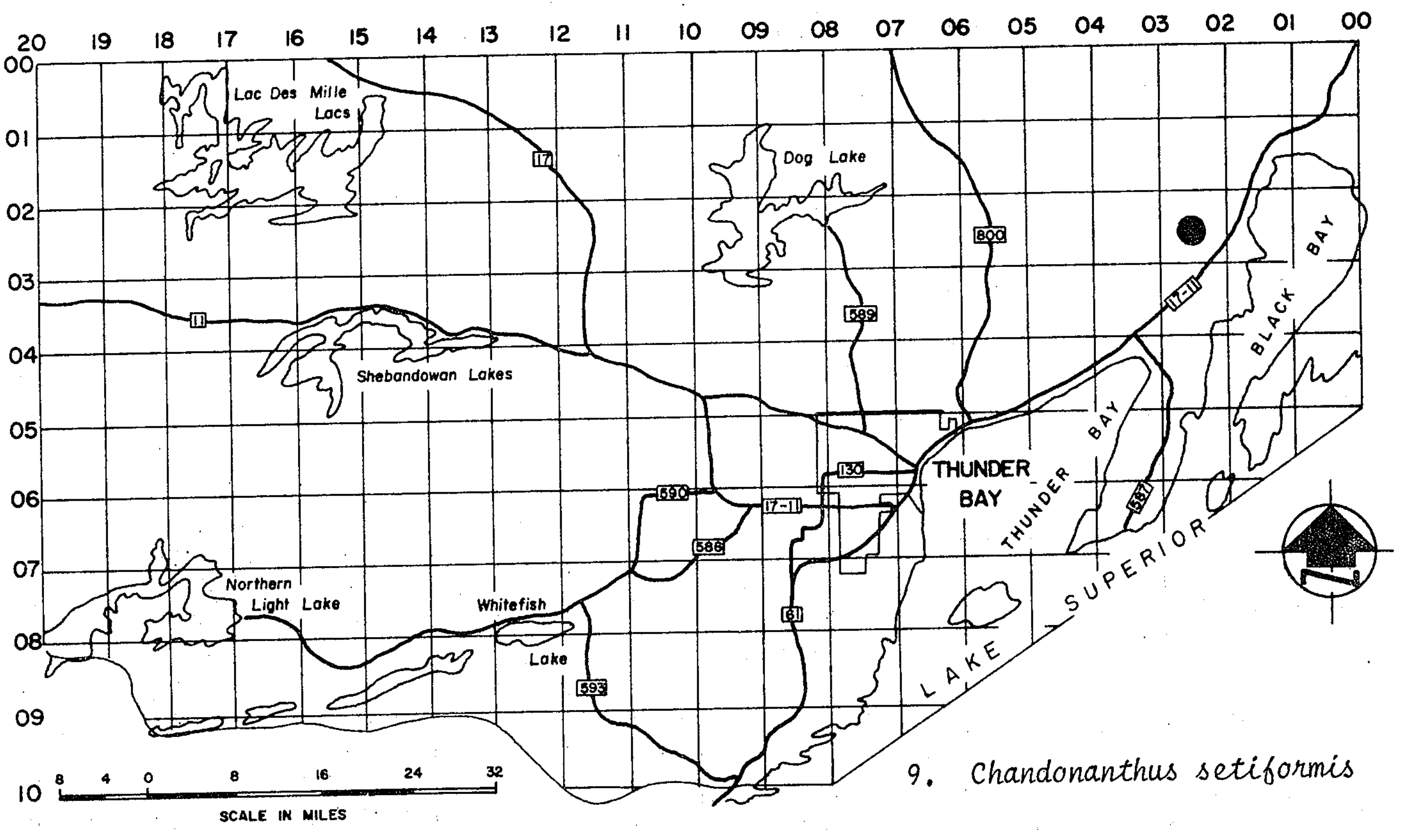
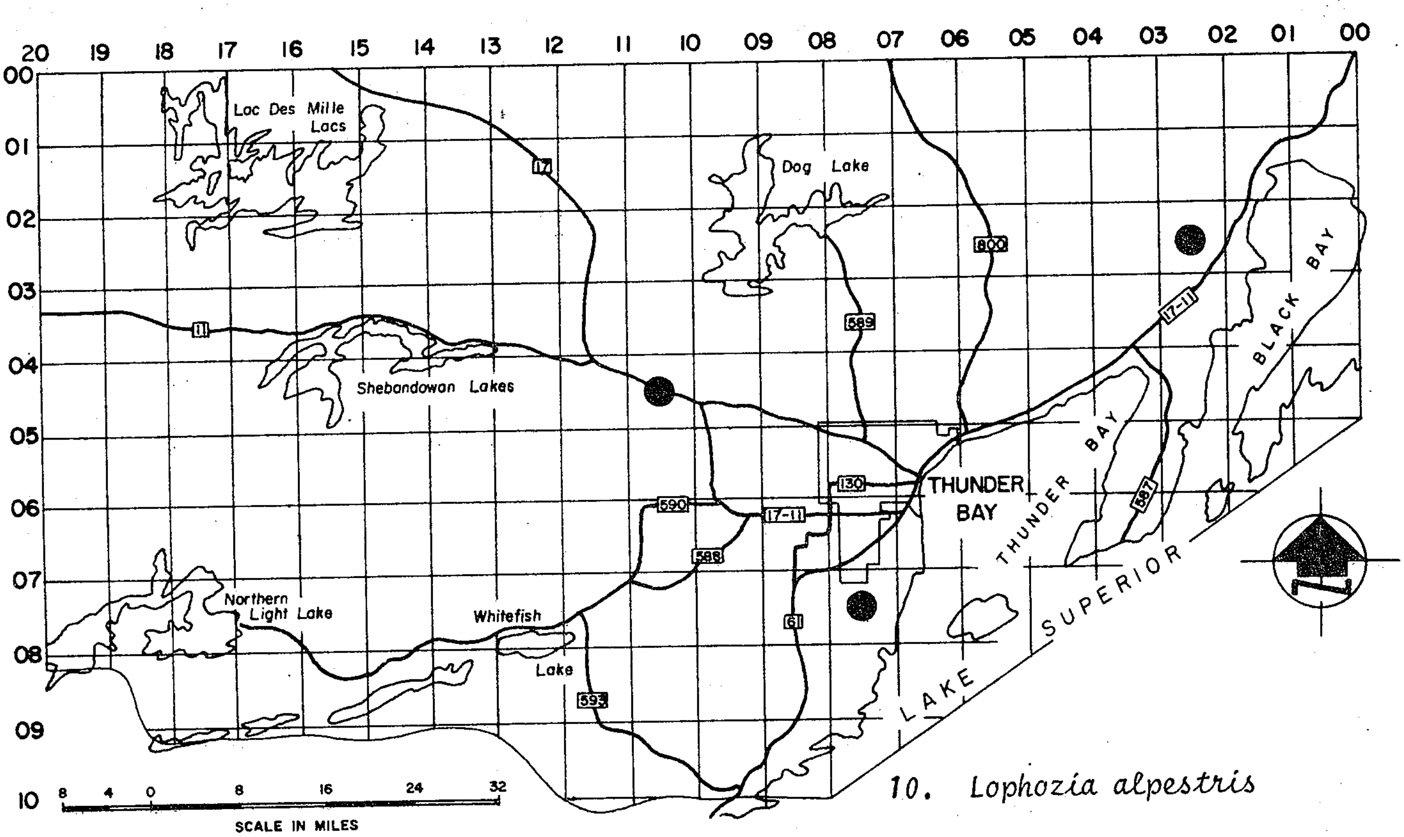
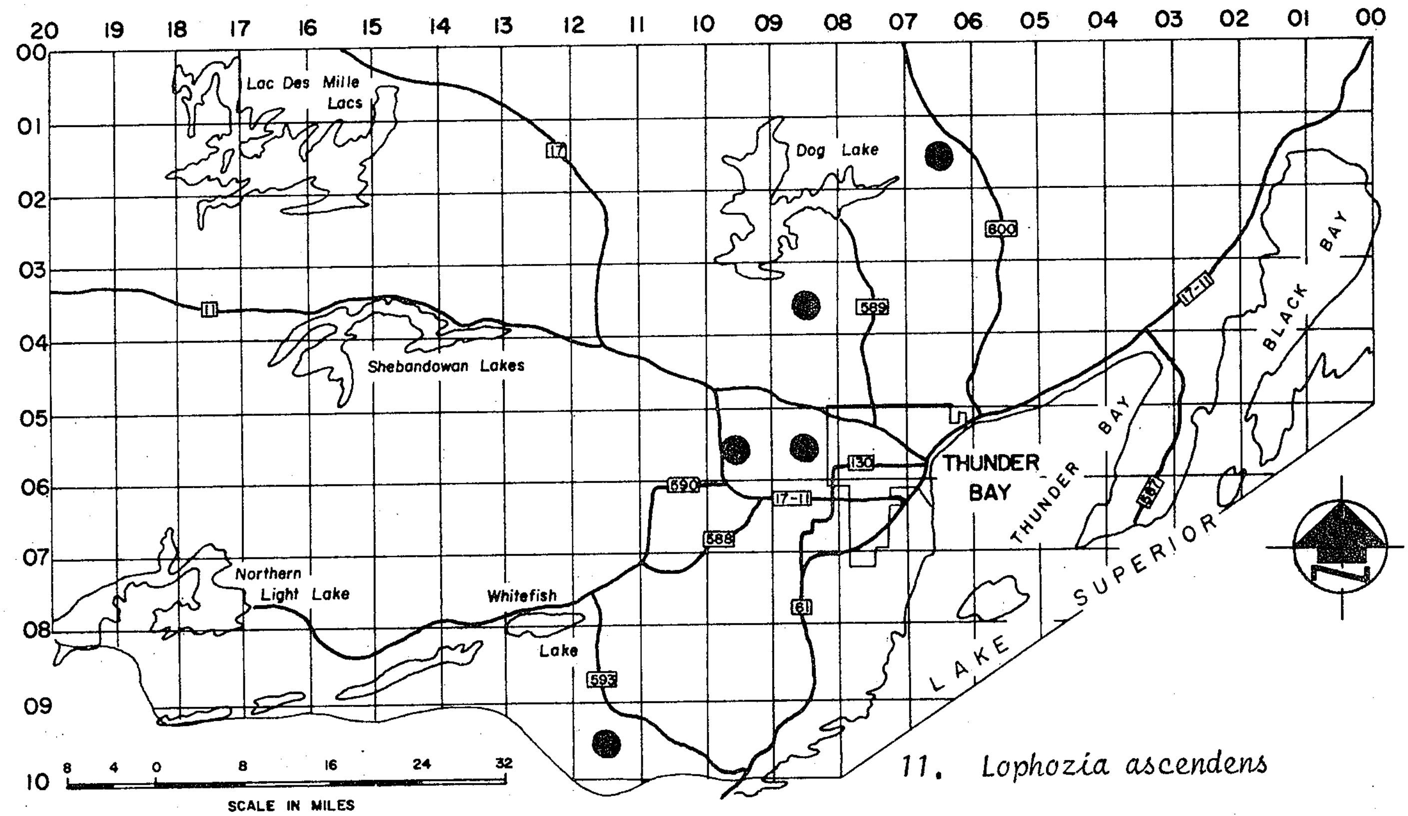


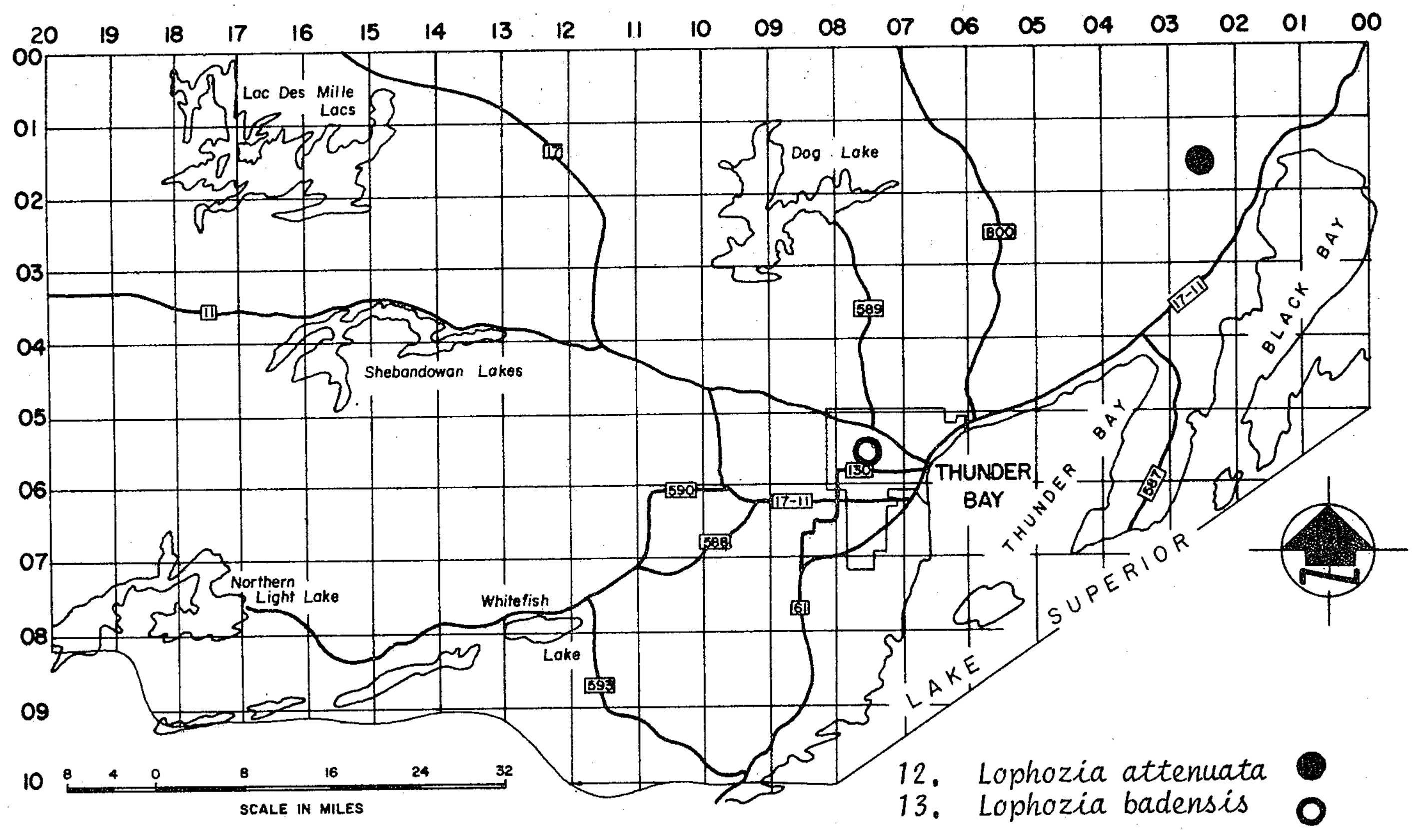
9. *Chandonanthus setiformis*



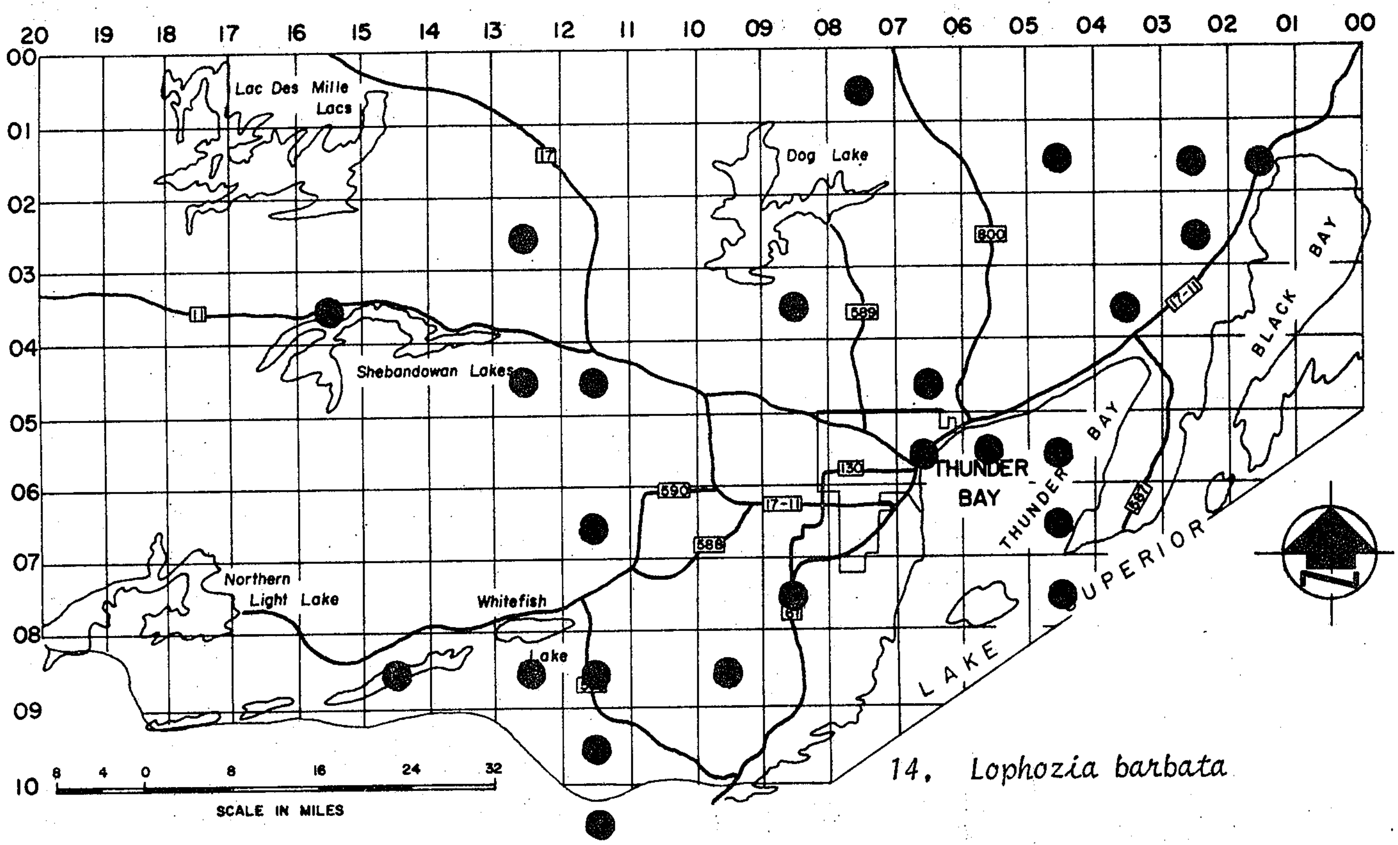
10. *Lophozia alpestris*



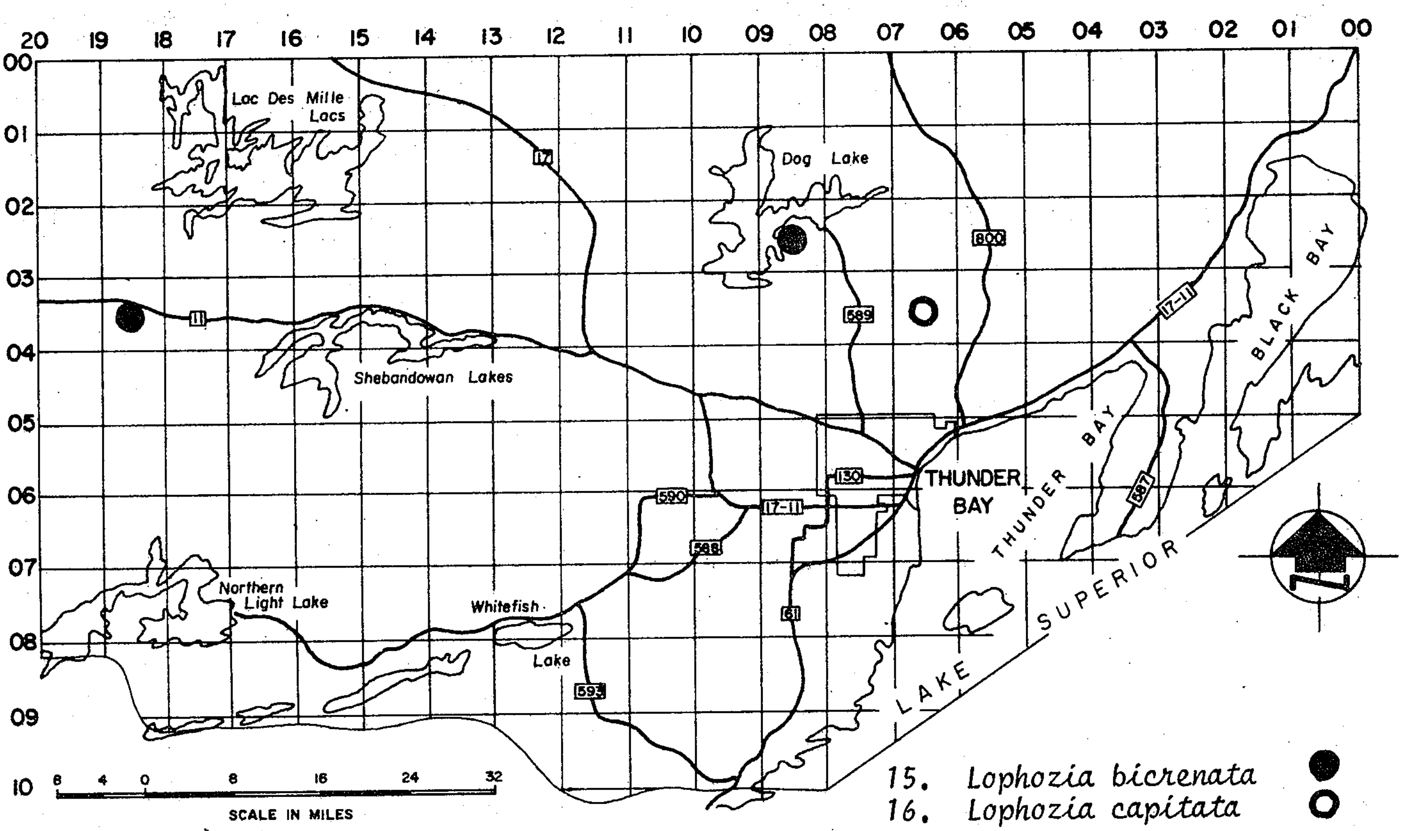
11. *Lophozia ascendens*



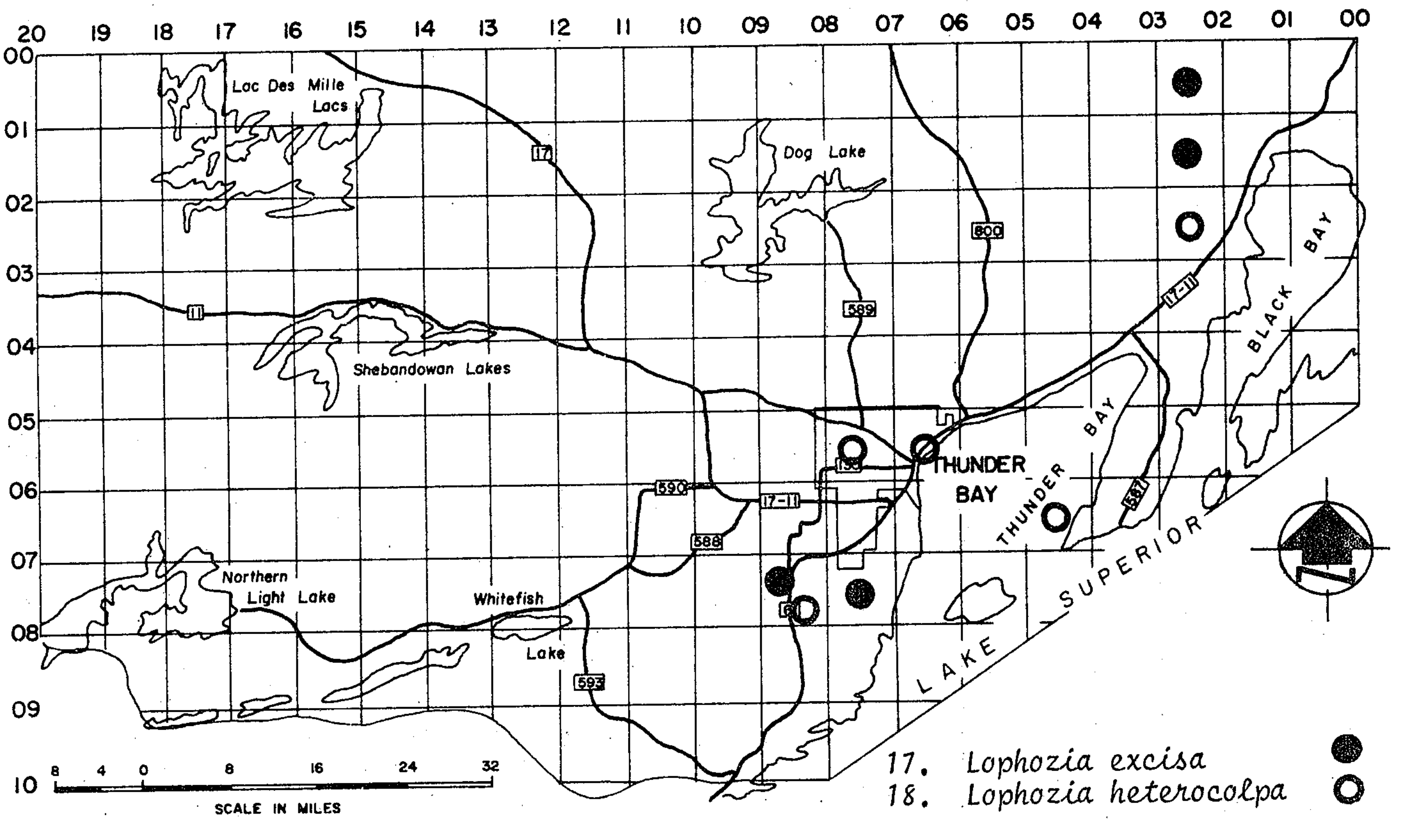
12. *Lophozia attenuata* ●
13. *Lophozia badensis* ○



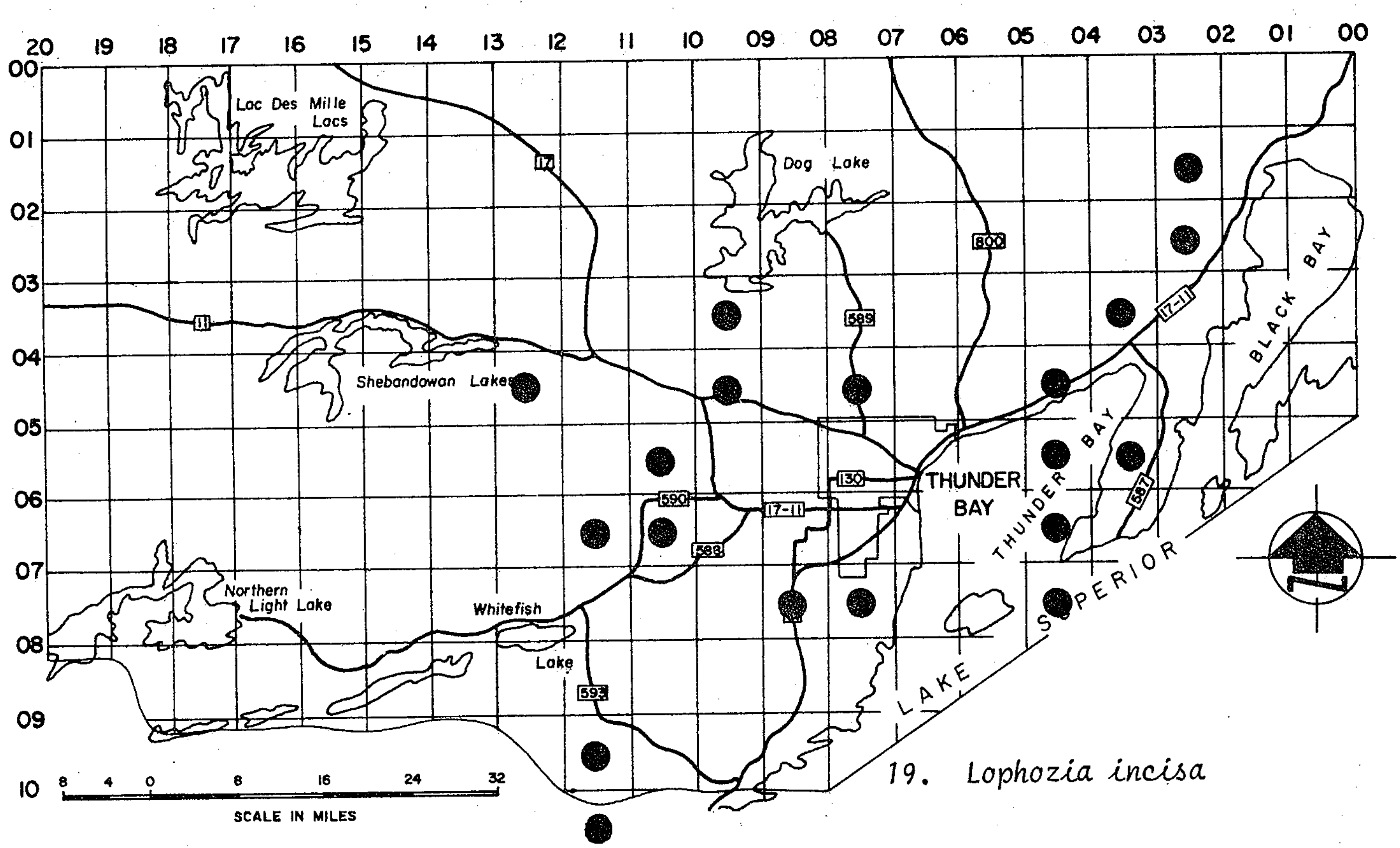
14. *Lophozia barbata*



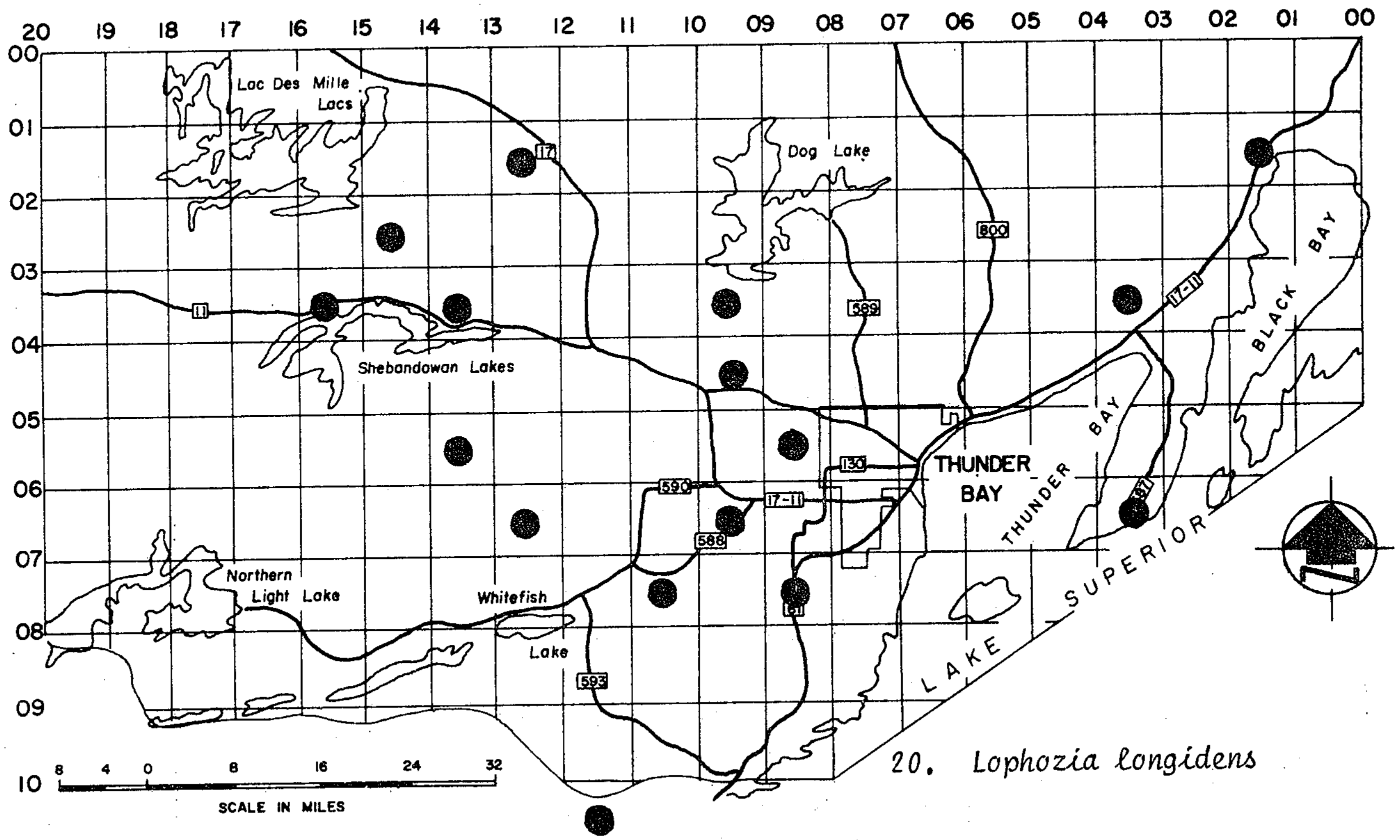
15. *Lophozia bicrenata* ●
16. *Lophozia capitata* ○



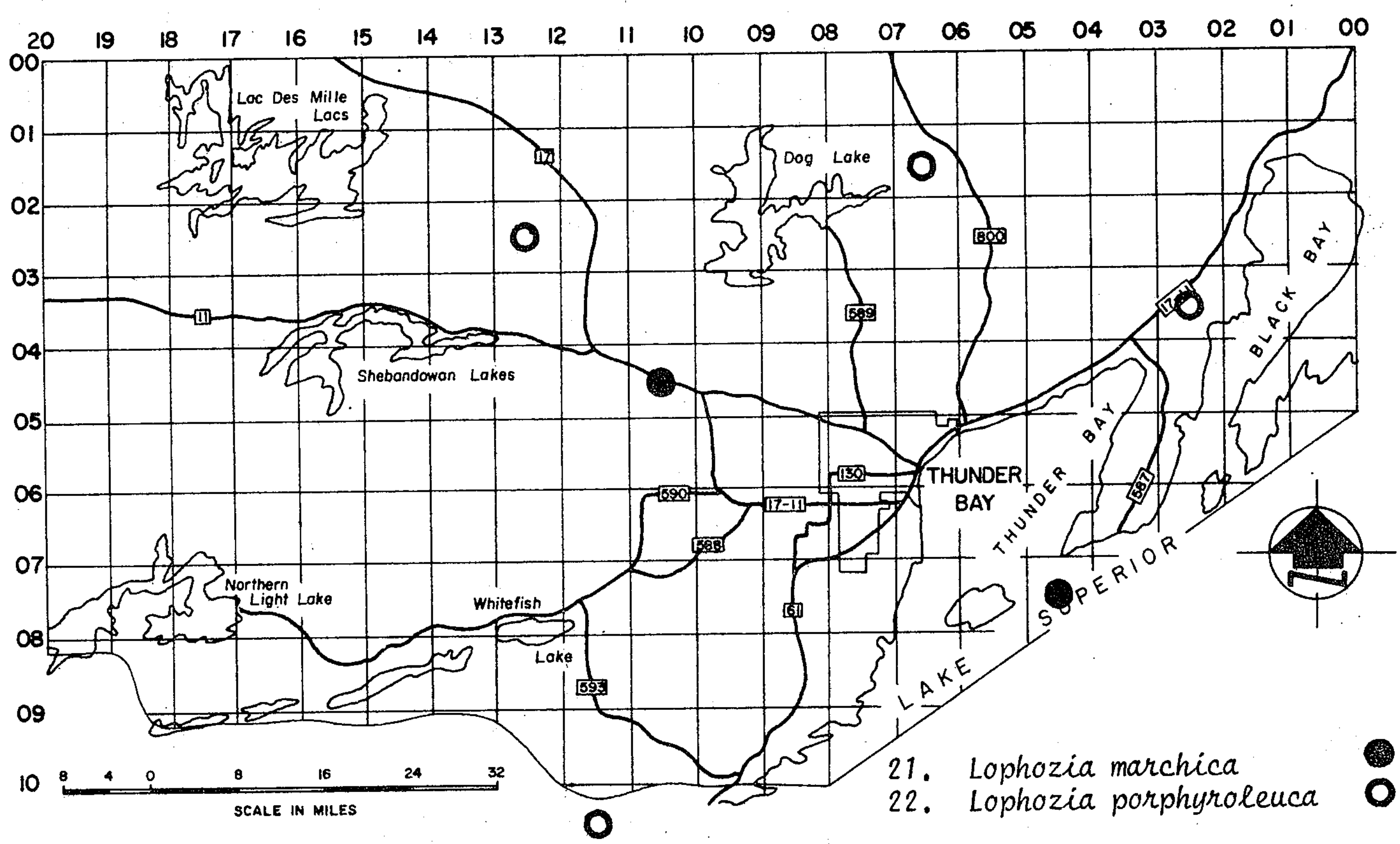
17. *Lophozia excisa* ●
18. *Lophozia heterocolpa* ○



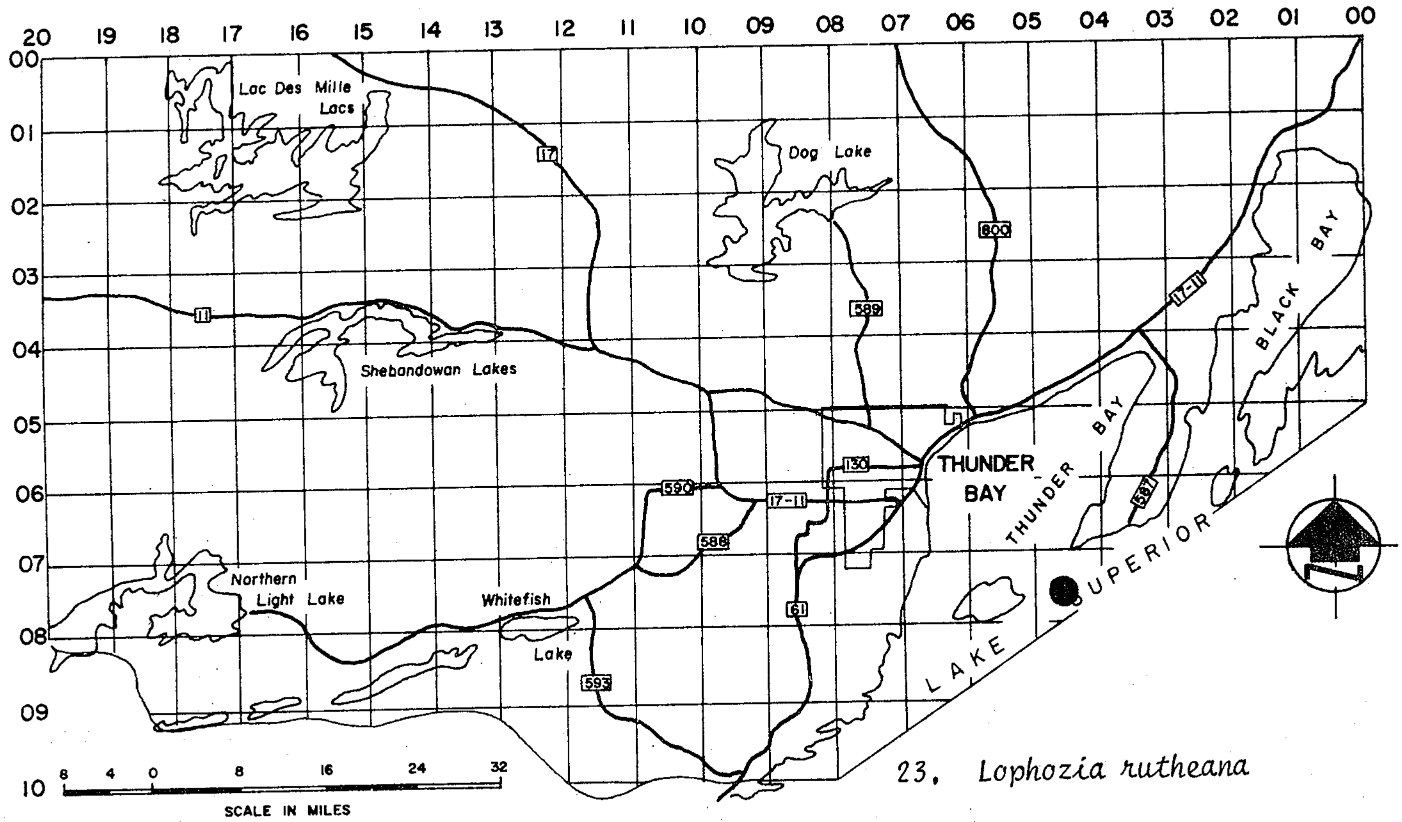
19. *Lophozia incisa*



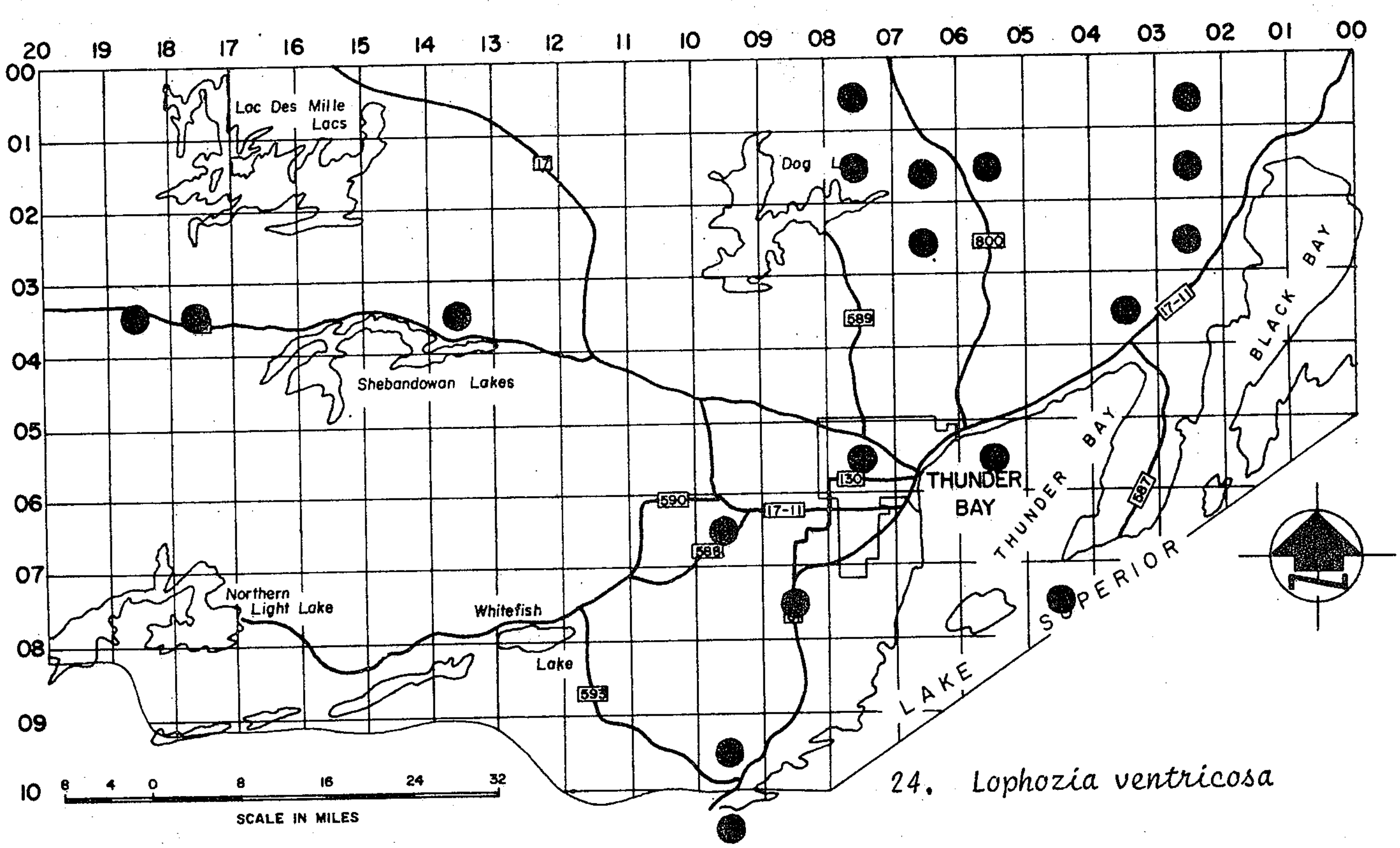
20. *Lophozia longidens*



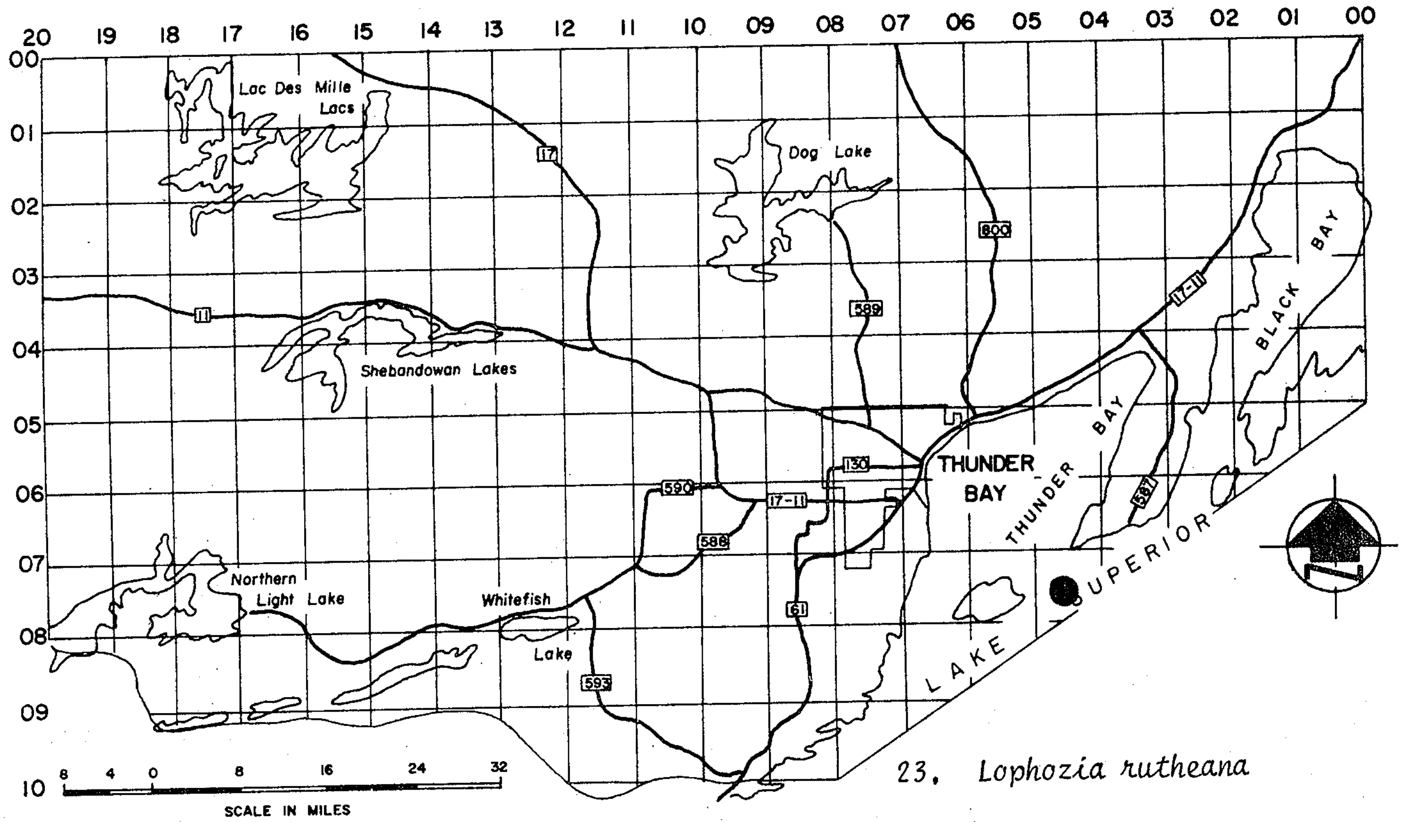
21. *Lophozia marchica* ●
22. *Lophozia porphyroleuca* ○



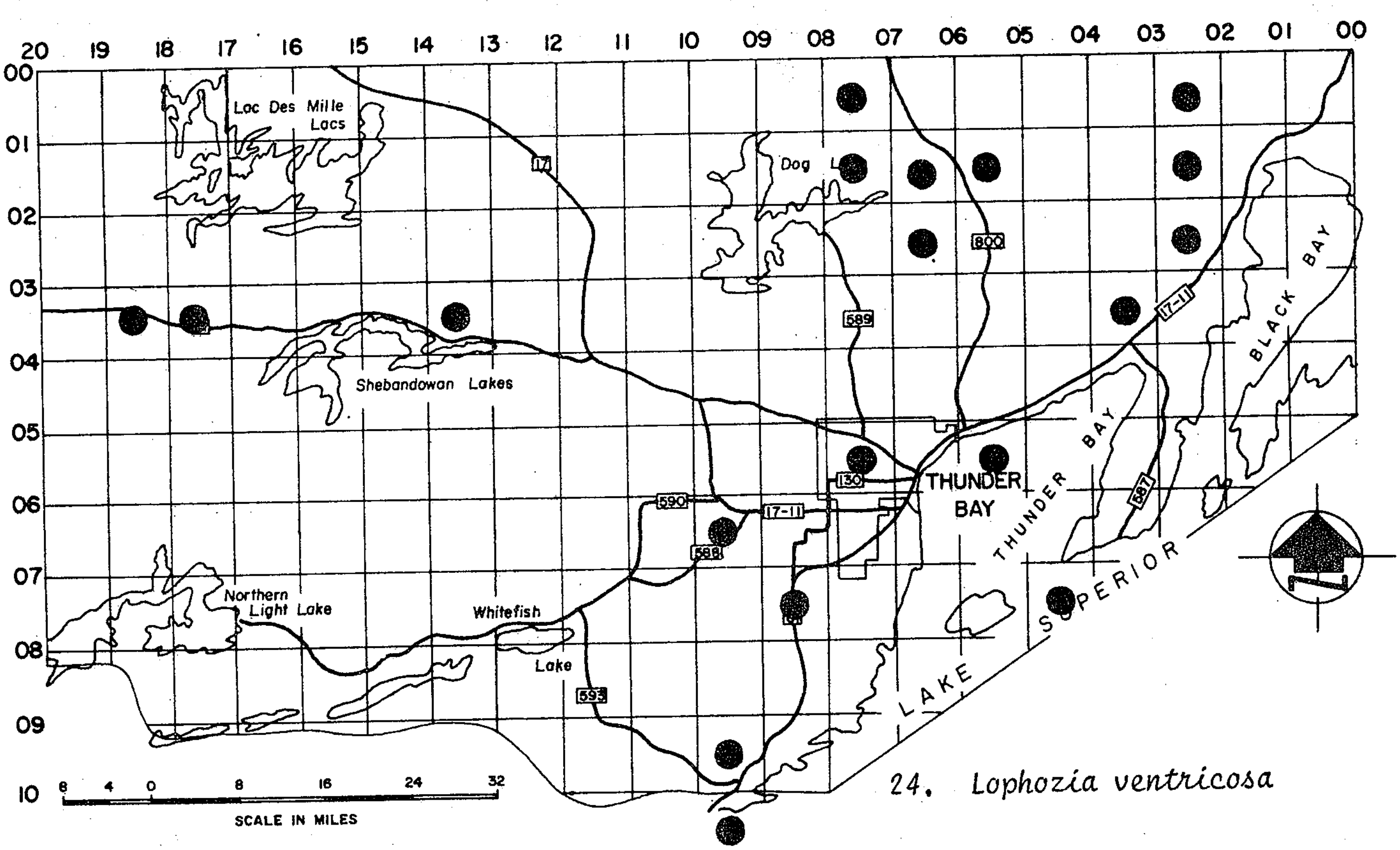
23. *Lophozia rutheana*



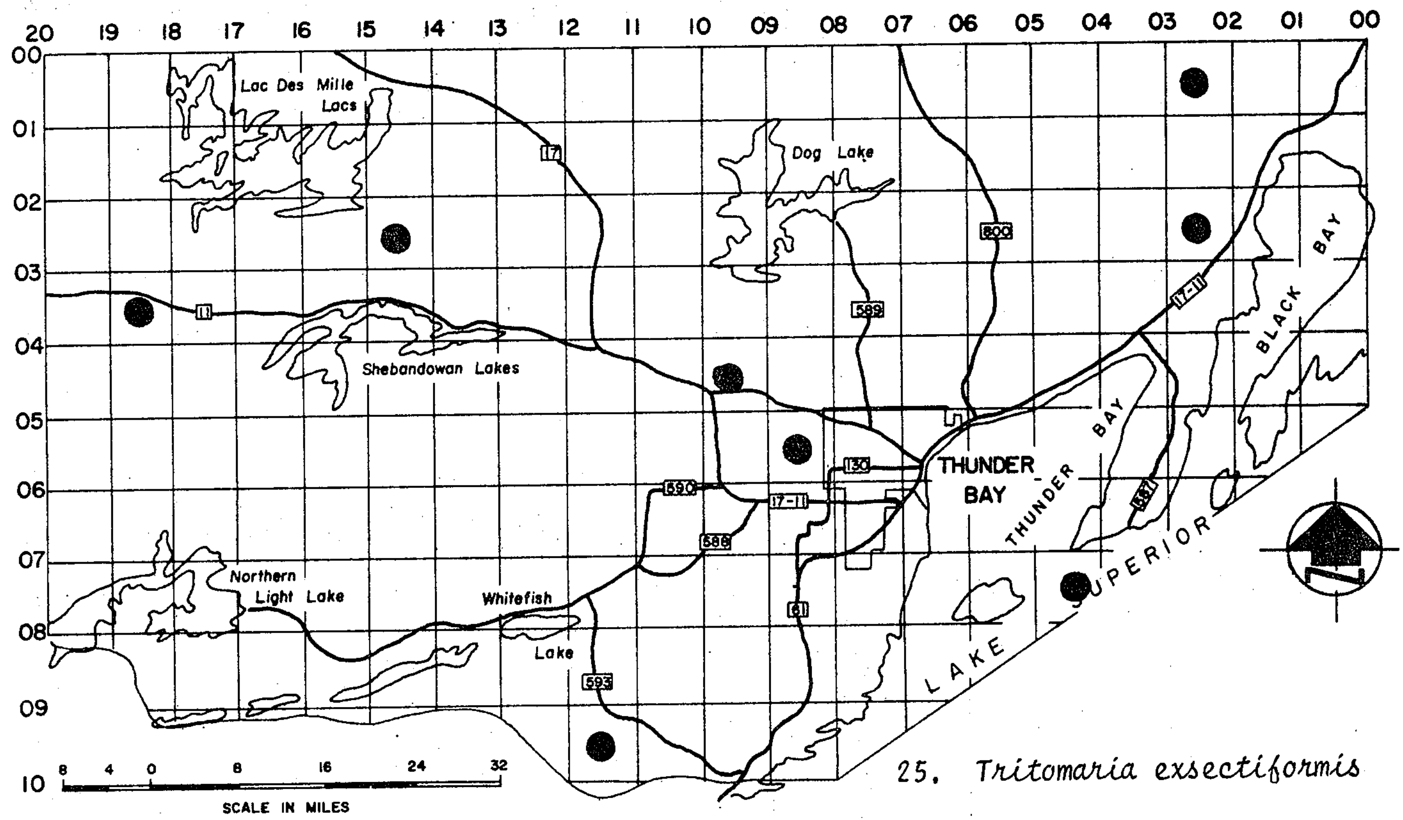
24. *Lophozia ventricosa*



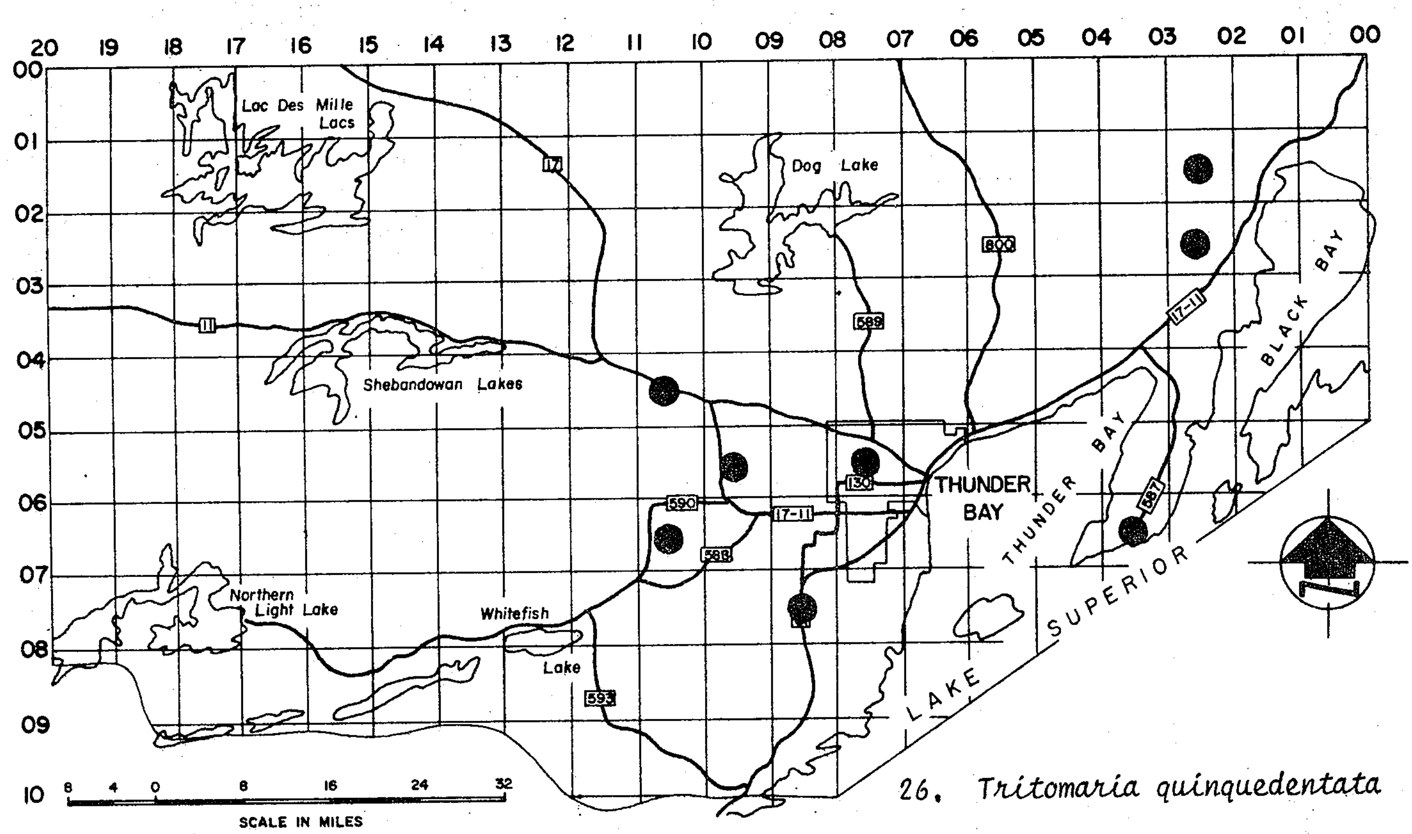
23. *Lophozia rutheana*



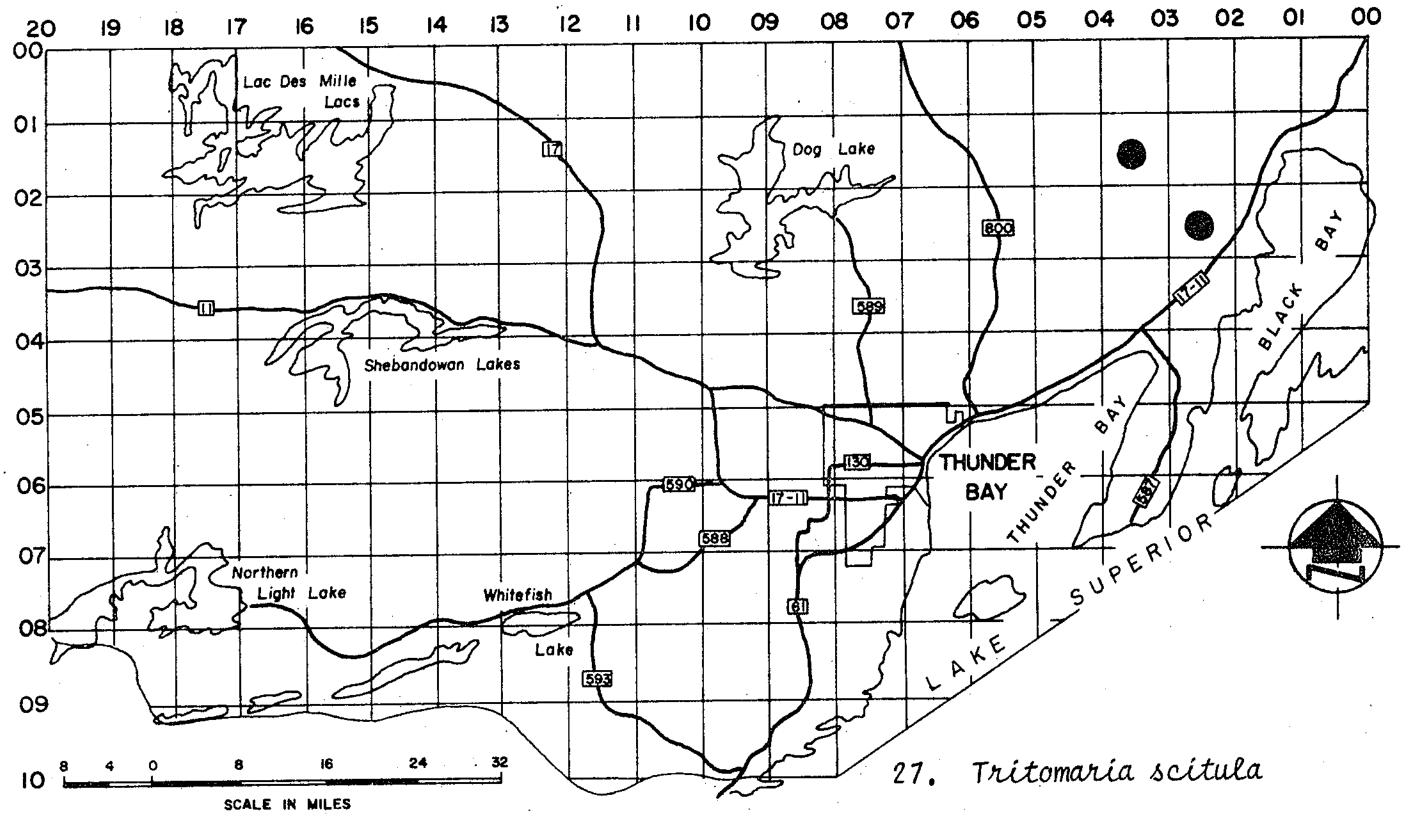
24. *Lophozia ventricosa*



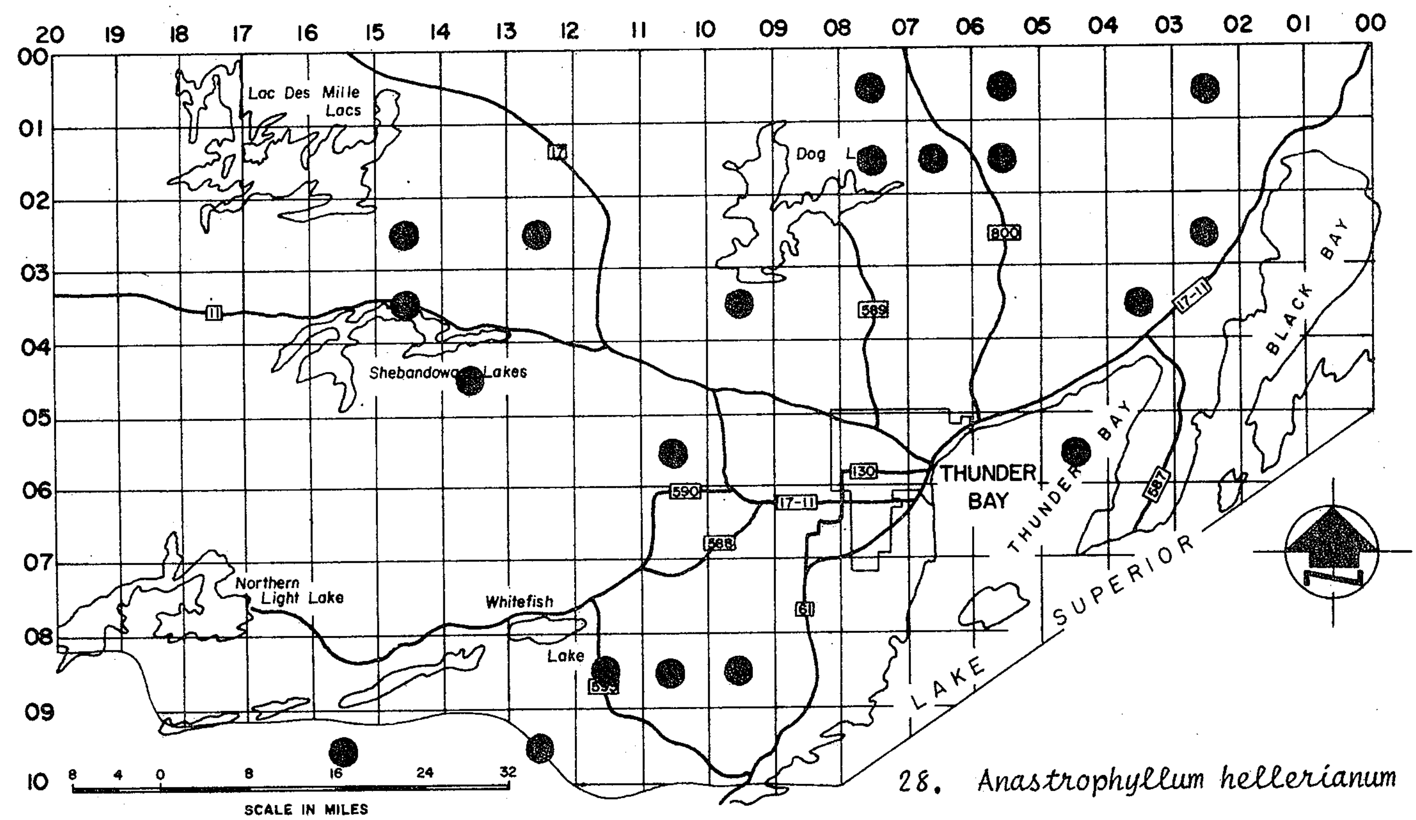
25. *Tritomaria exsectiformis*



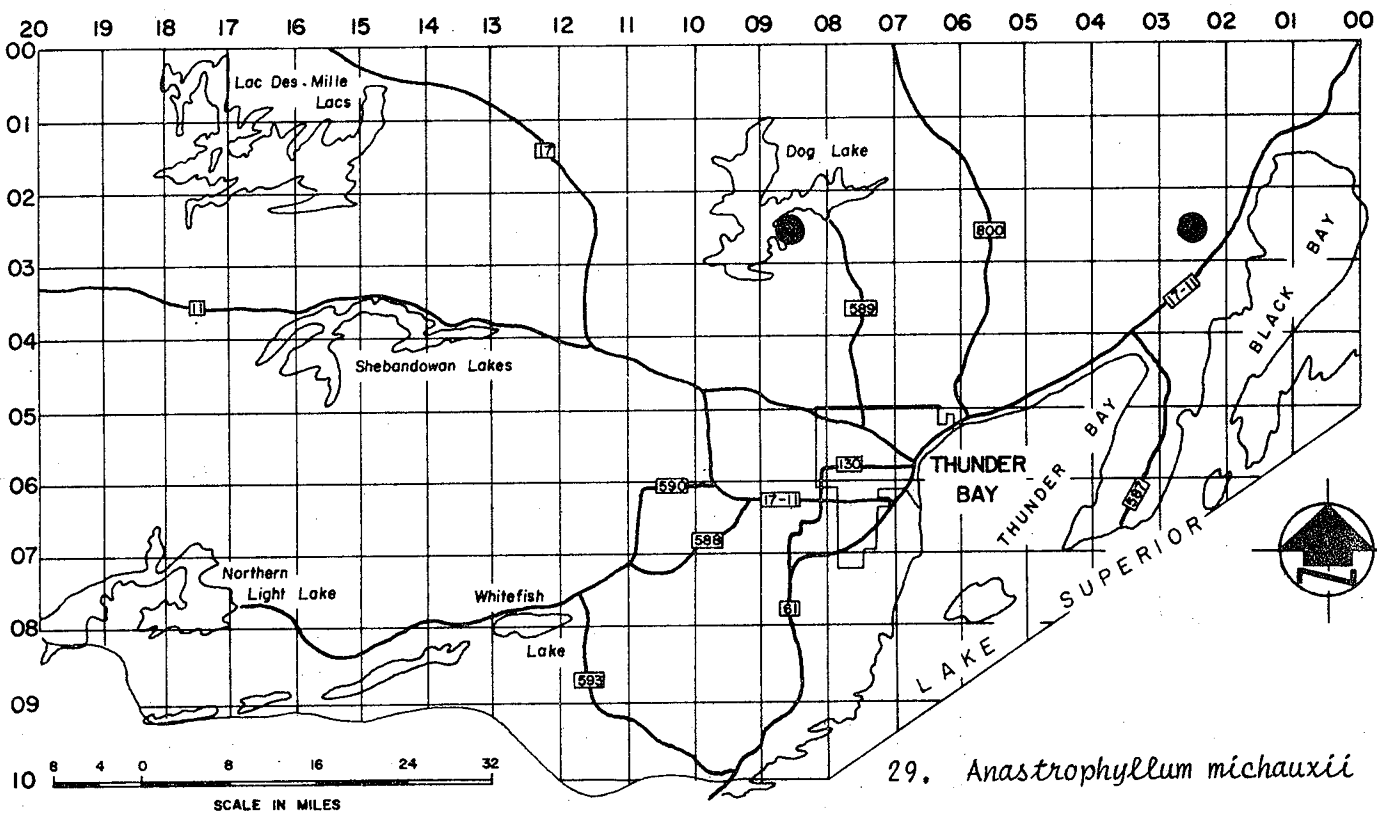
26. *Tritomaria quinquedentata*



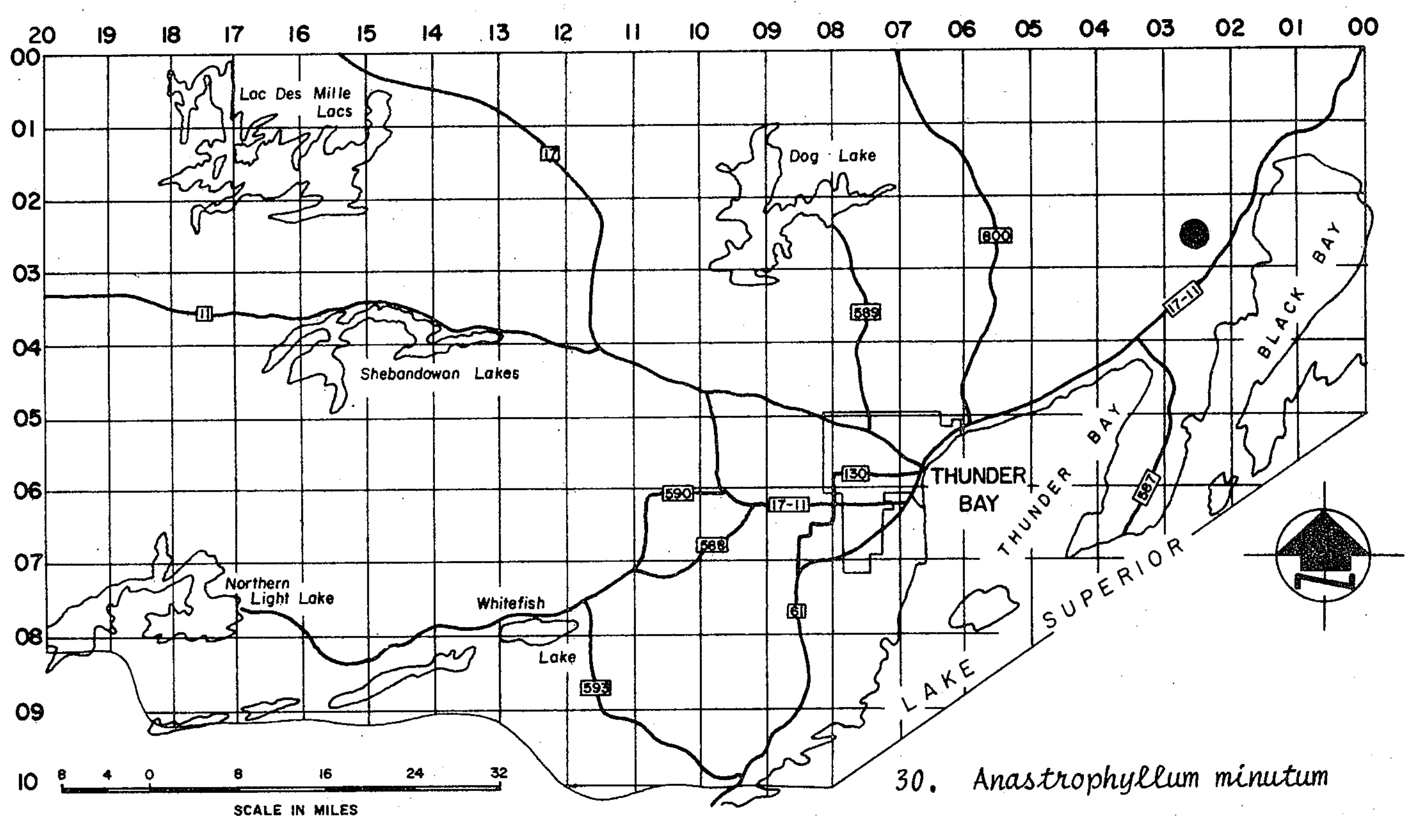
27. *Tritomaria scitula*



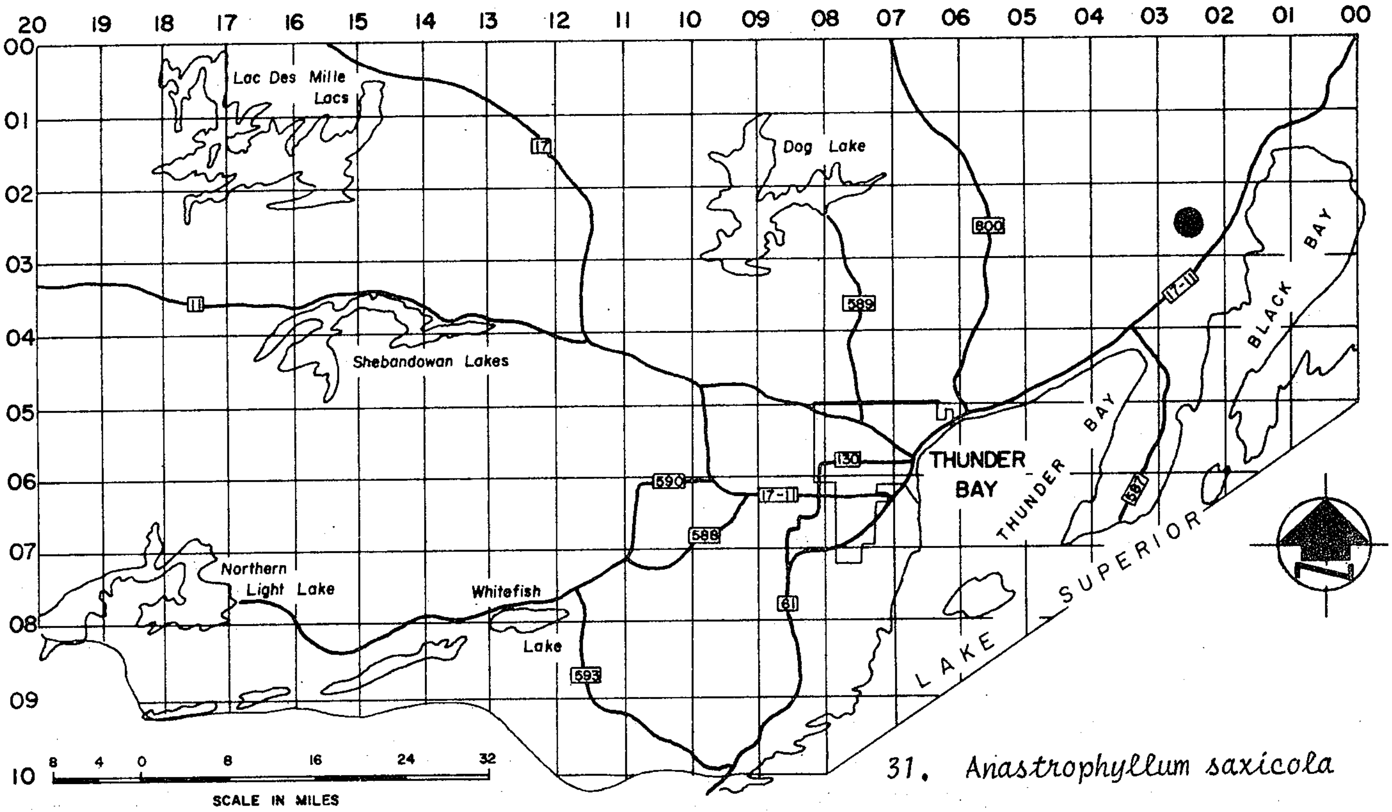
28. *Anastrophyllum hellerianum*



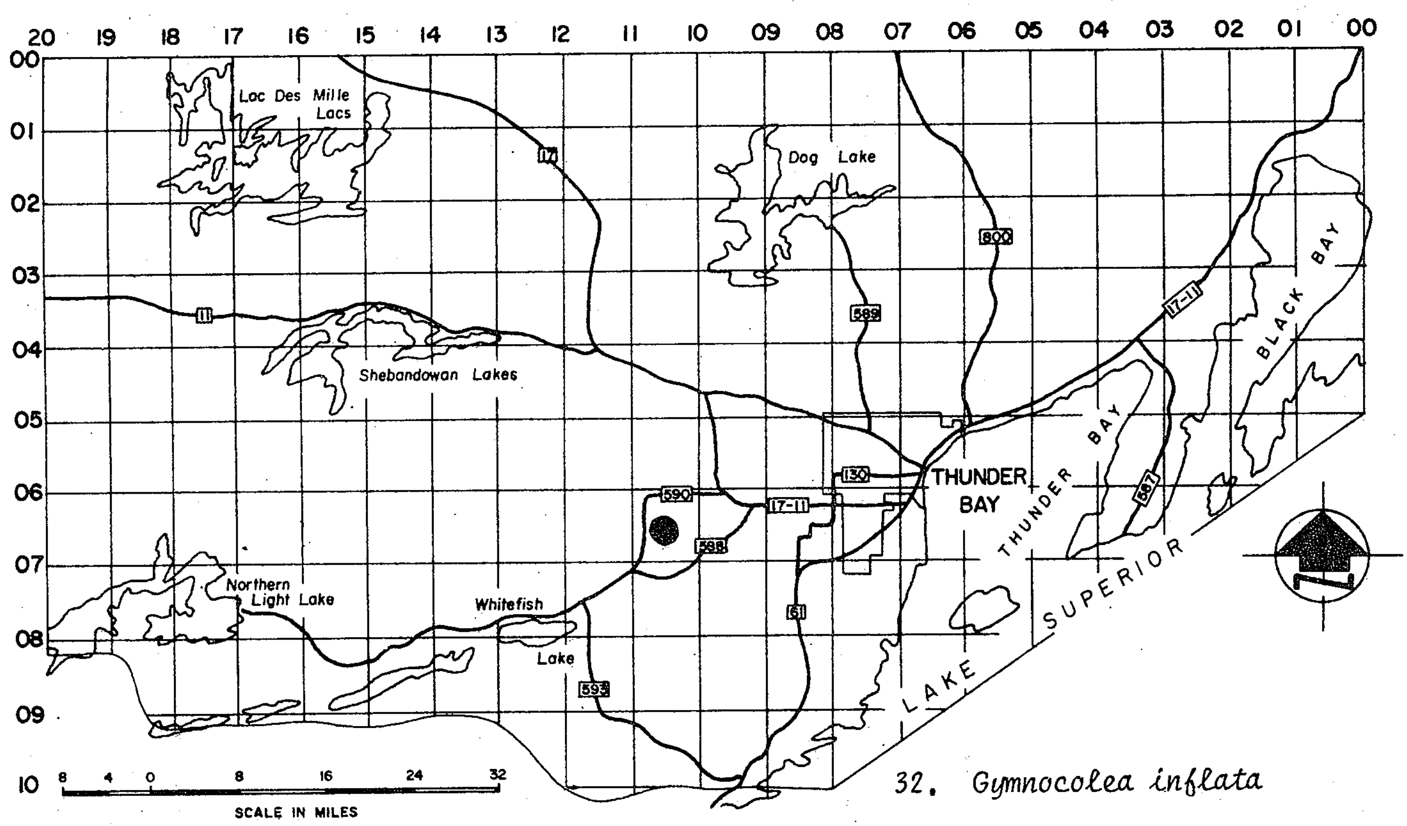
29. *Anastrophyllum michauxii*



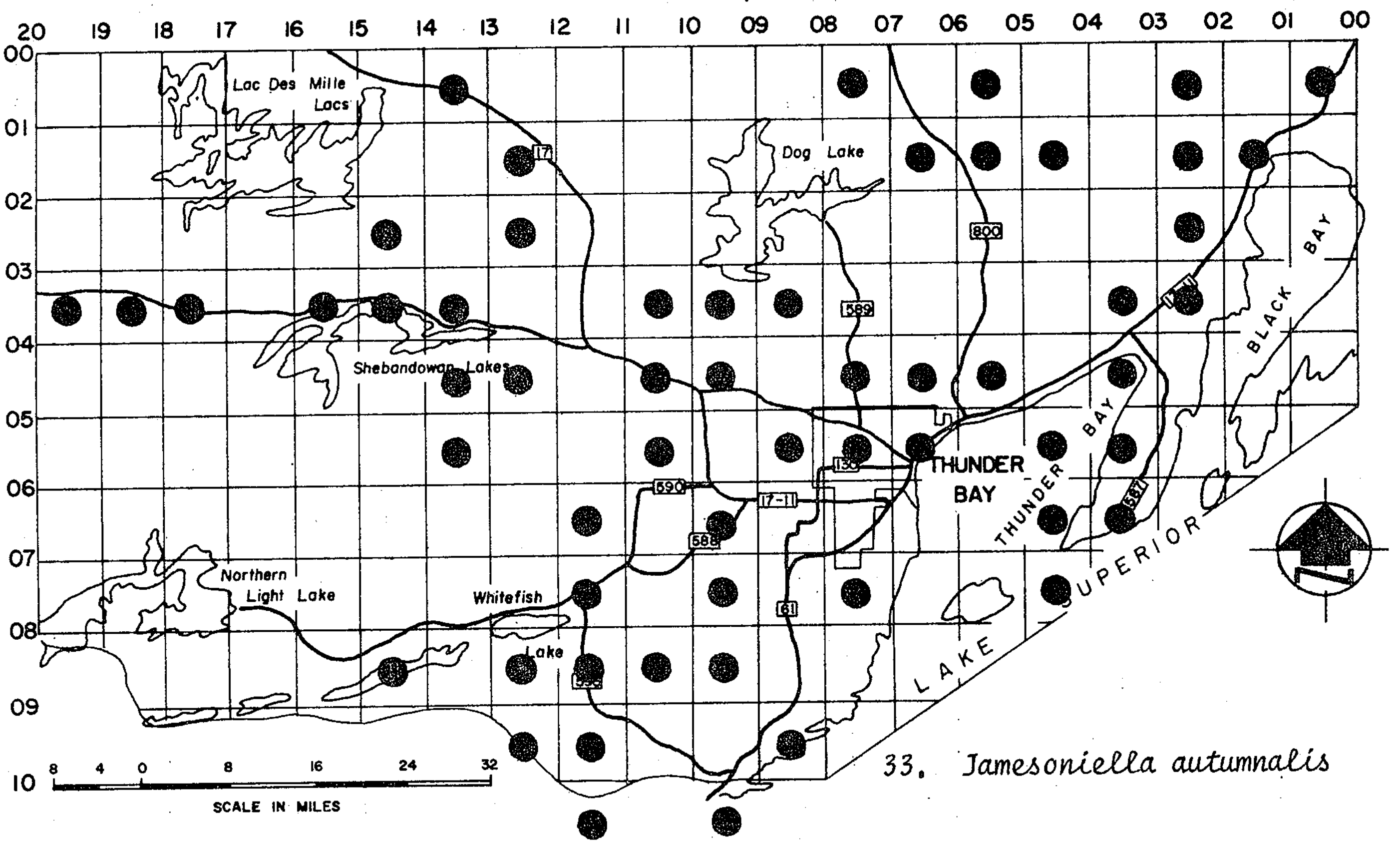
30. *Anastrophyllum minutum*



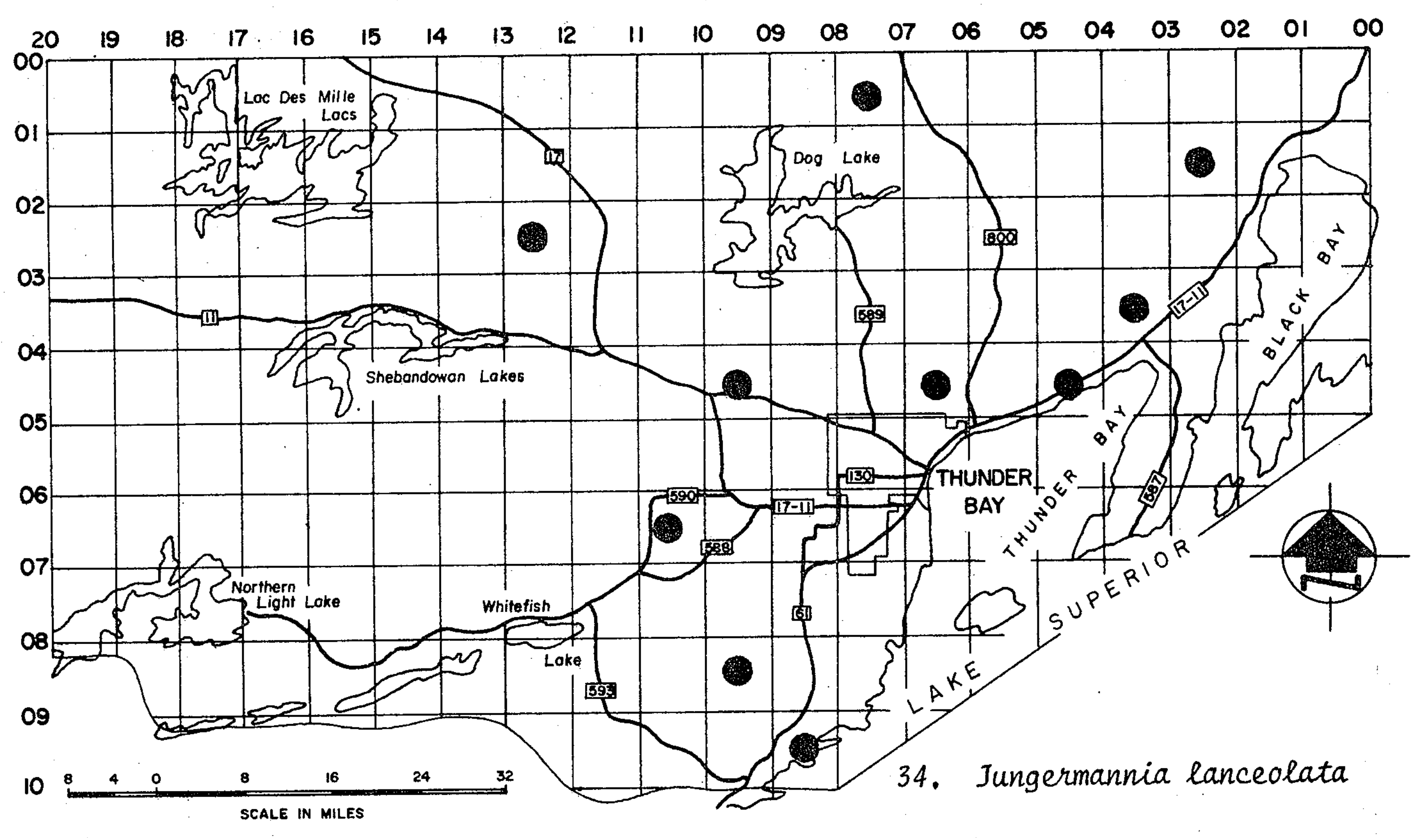
31. *Anastrophyllum saxicola*



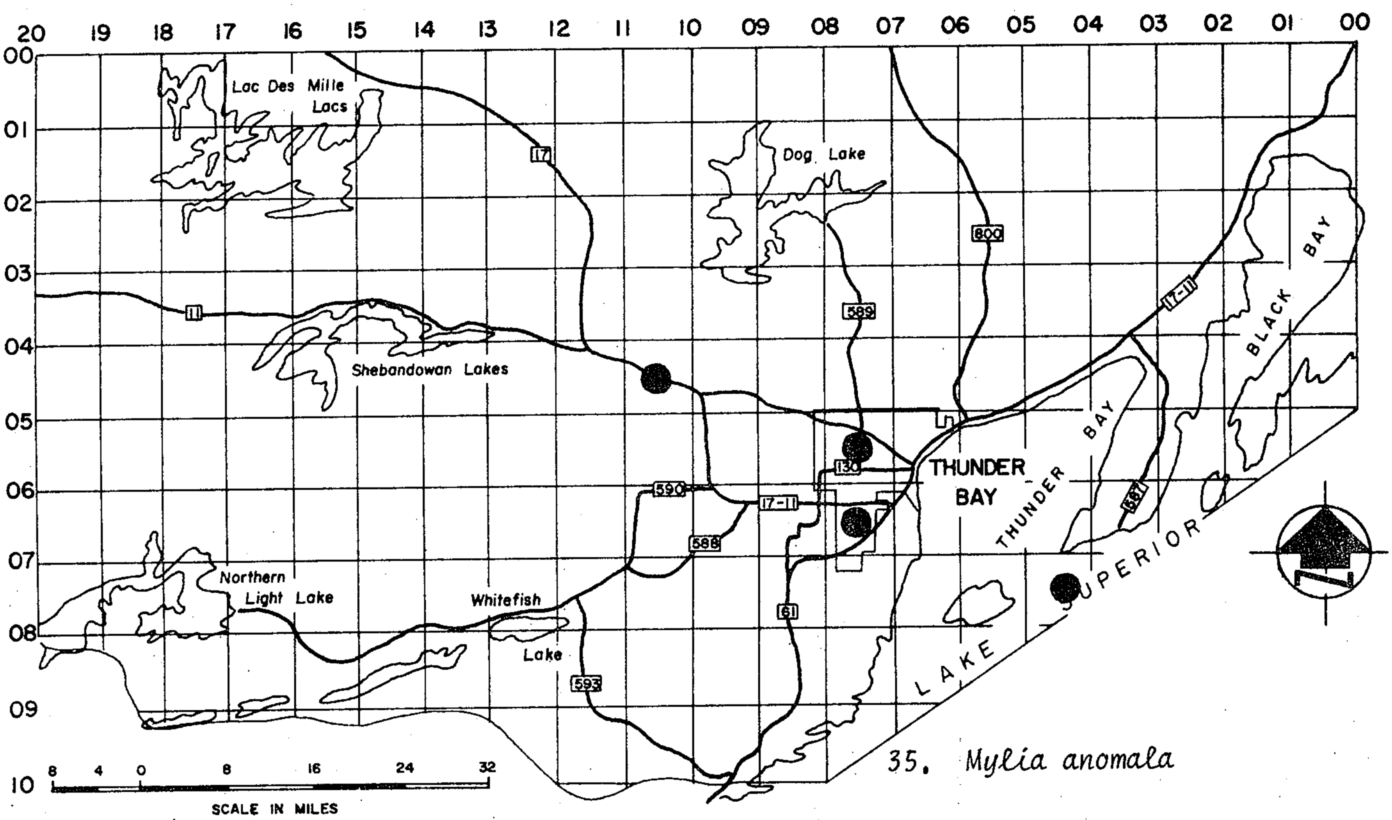
32. *Gymnocolea inflata*



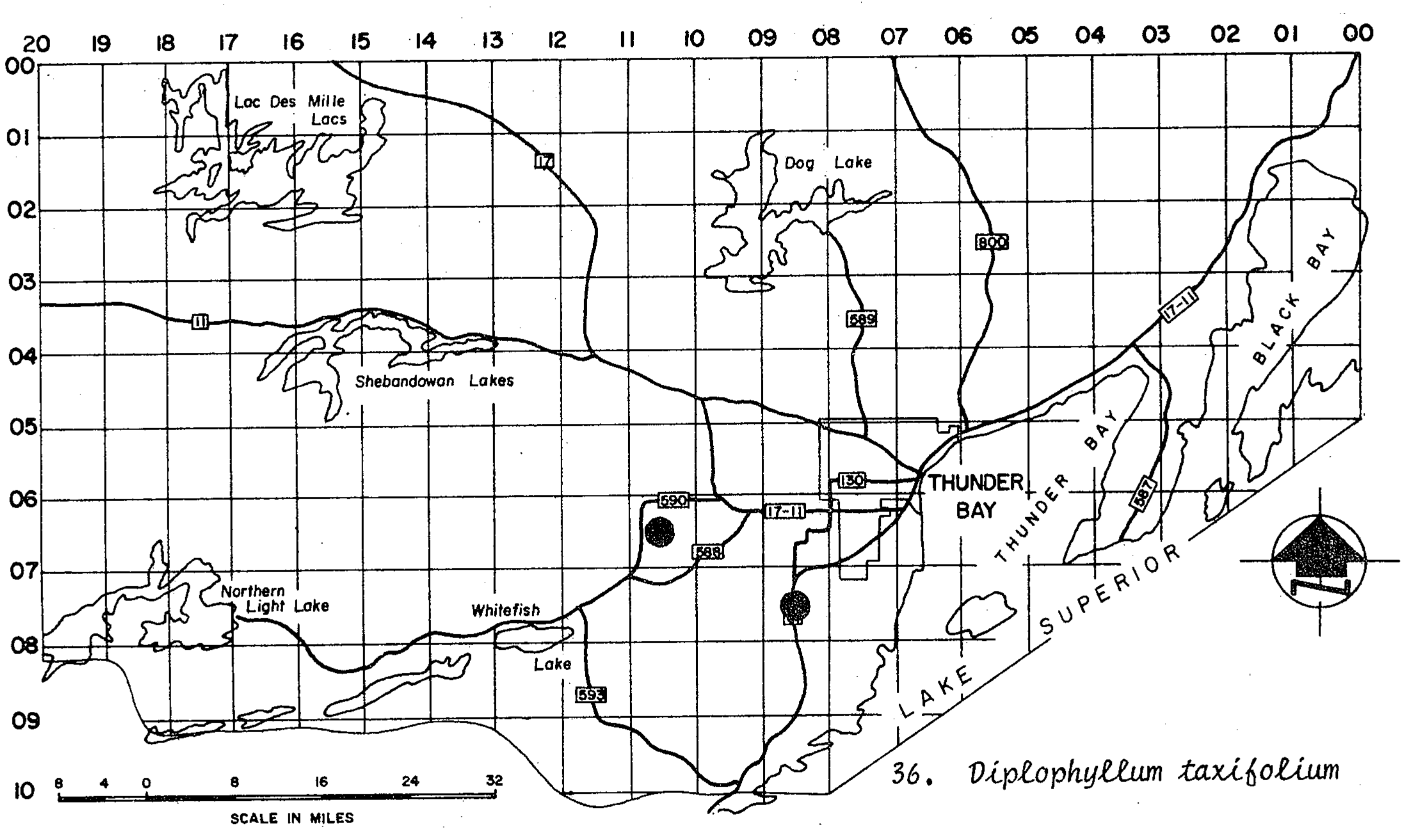
33. *Jamesoniella autumnalis*



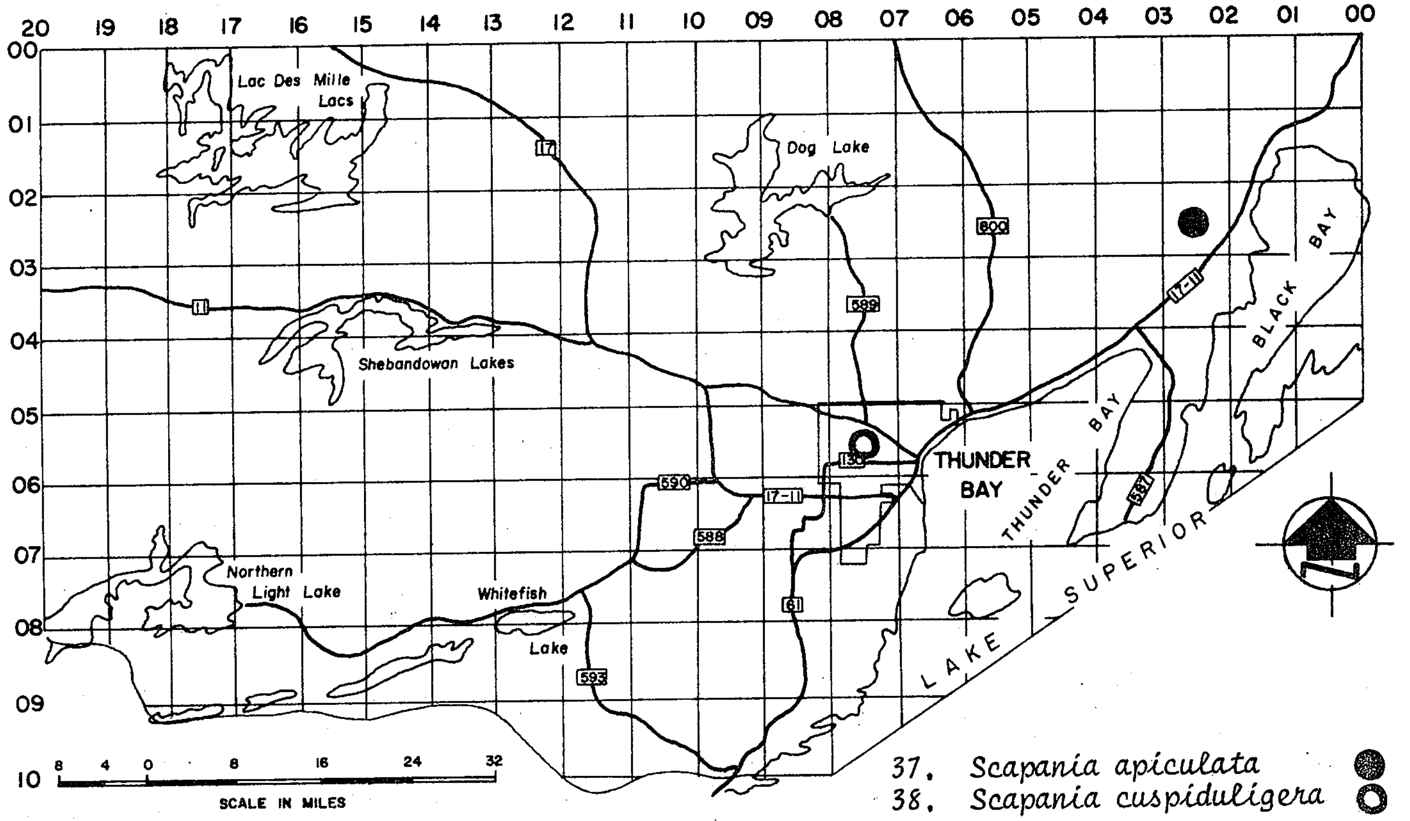
34. *Jungermannia lanceolata*



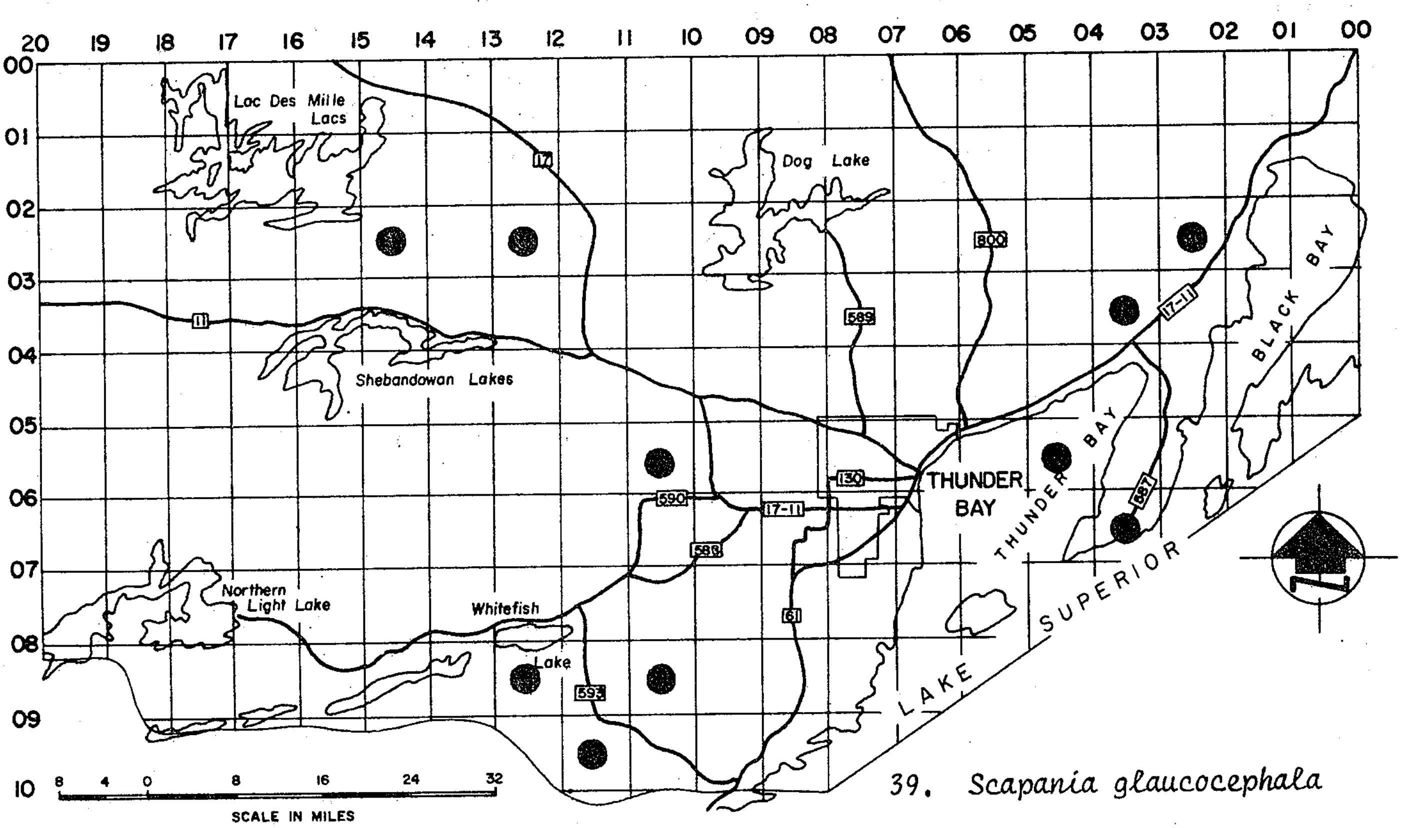
35. *Mylia anomala*



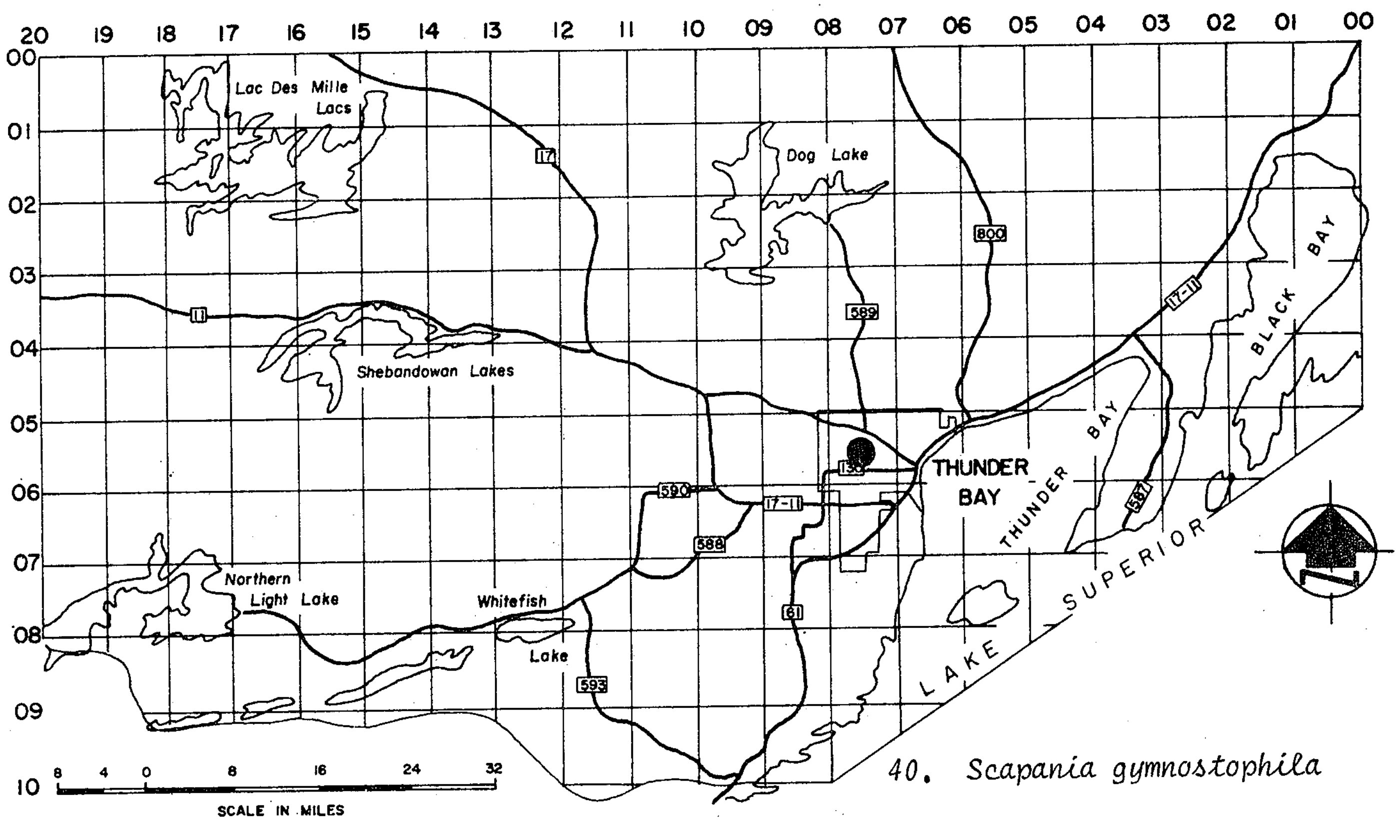
36. *Diplophyllum taxifolium*



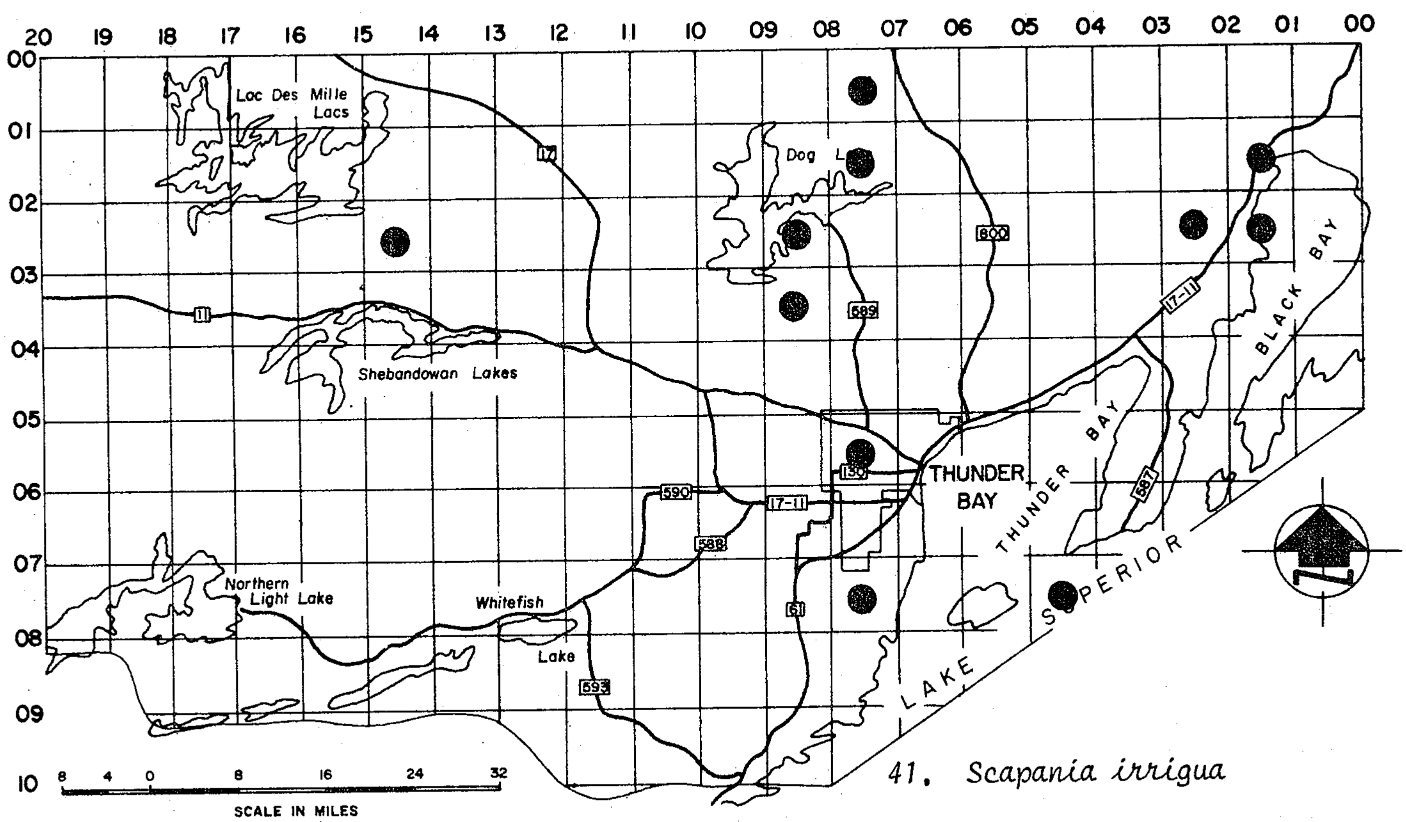
37. *Scapania apiculata* ●
38. *Scapania cuspiduligera* ○



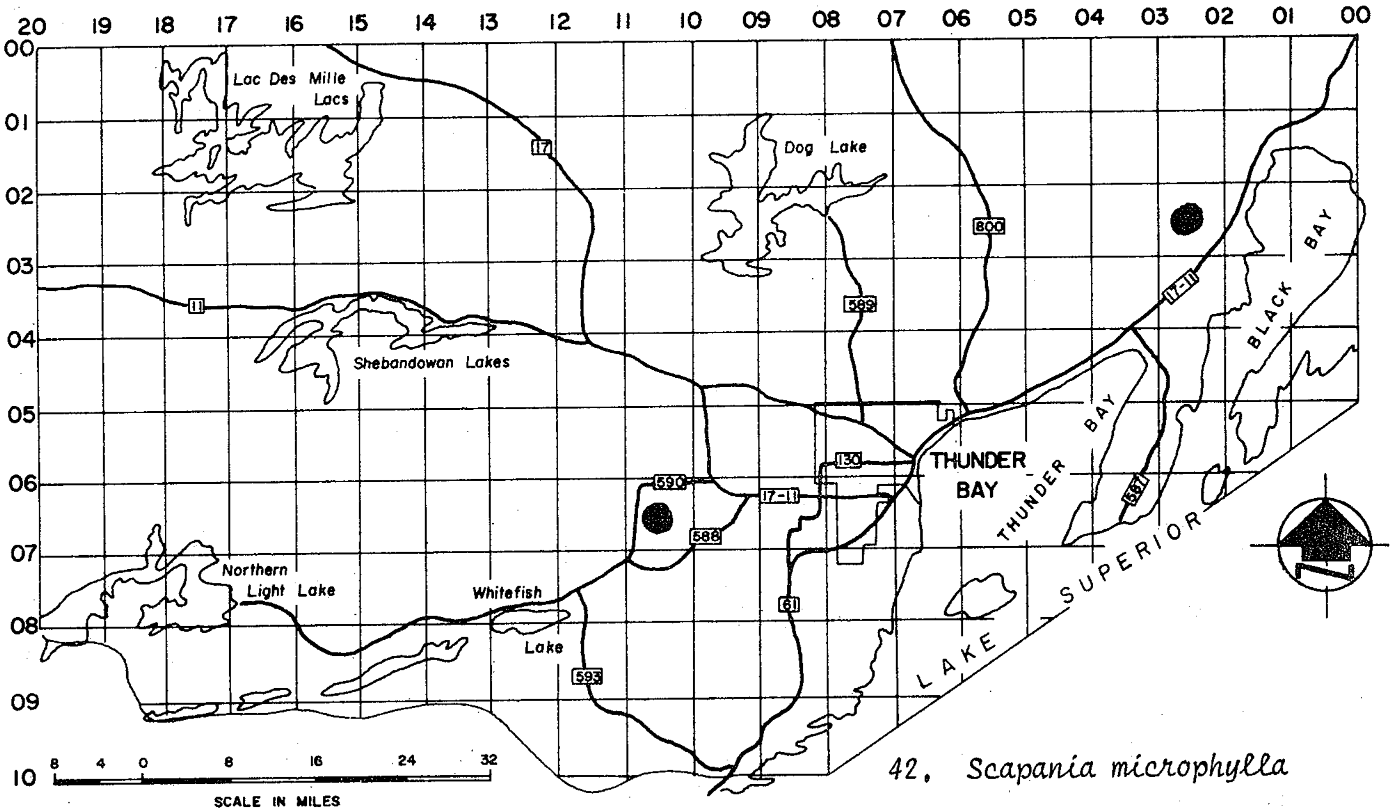
39. *Scapania glaucocephala*



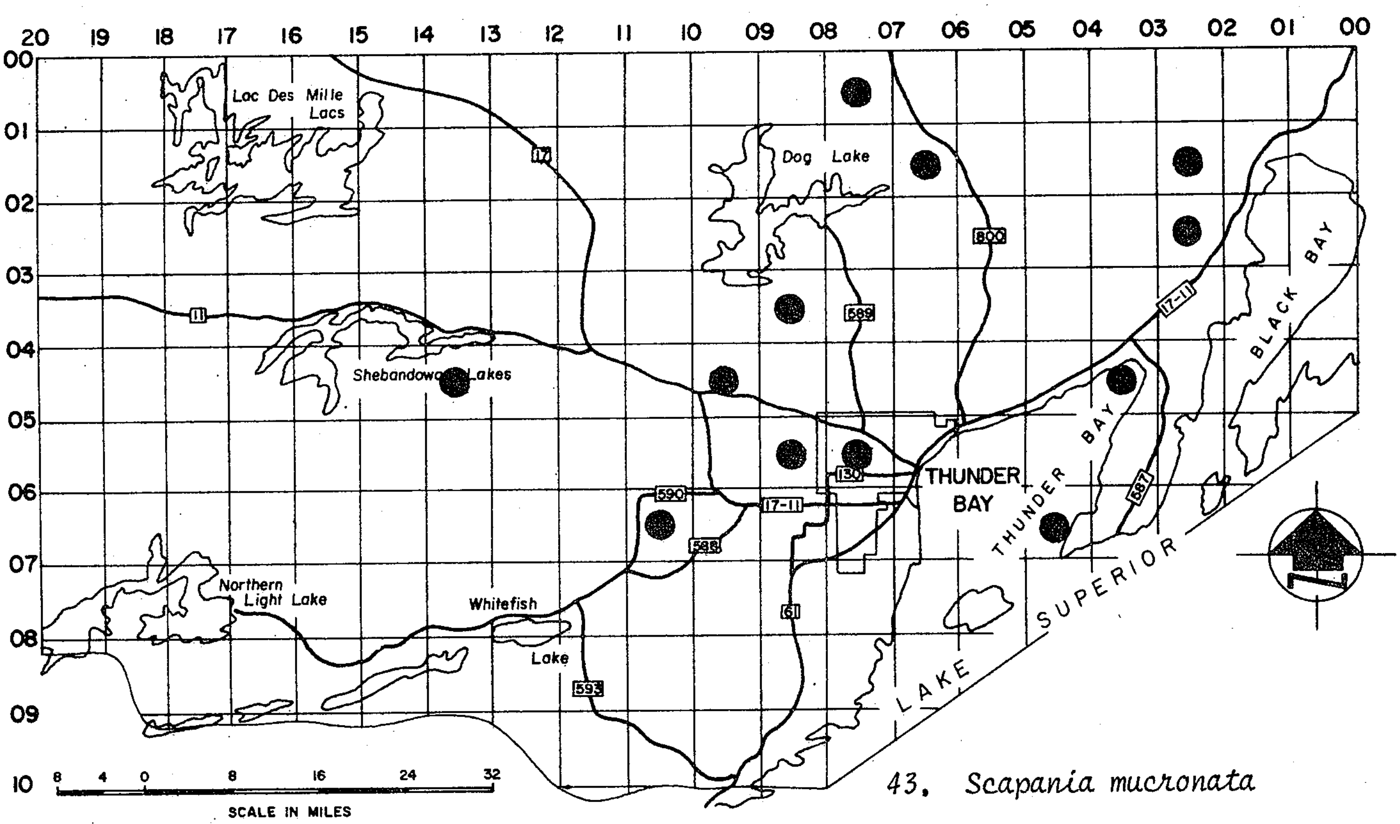
40. *Scapania gymnostophila*



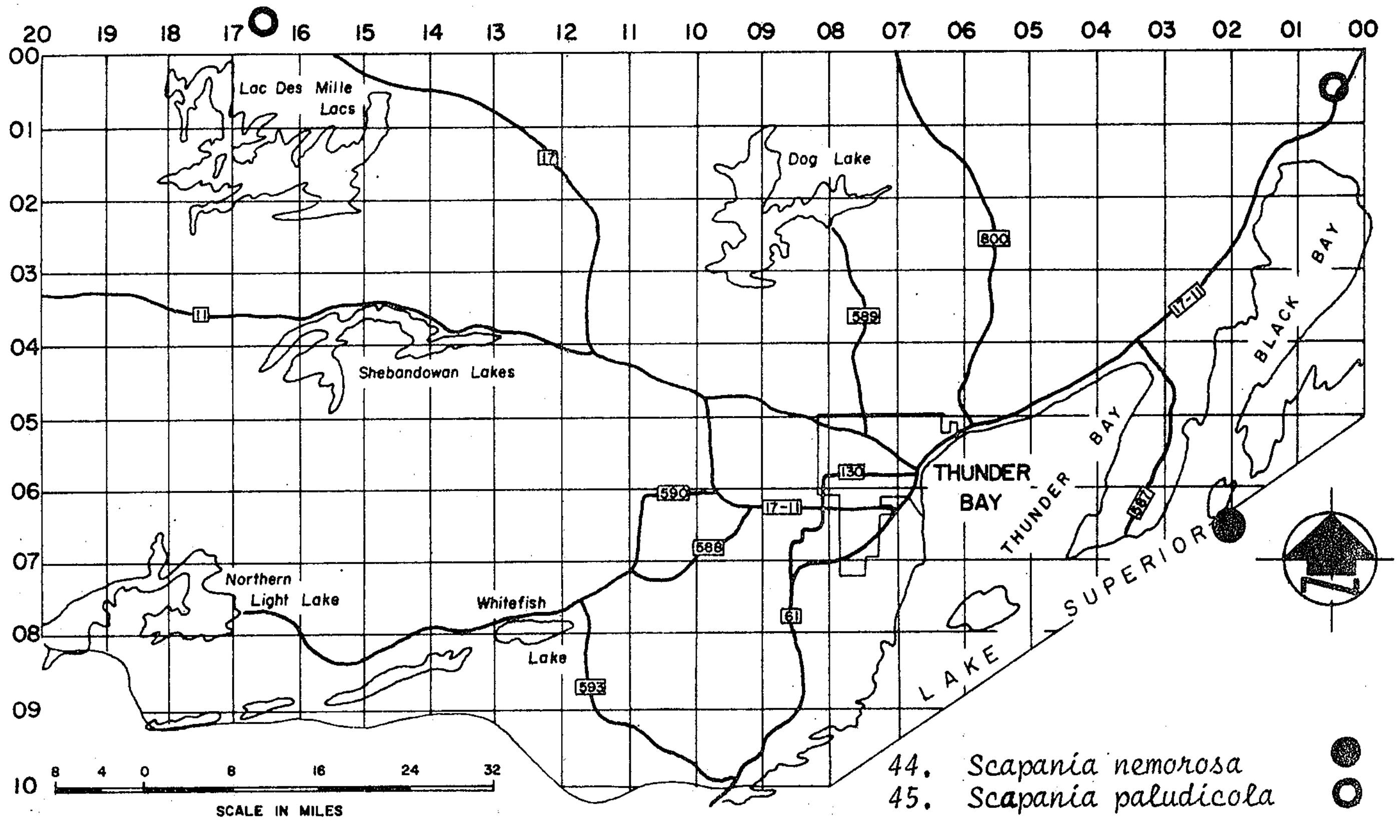
41. *Scapania irrigua*



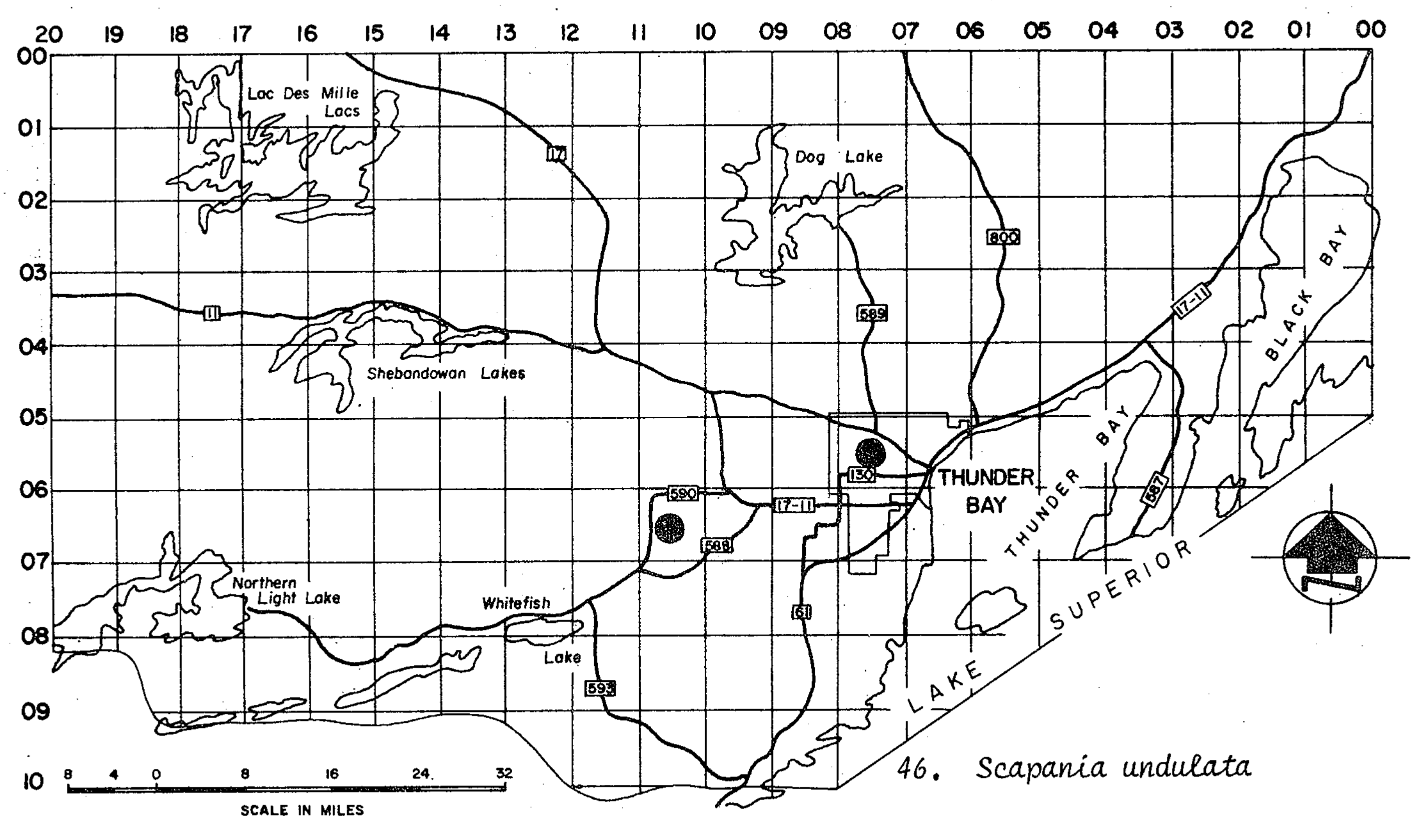
42. *Scapania microphylla*



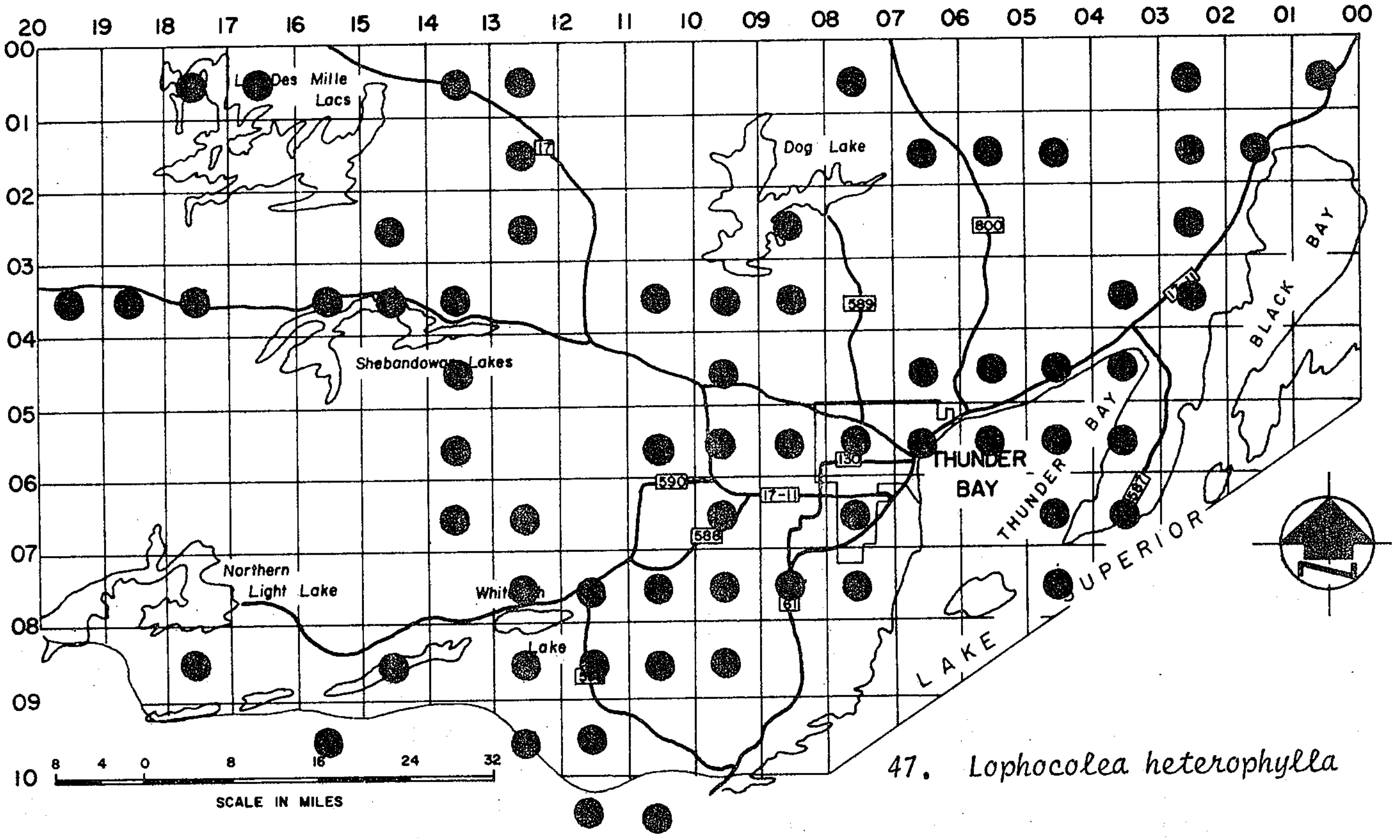
43. *Scapania mucronata*



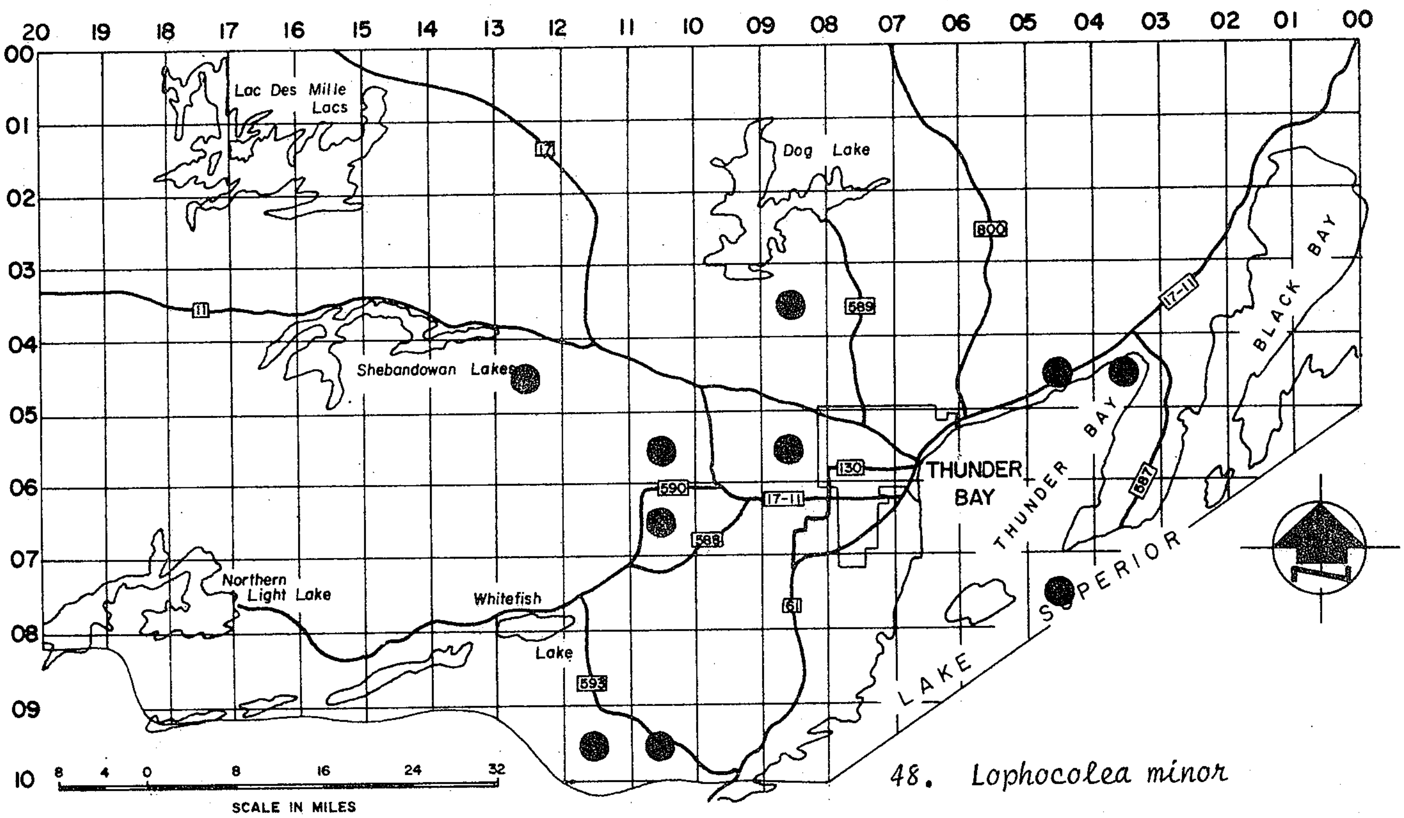
44. *Scapania nemorosa* ●
45. *Scapania paludicola* ○



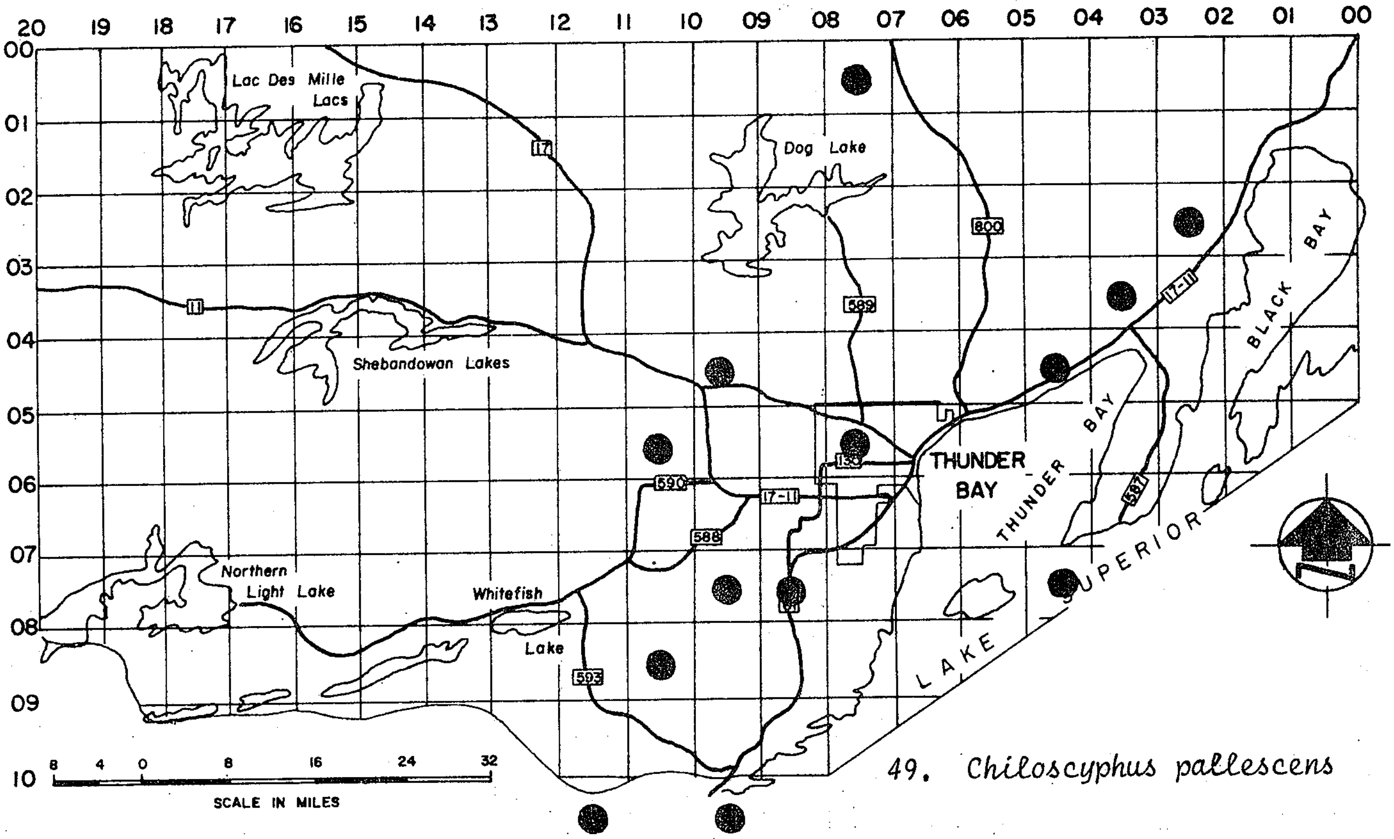
46. *Scapania undulata*



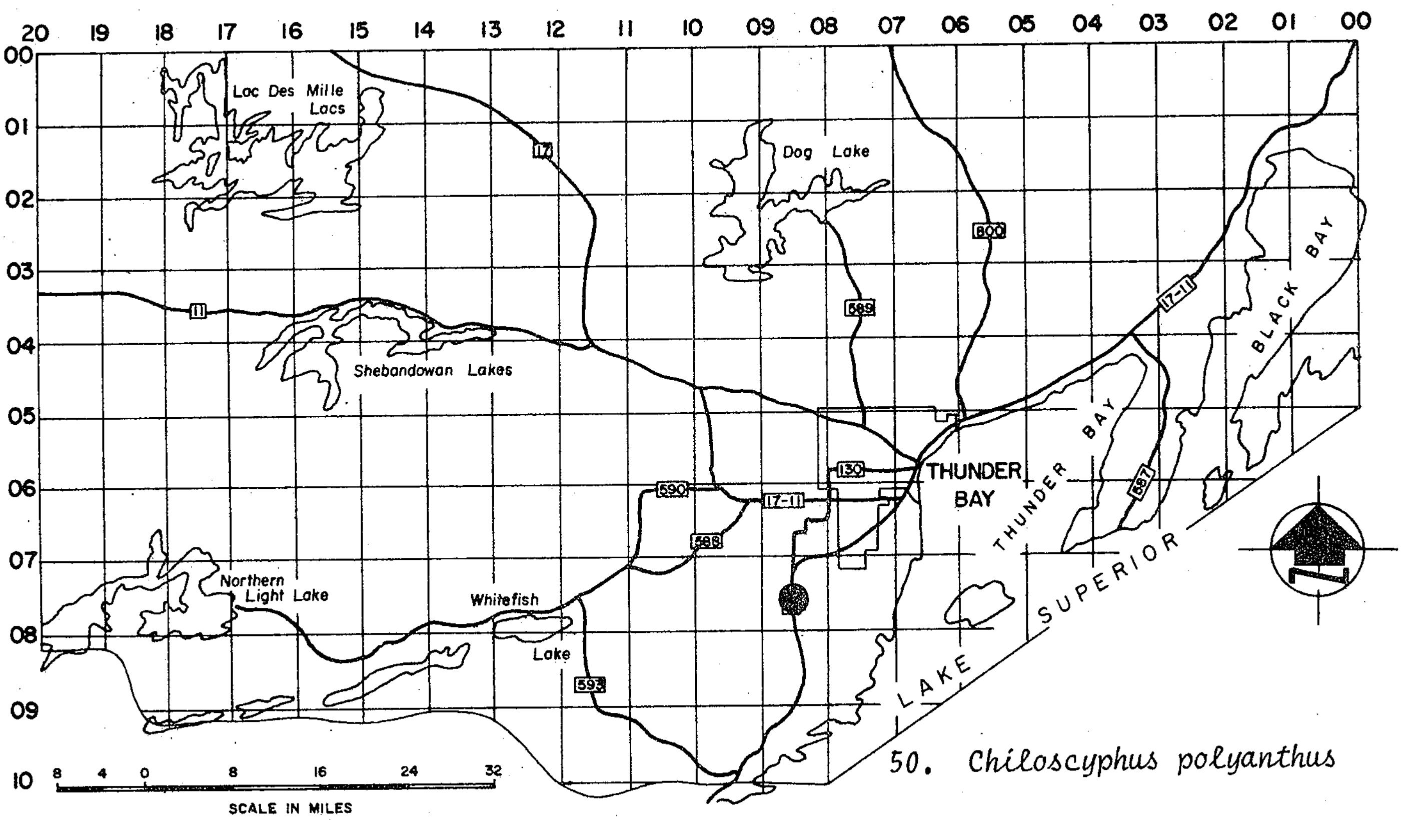
47. *Lophocolea heterophylla*



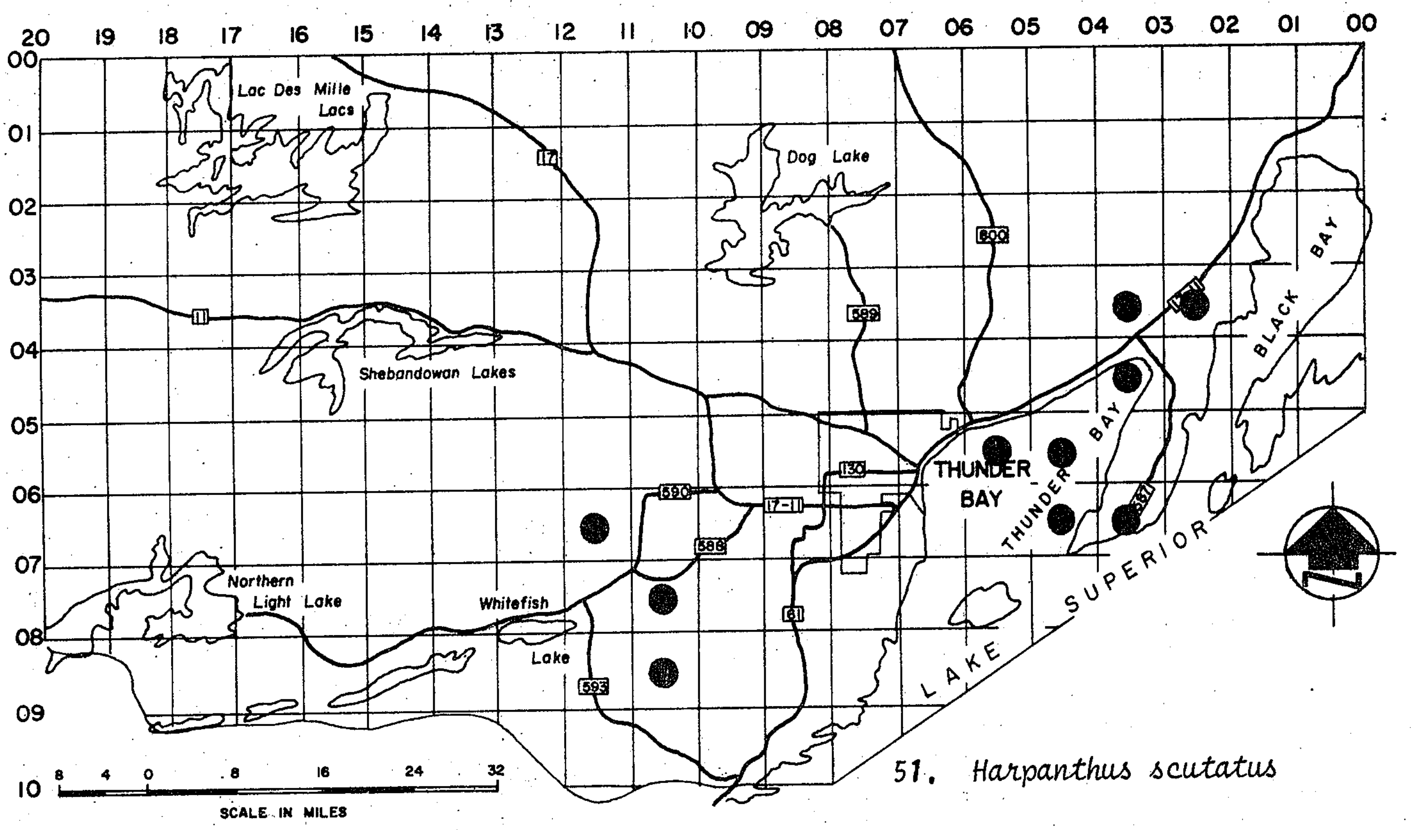
48. *Lophocolea minor*



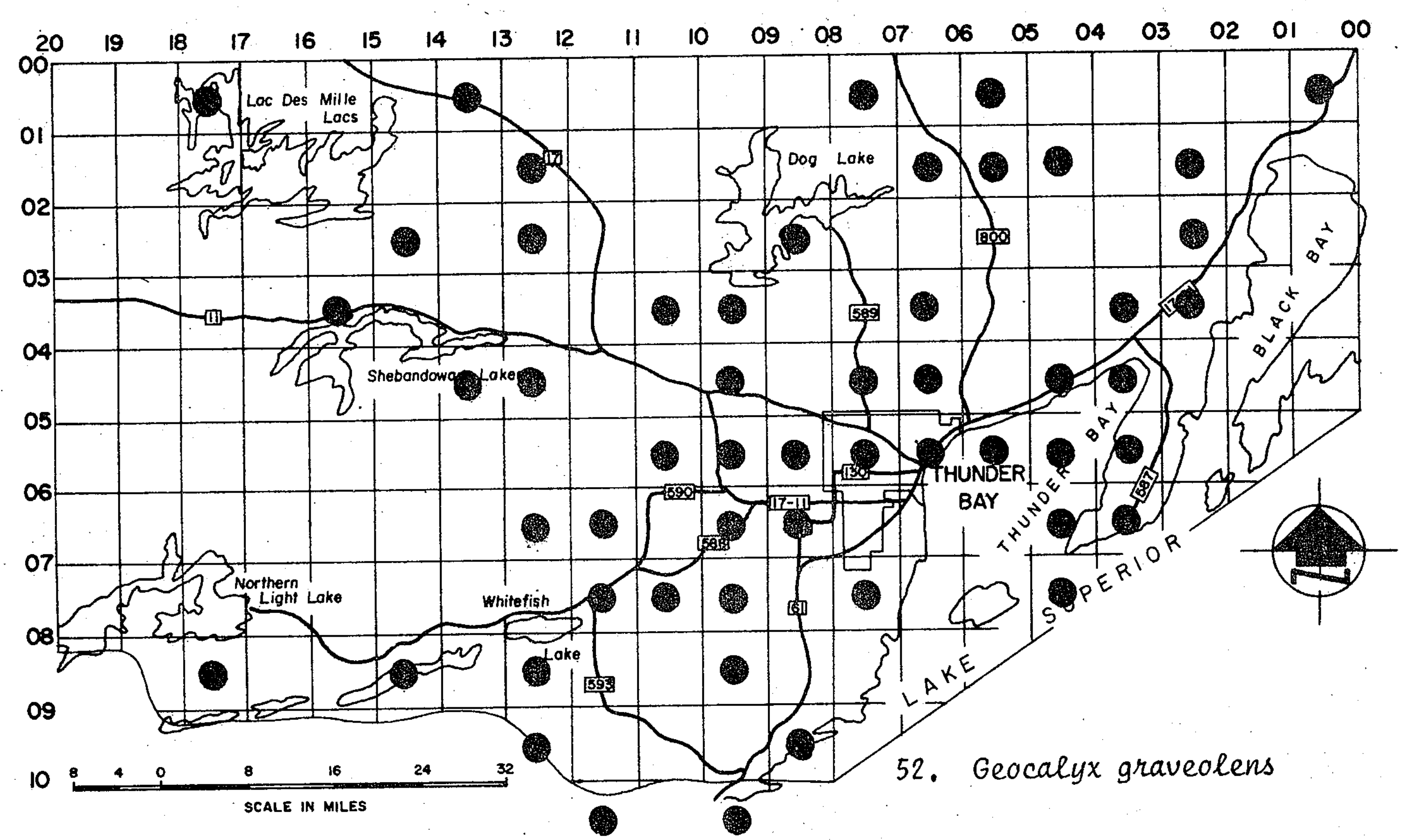
49. *Chiloscyphus pallescens*



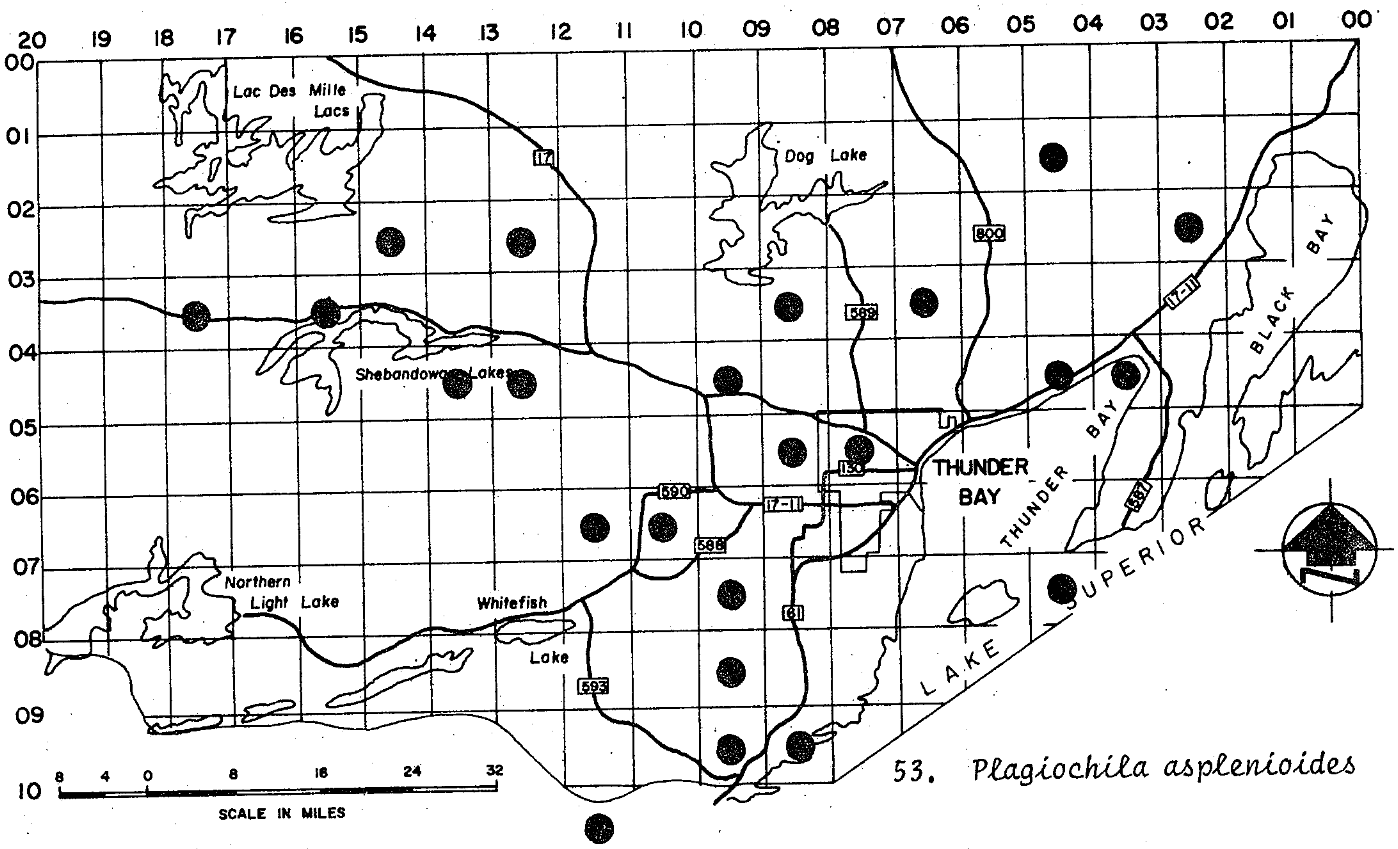
50. *Chiloscyphus polyanthus*



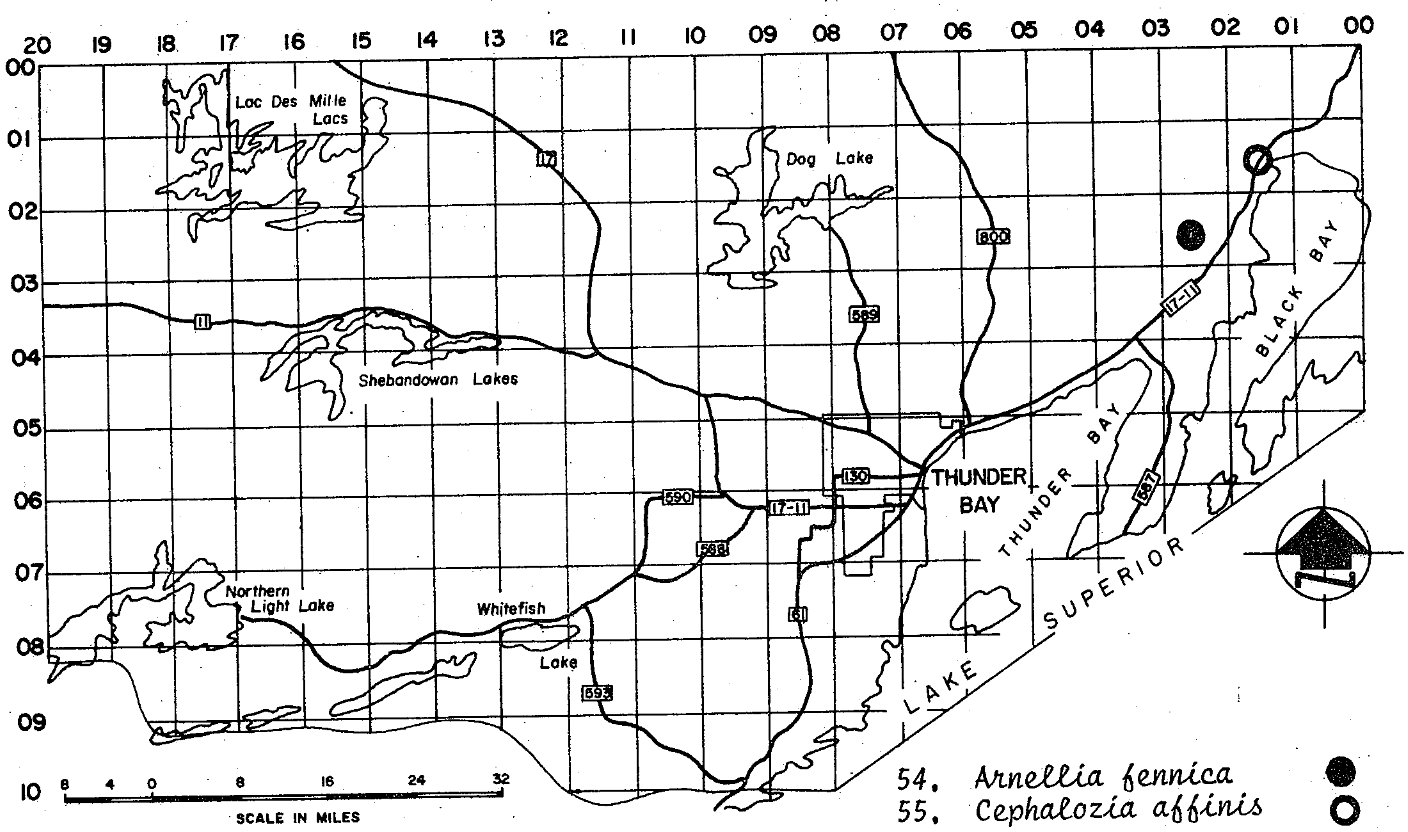
51. *Harpanthus scutatus*



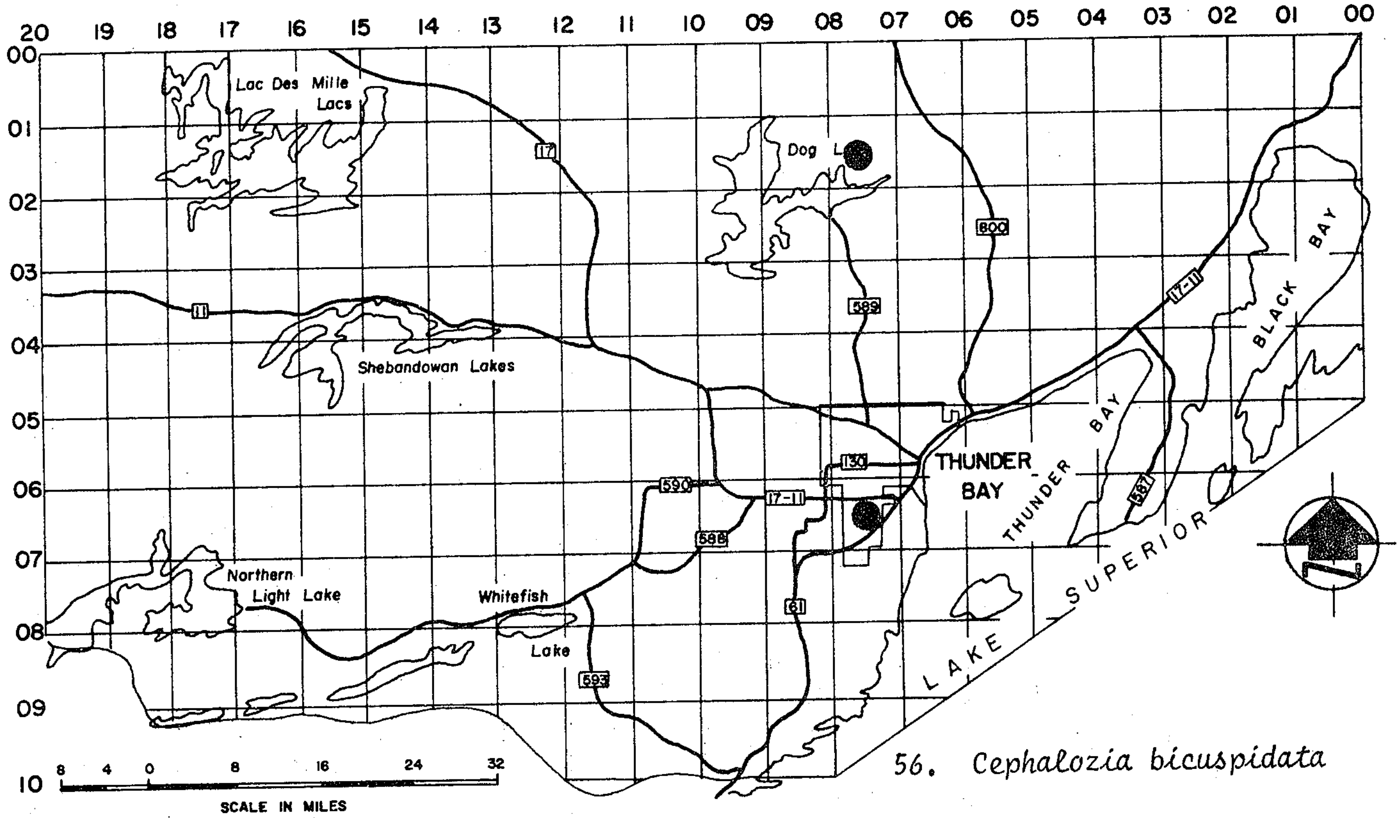
52. *Geocalyx graveolens*



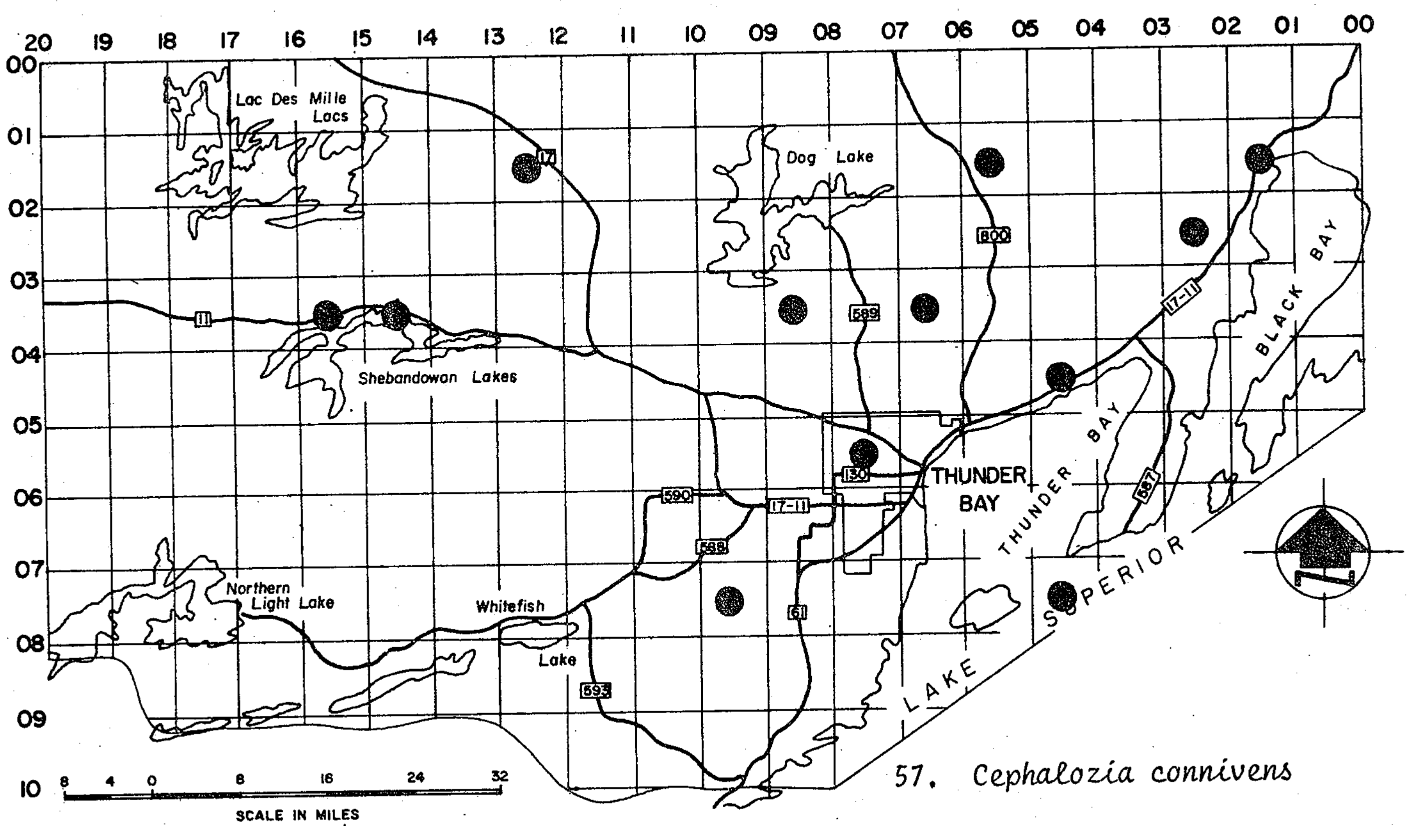
53. *Plagiochila asplenioides*



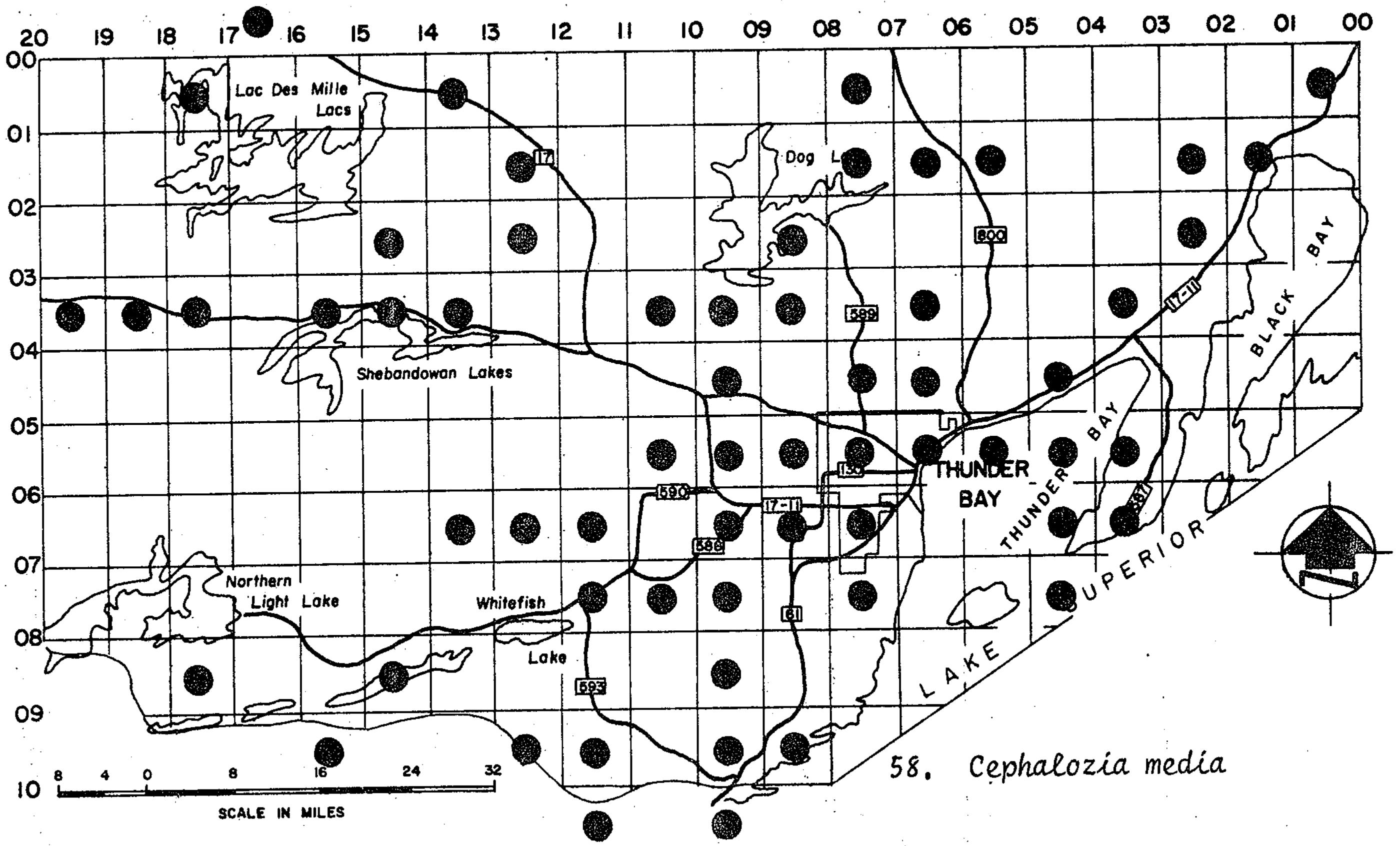
54. *Arnellia fennica* ●
55. *Cephalozia affinis* ○



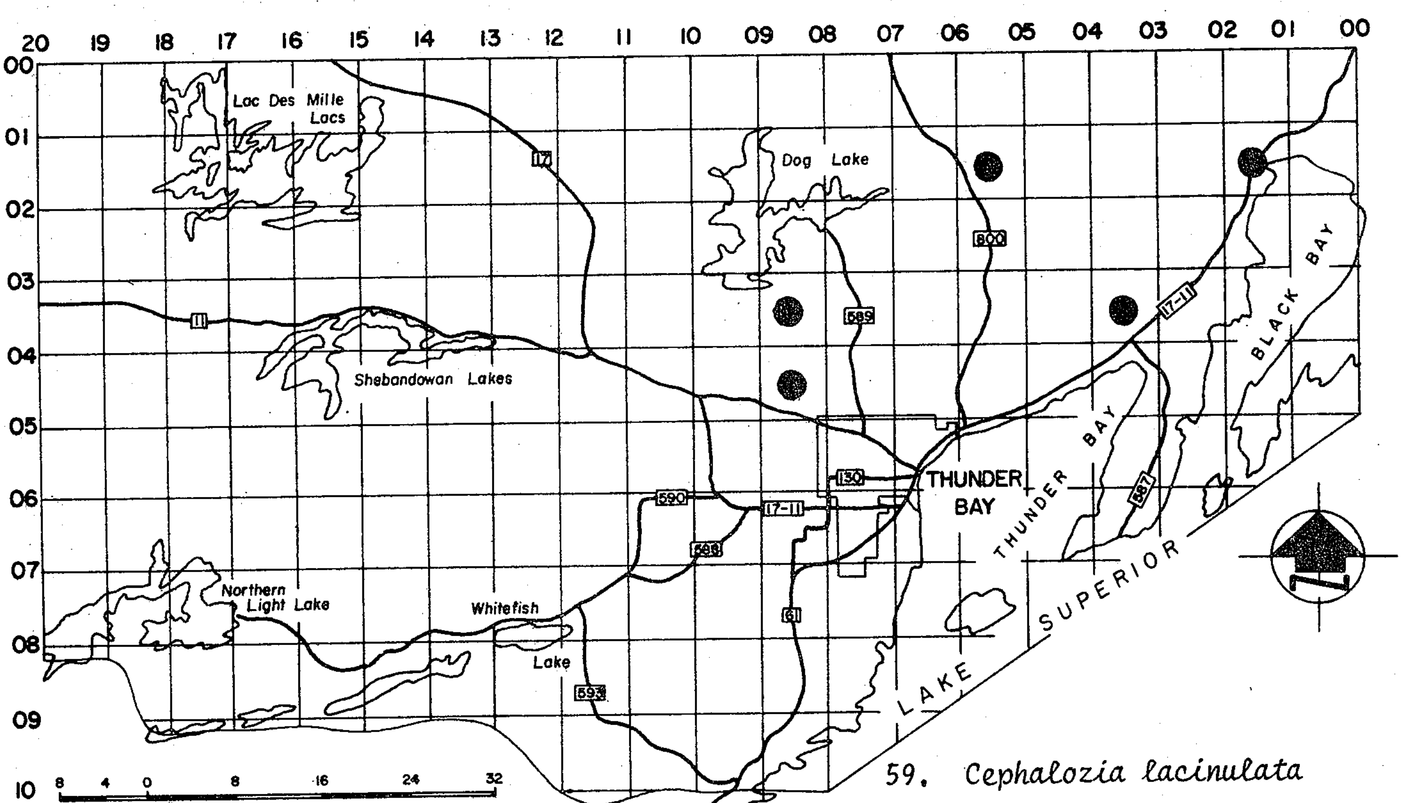
56. *Cephalozia bicuspidata*



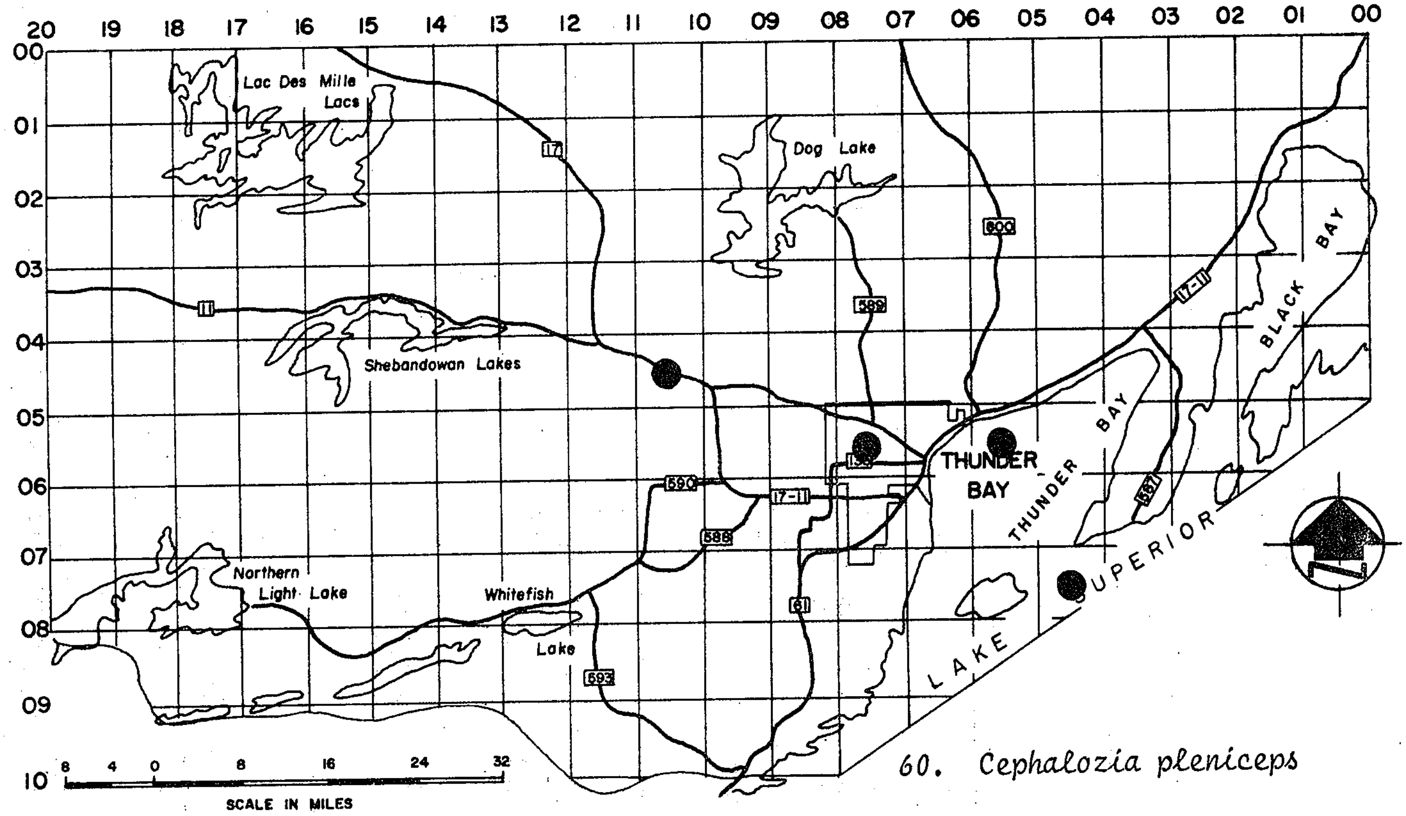
57. *Cephalozia connivens*



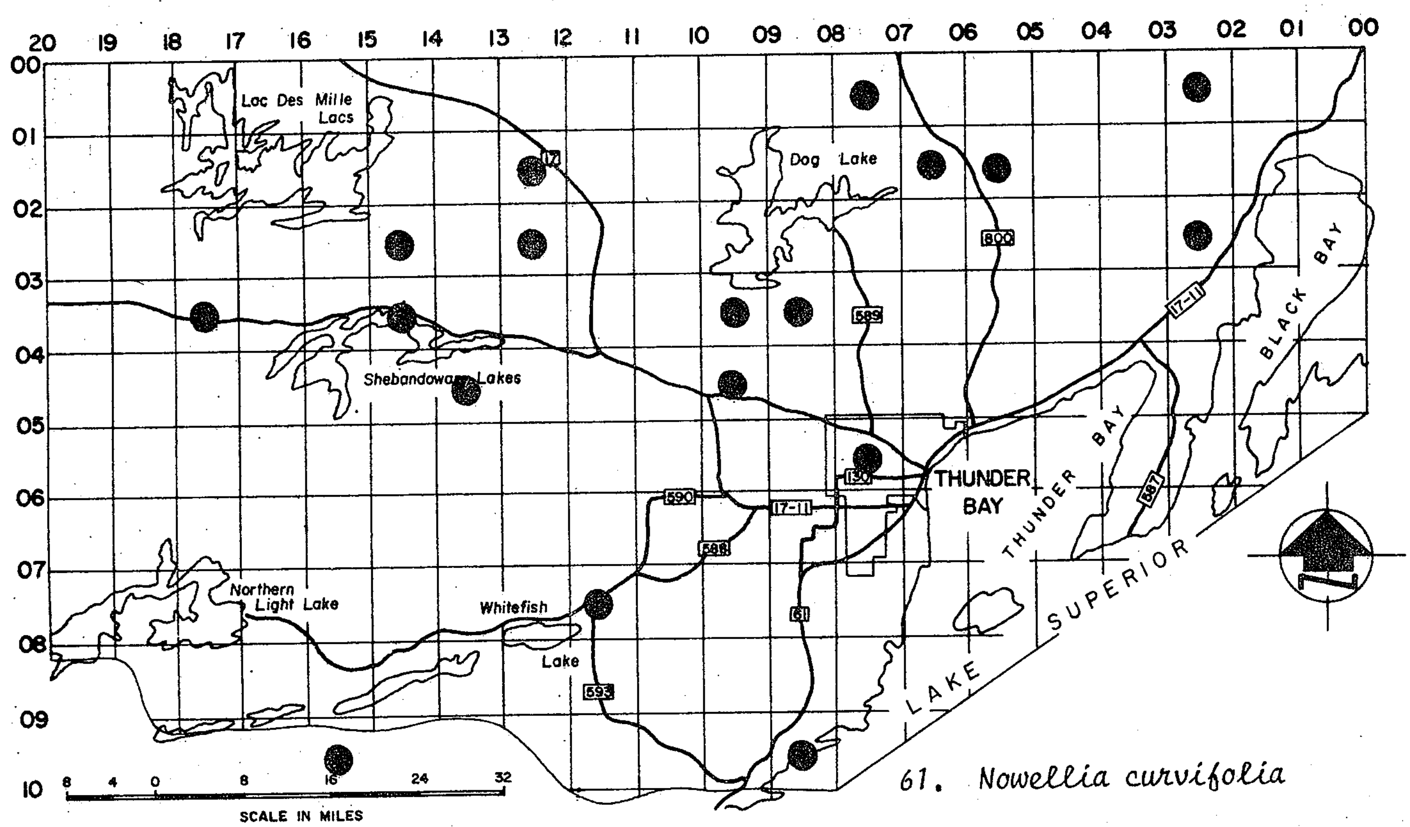
58. *Cephalozia media*



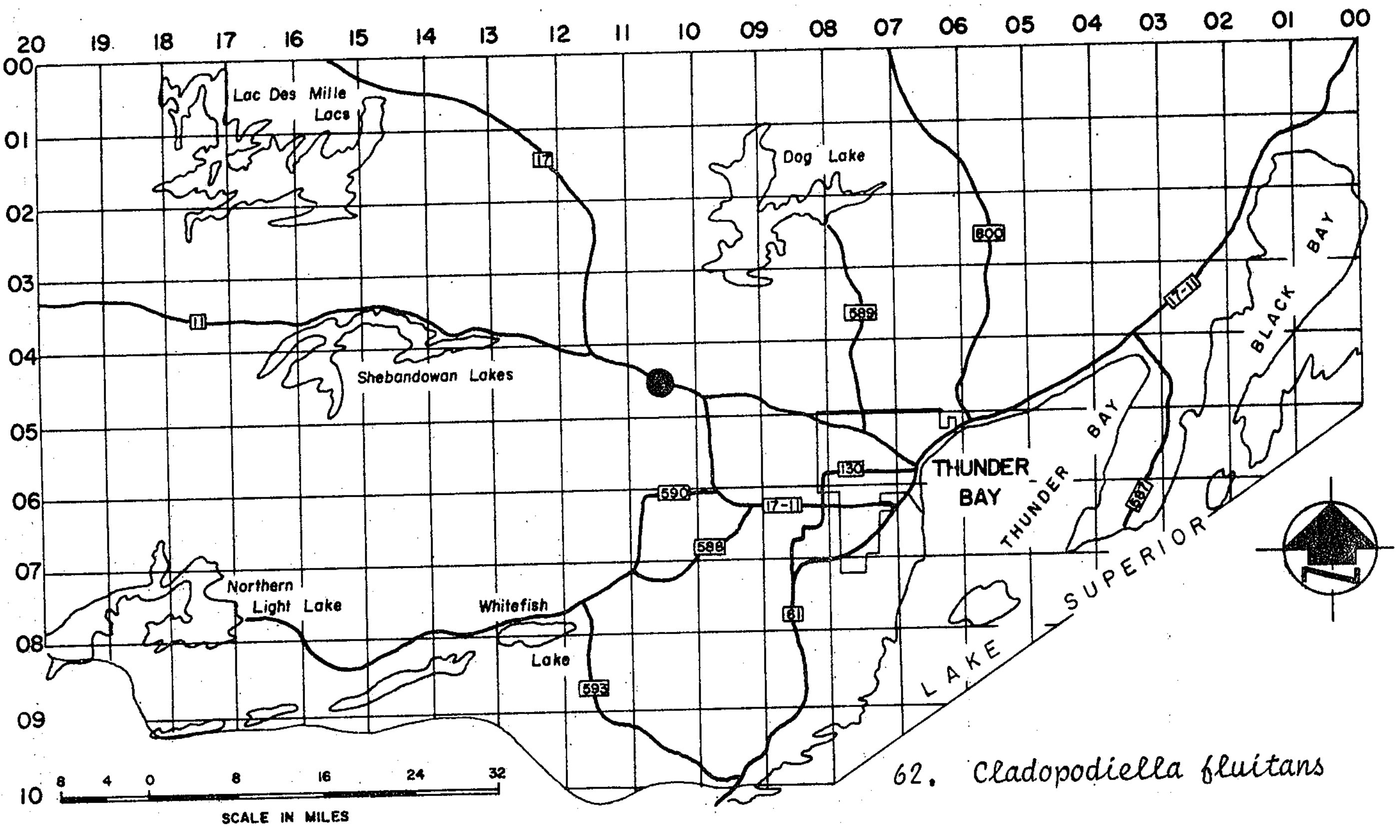
59. *Cephalozia lacinulata*



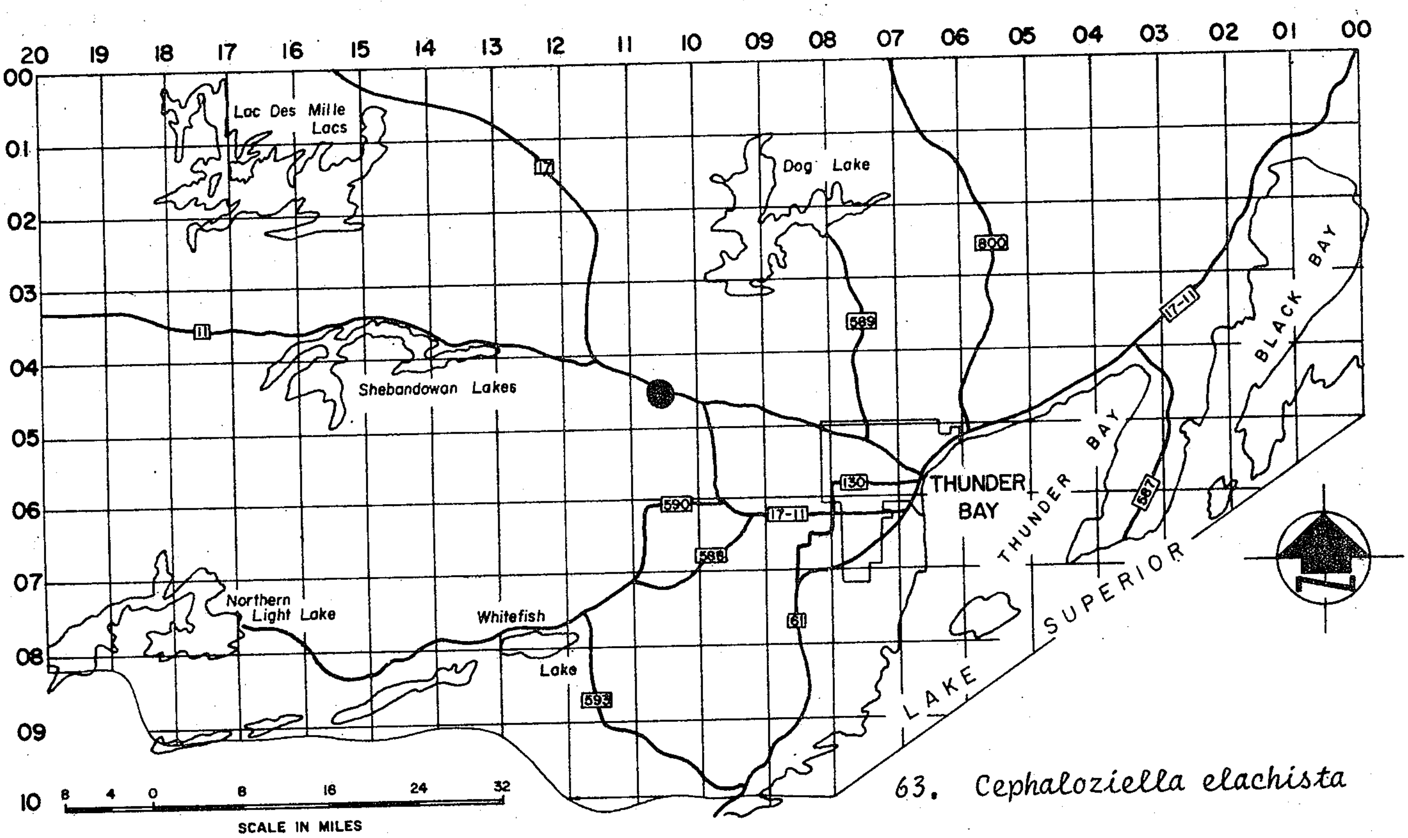
60. *Cephalozia pleniceps*



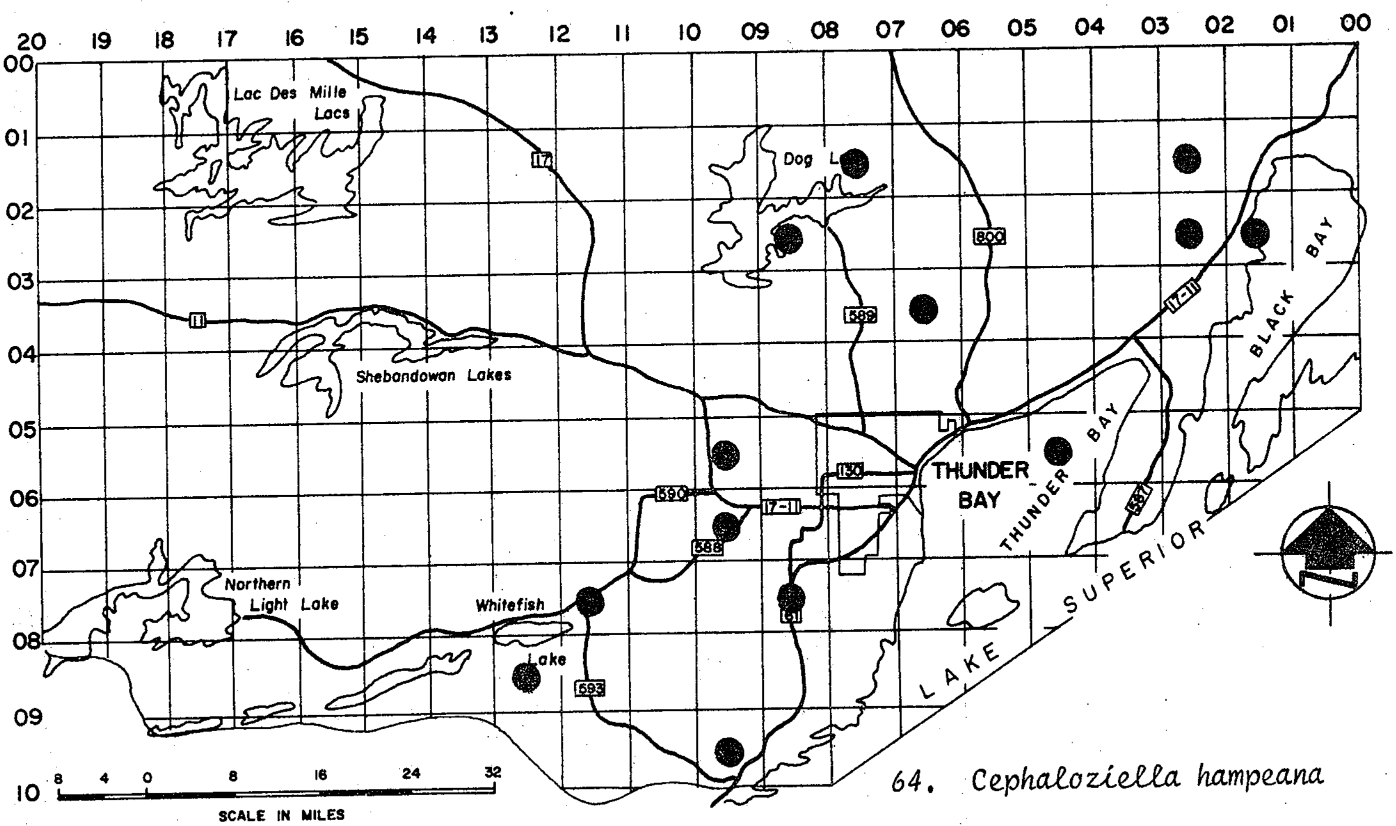
61. *Nowellia curvifolia*



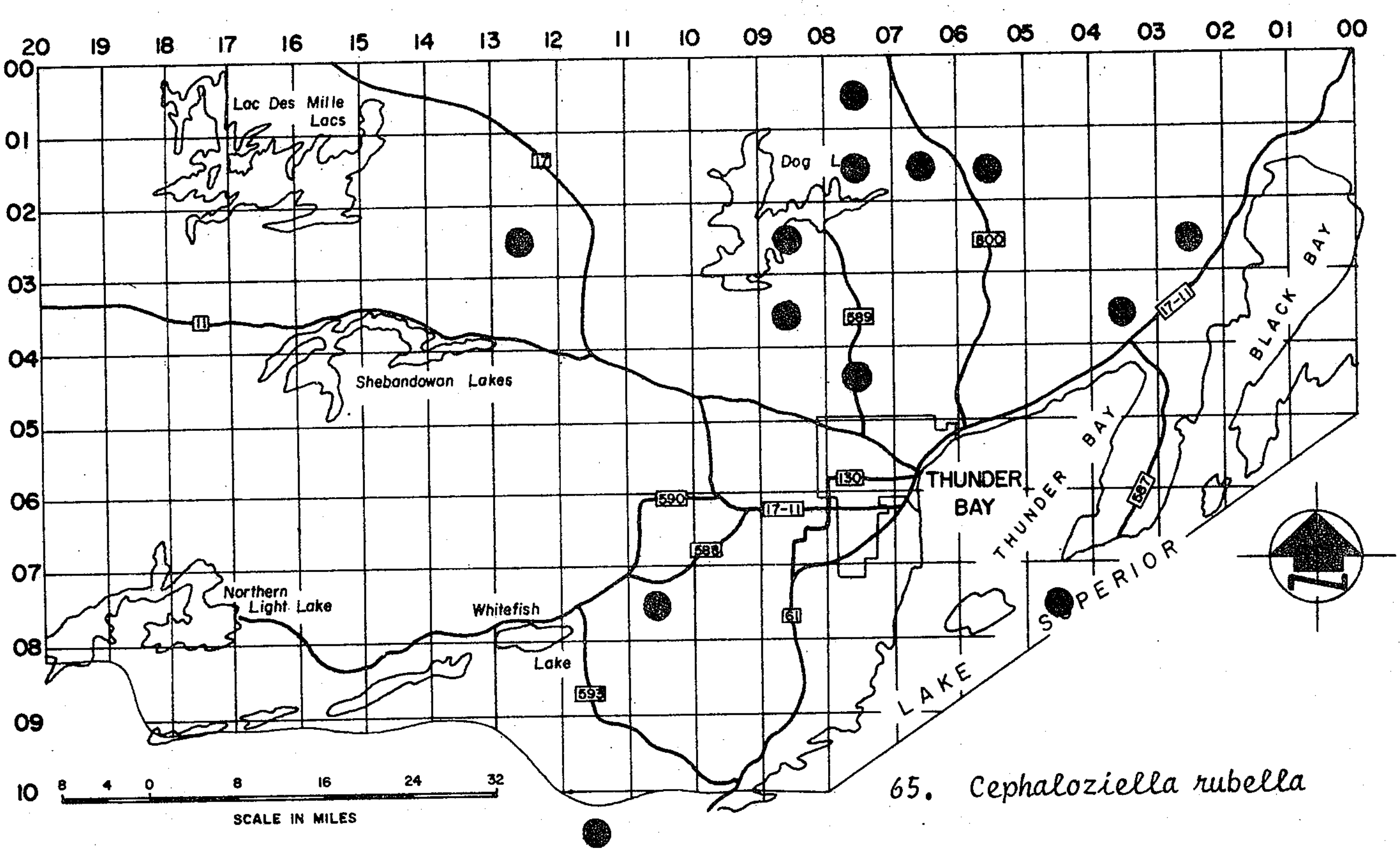
62. *Cladopodiella fluitans*



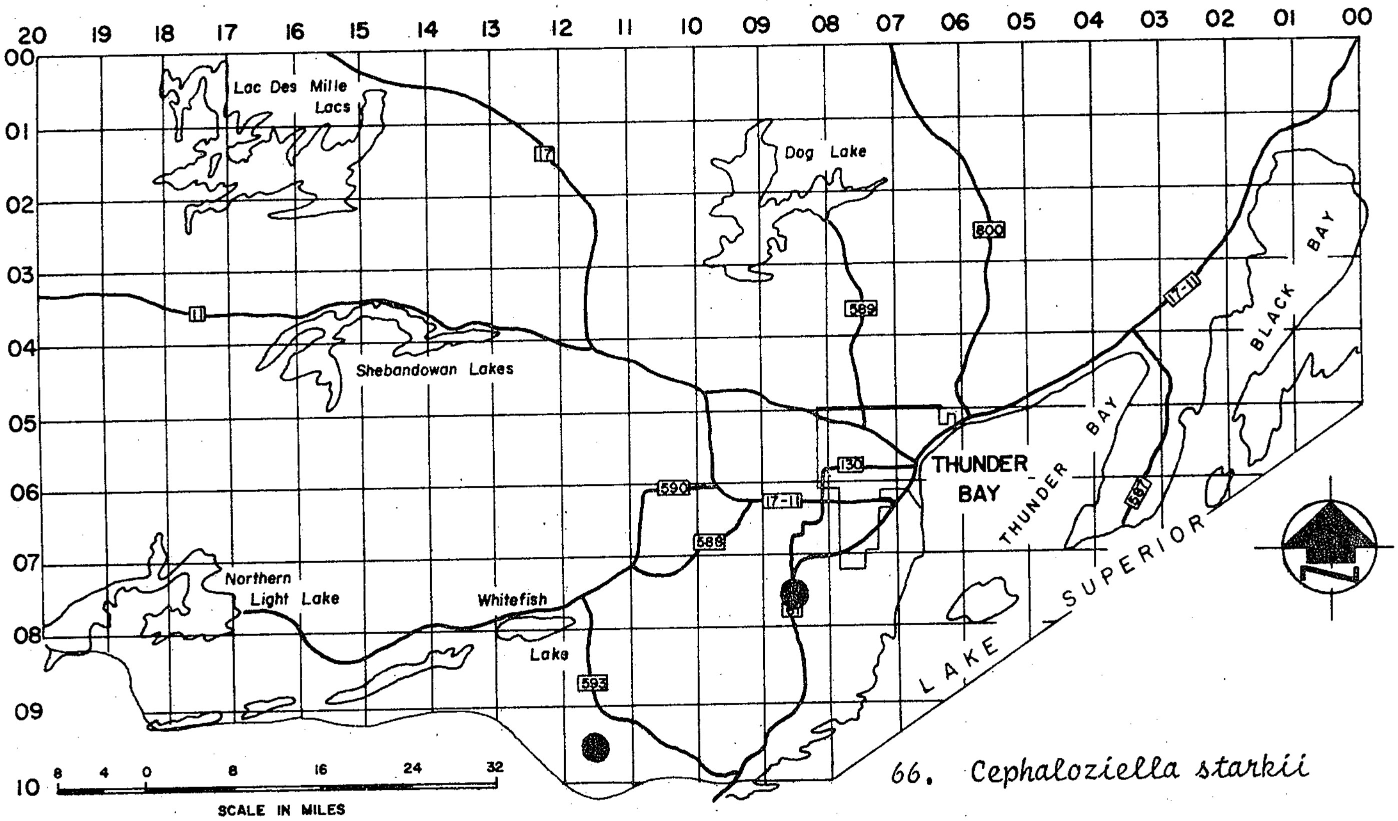
63. *Cephaloziella elachista*



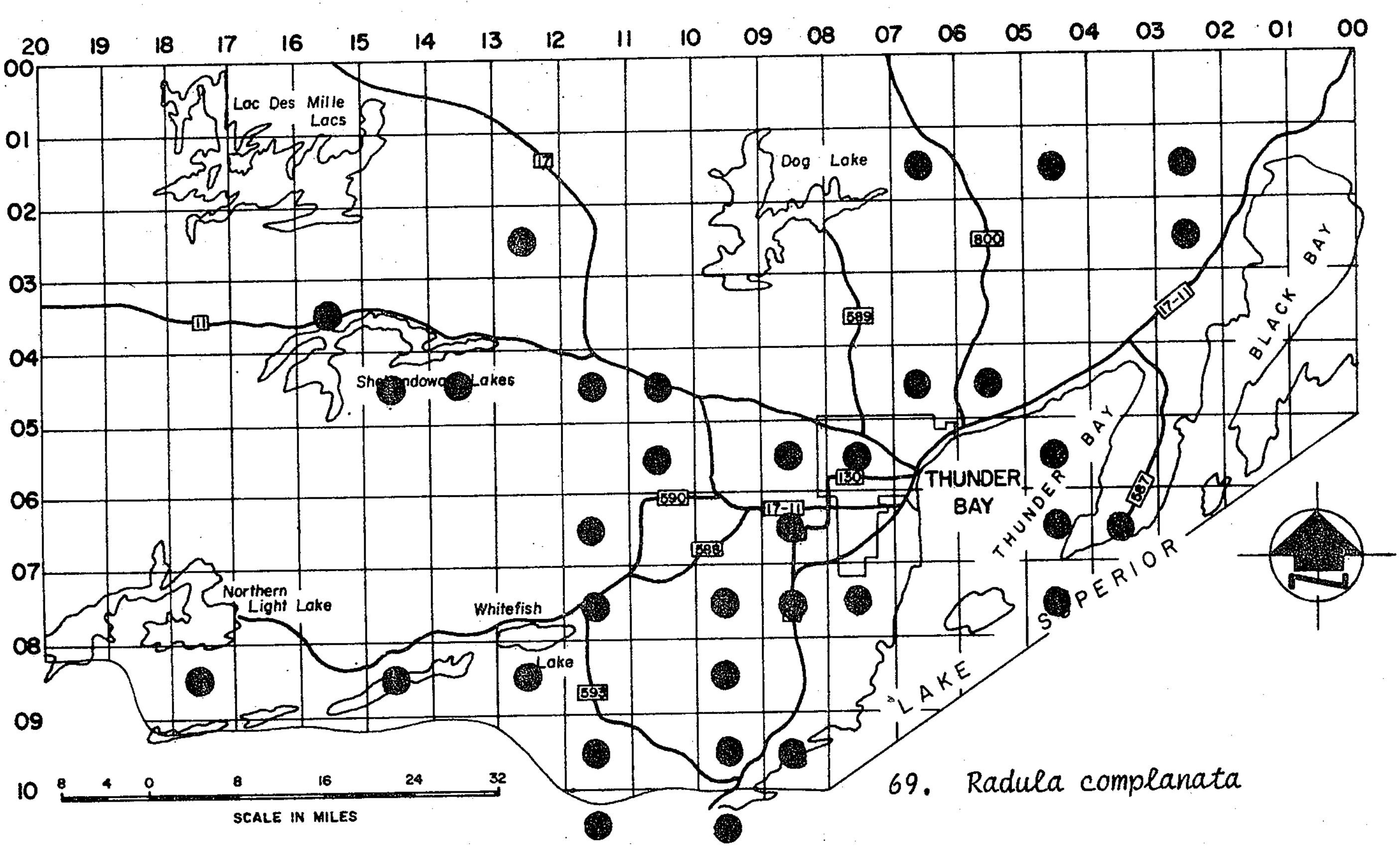
64. *Cephaloziella hampeana*



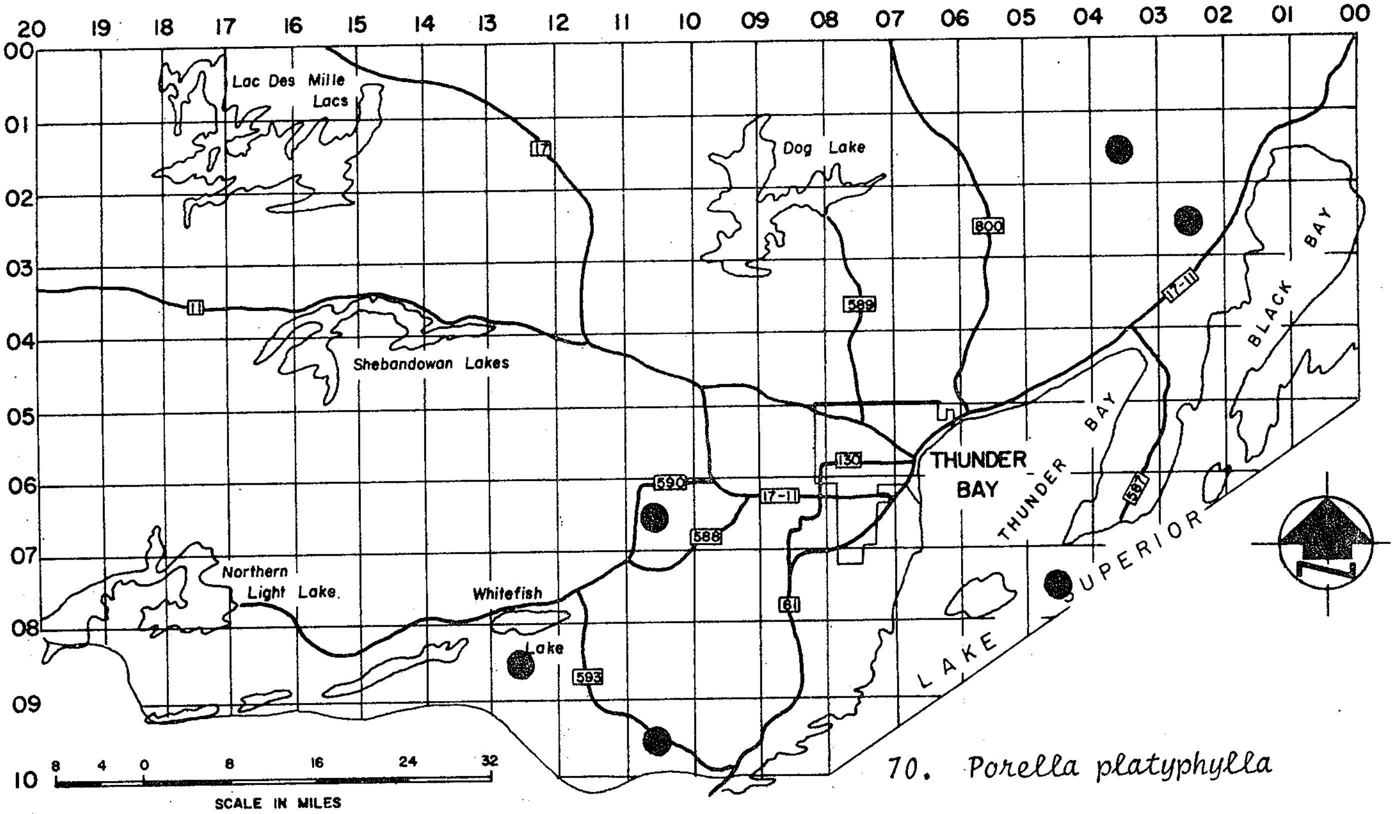
65. *Cephaloziella rubella*



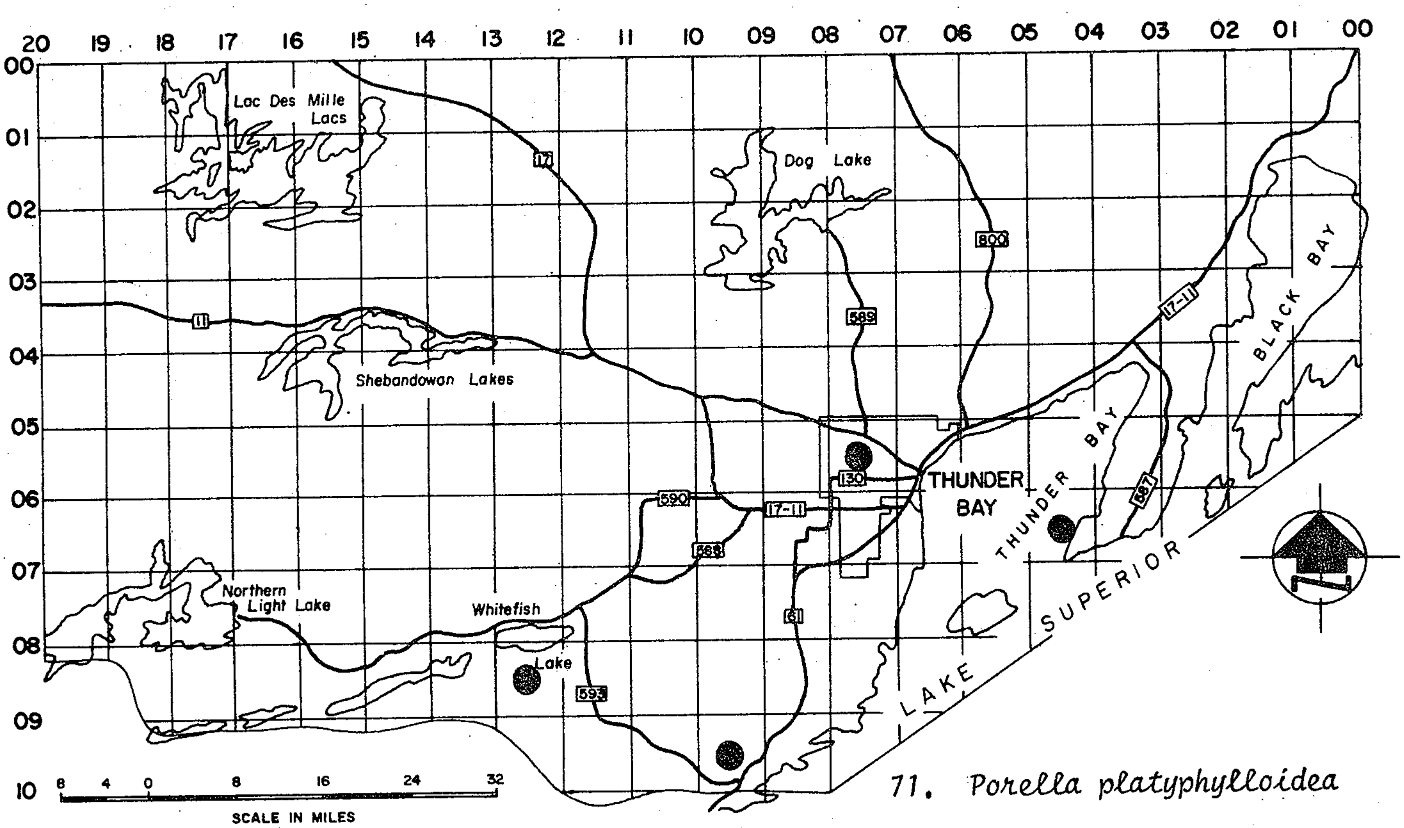
66. *Cephaloziella starkii*



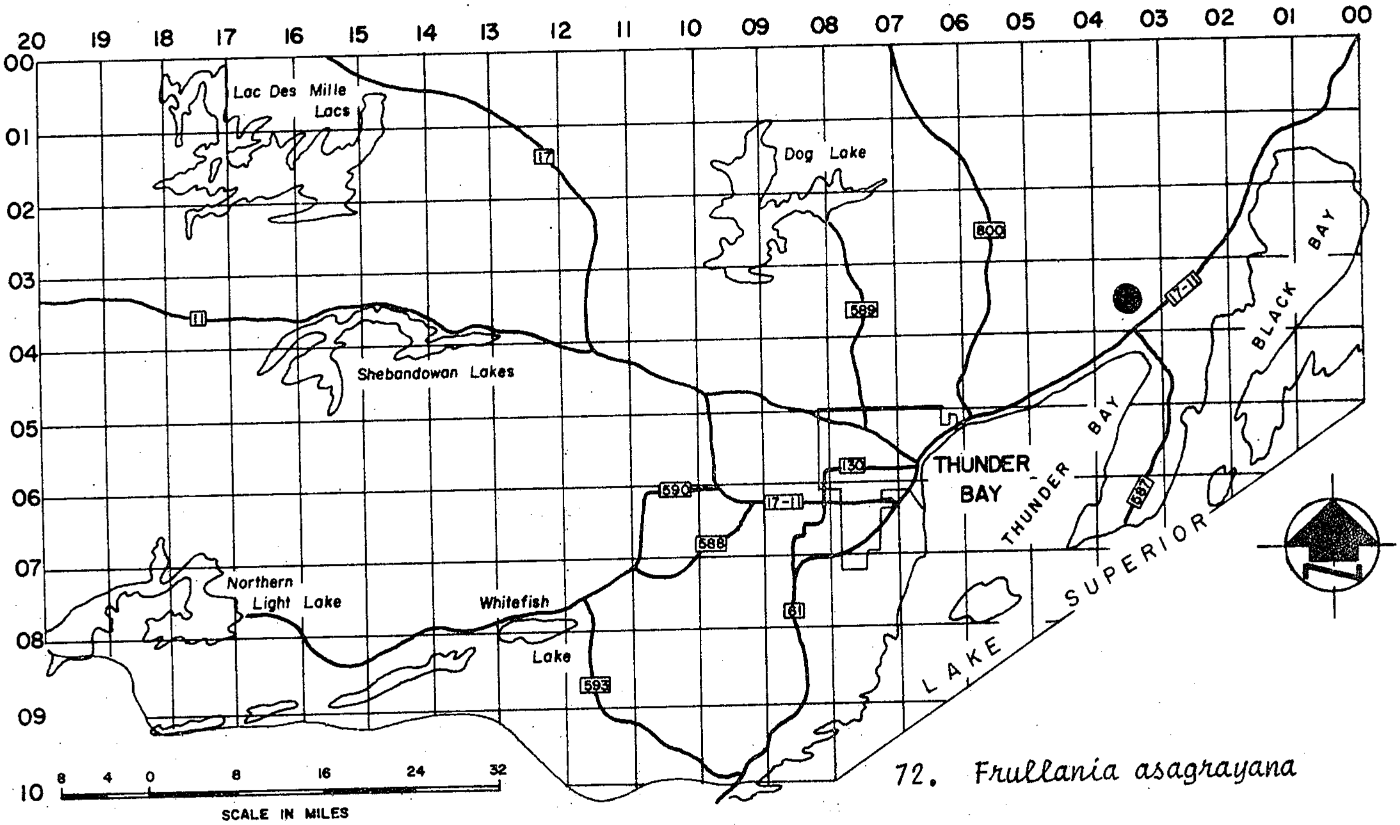
69. *Radula complanata*



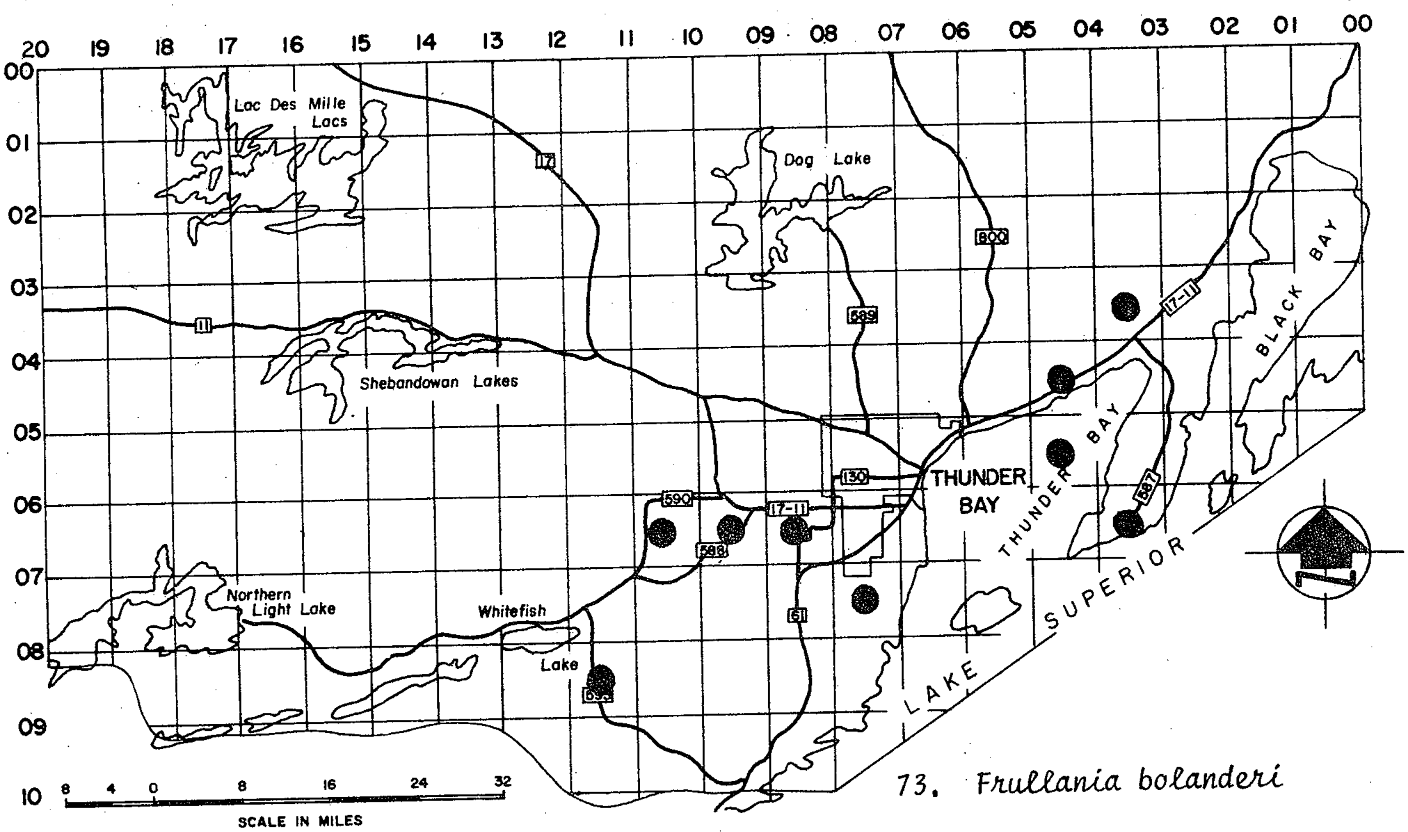
70. *Porella platyphylla*



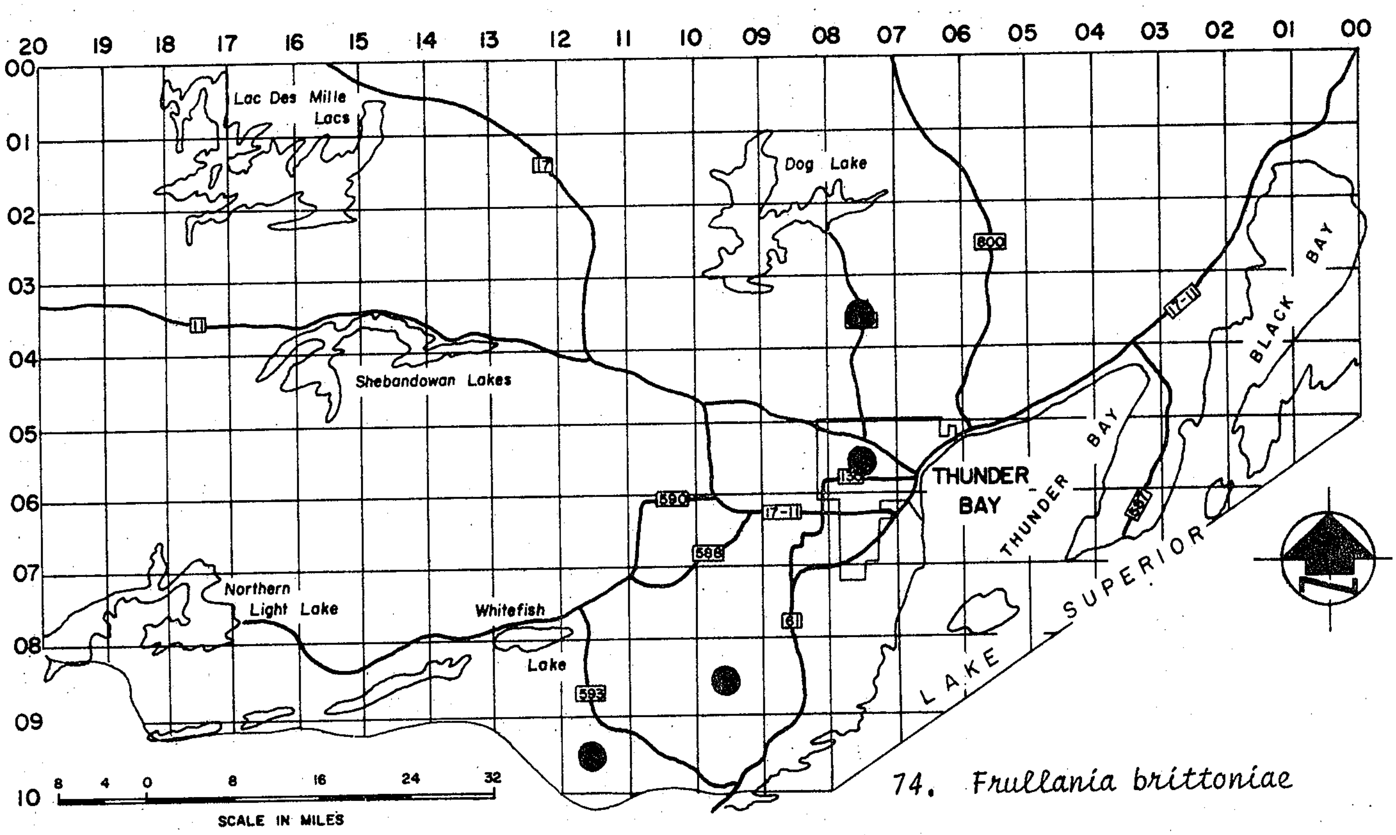
71. *Porella platyphylloidea*



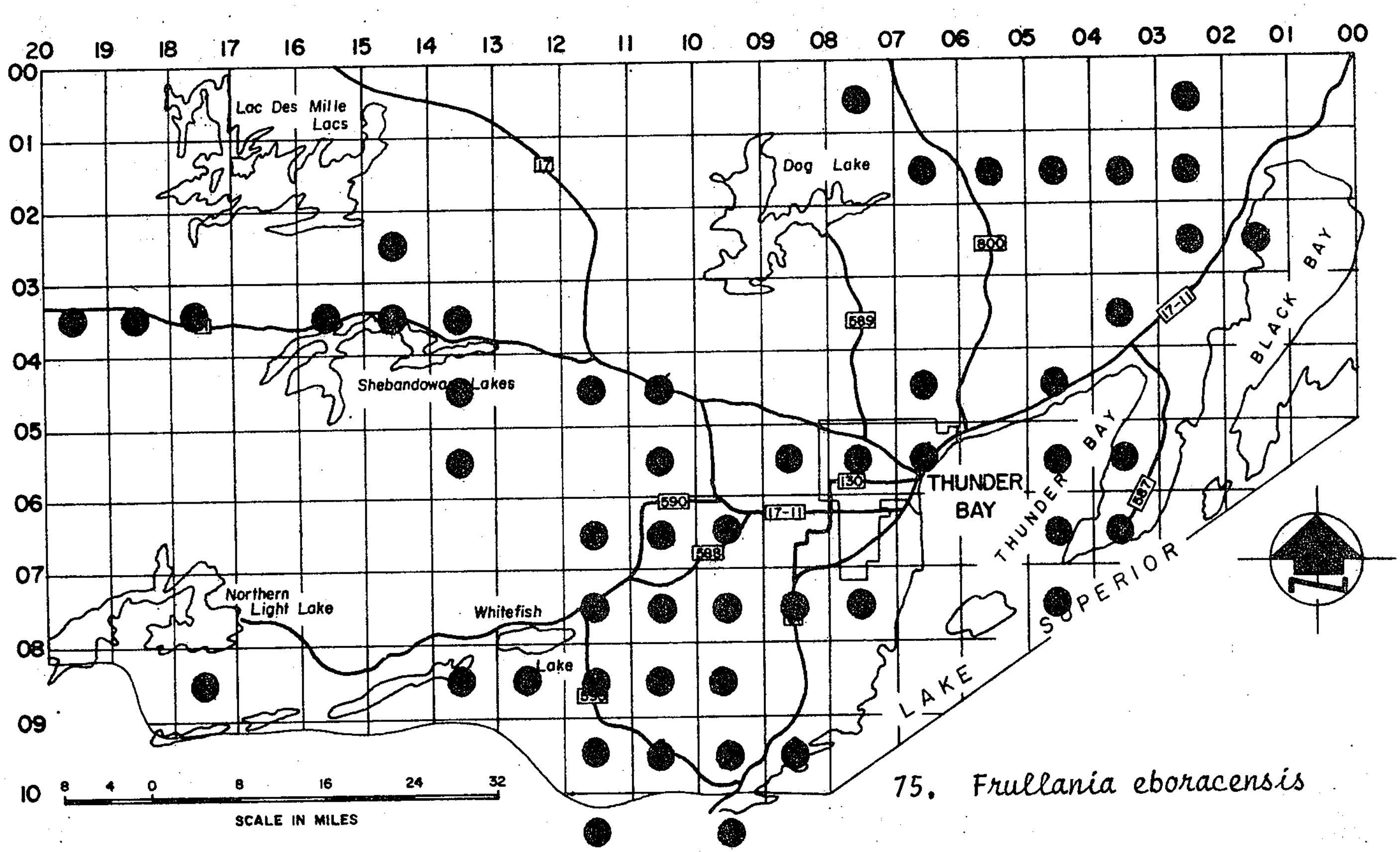
72. *Frullania asagrayana*



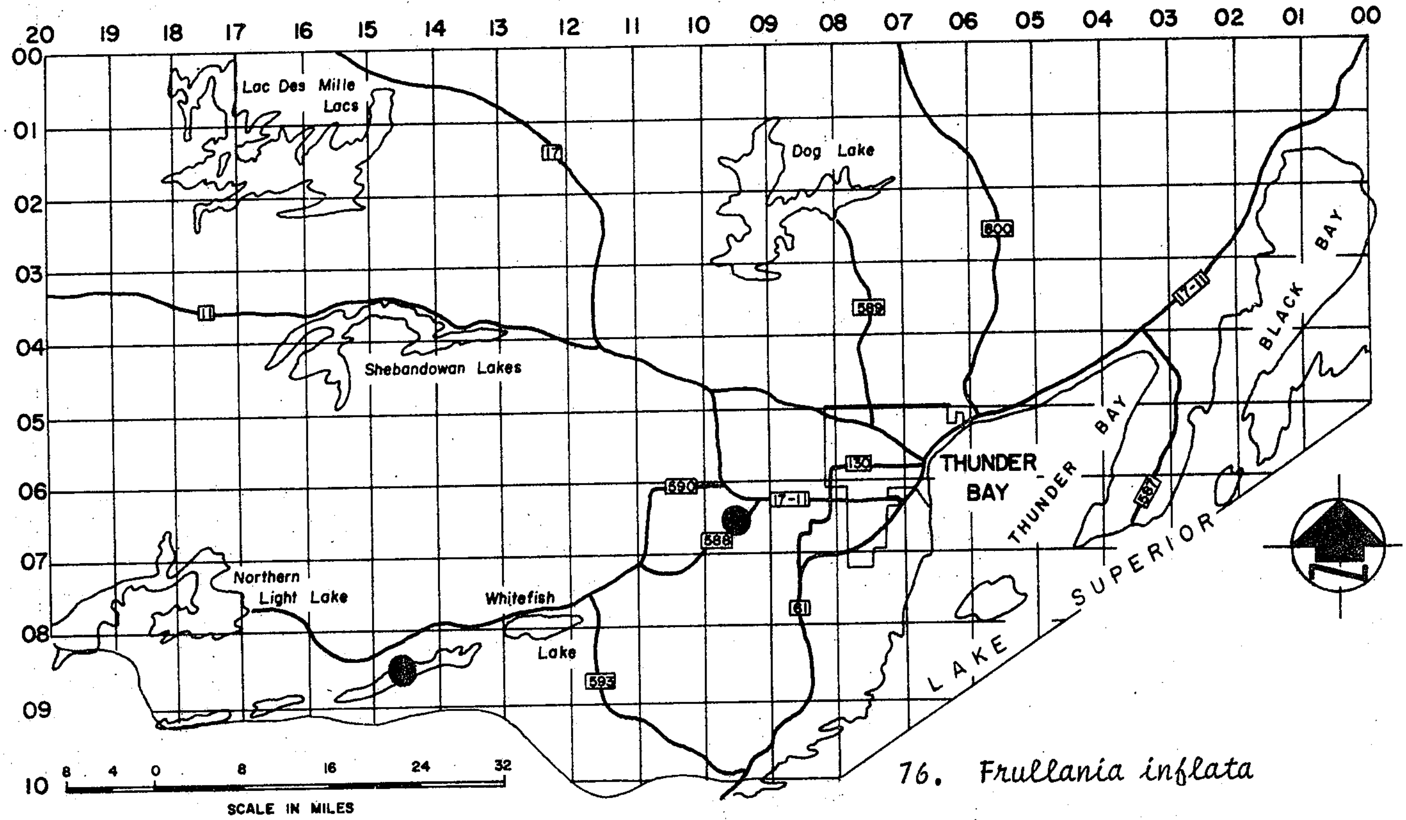
73. *Frullania bolanderi*



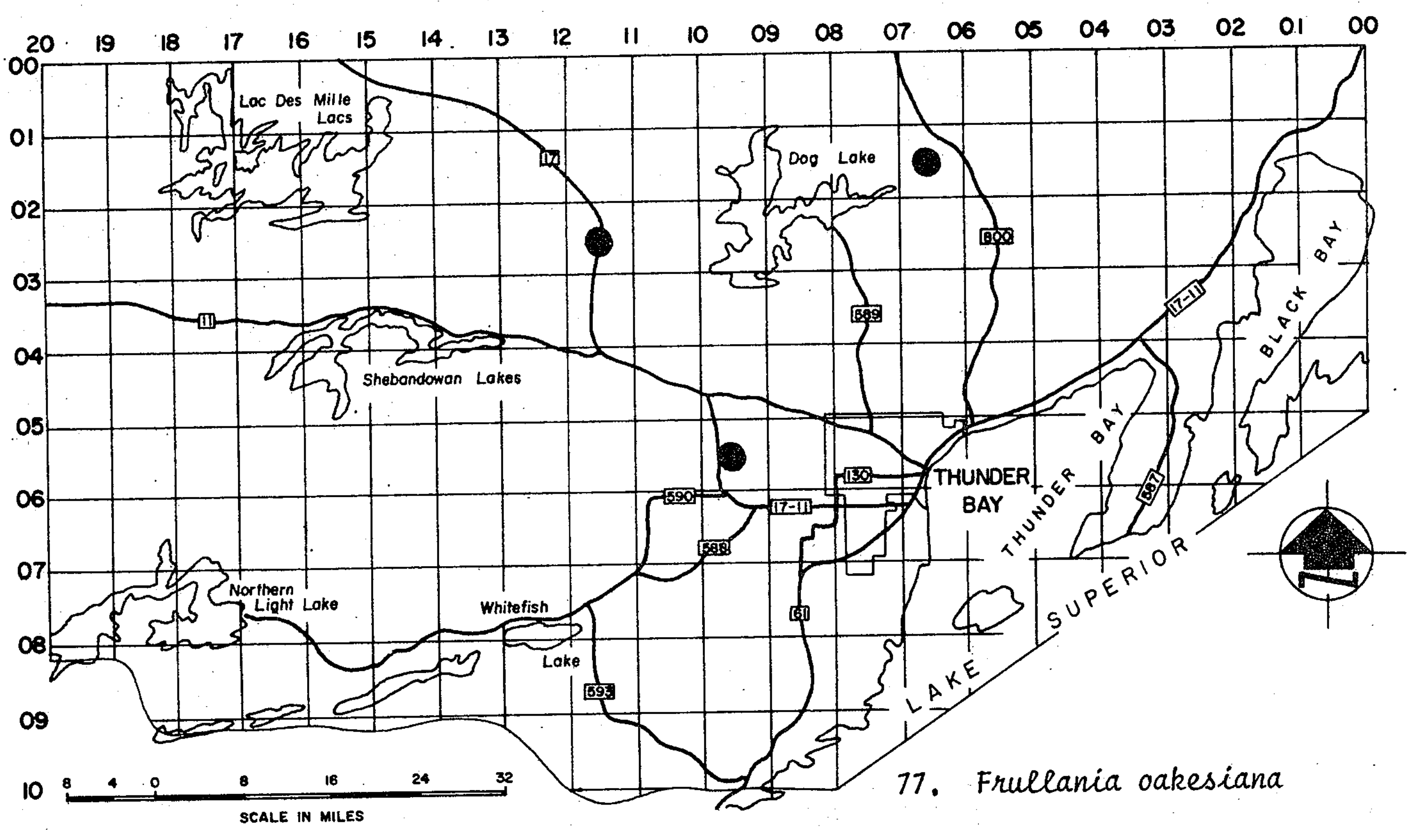
74. *Frullania brittoniae*



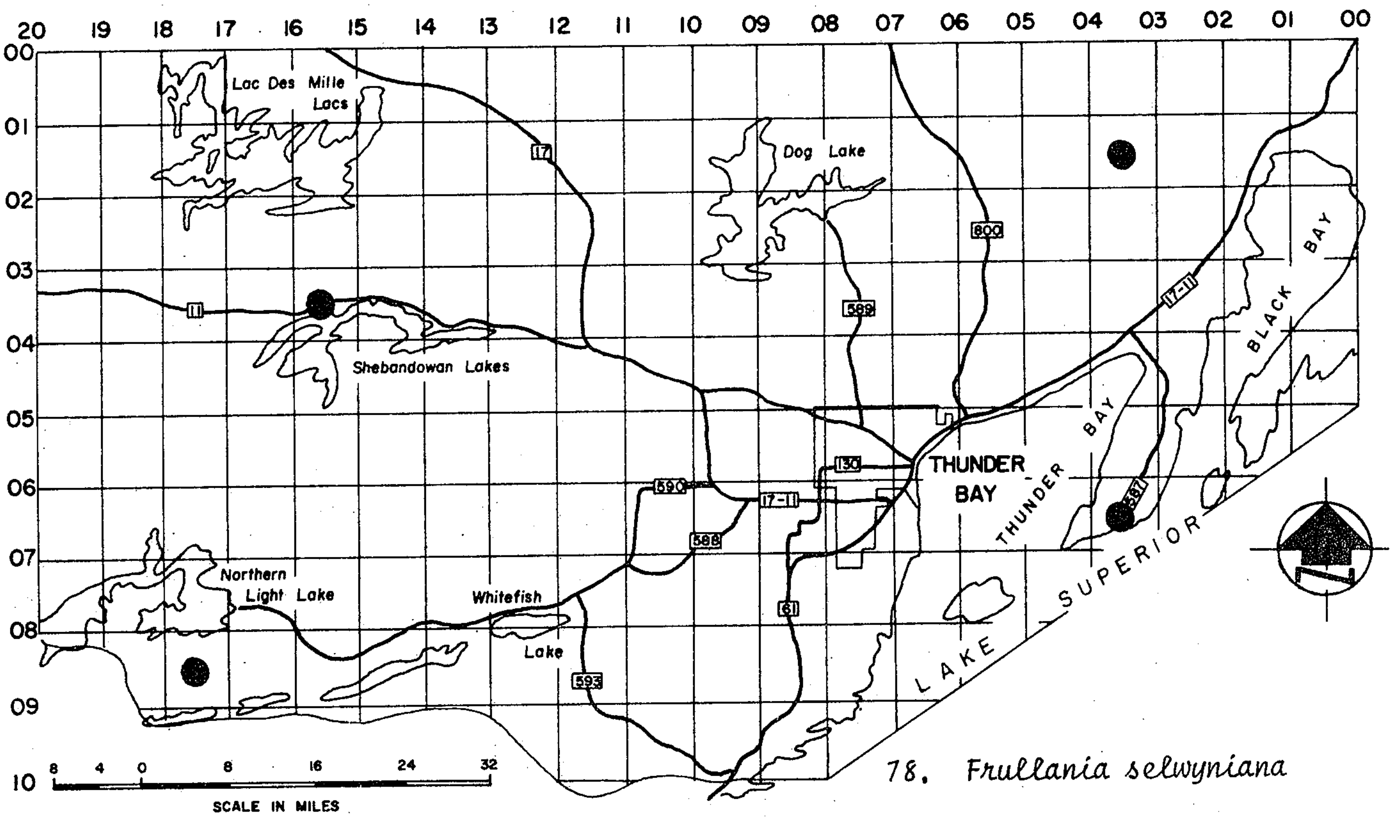
75. *Frullania eboracensis*



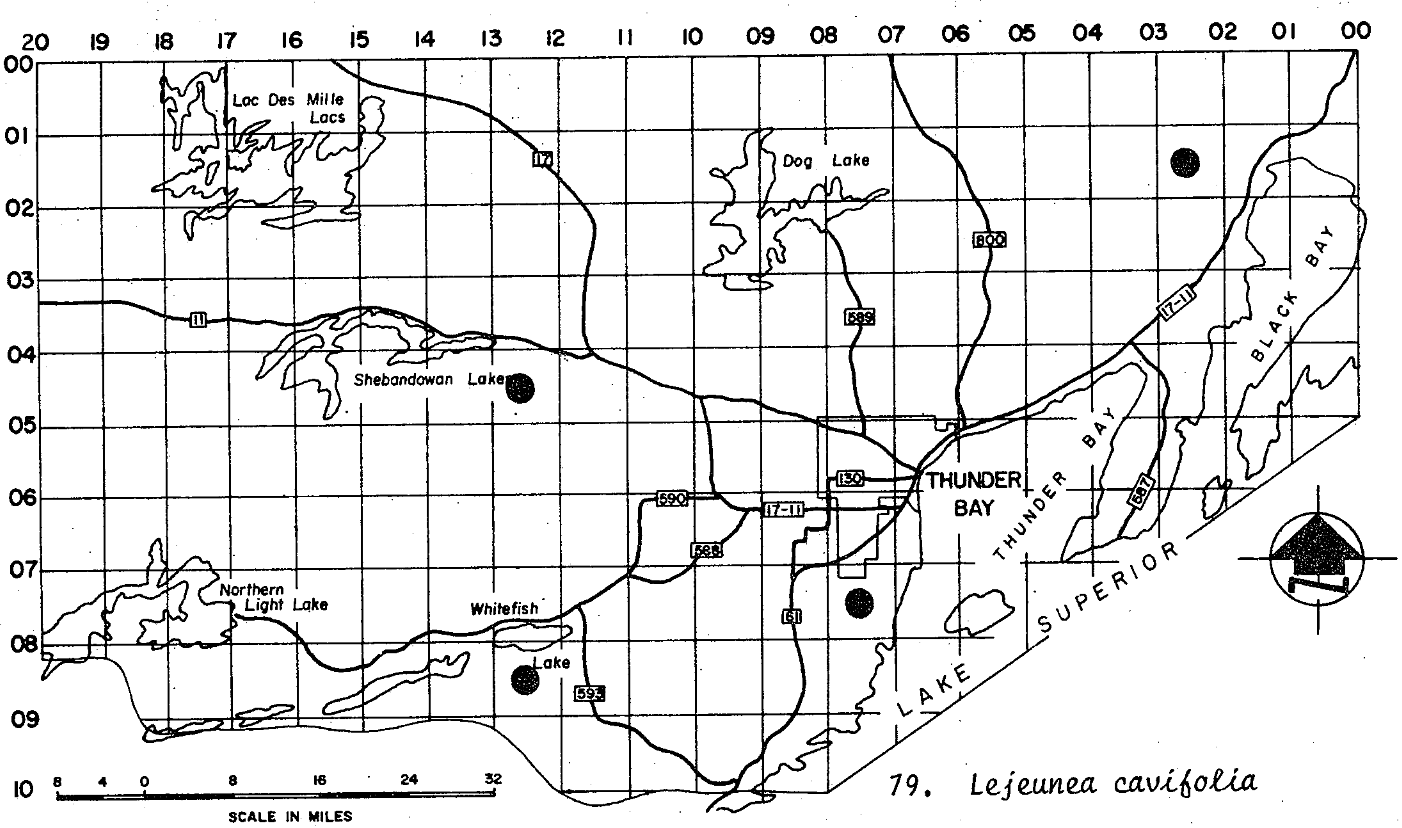
76. *Frullania inflata*



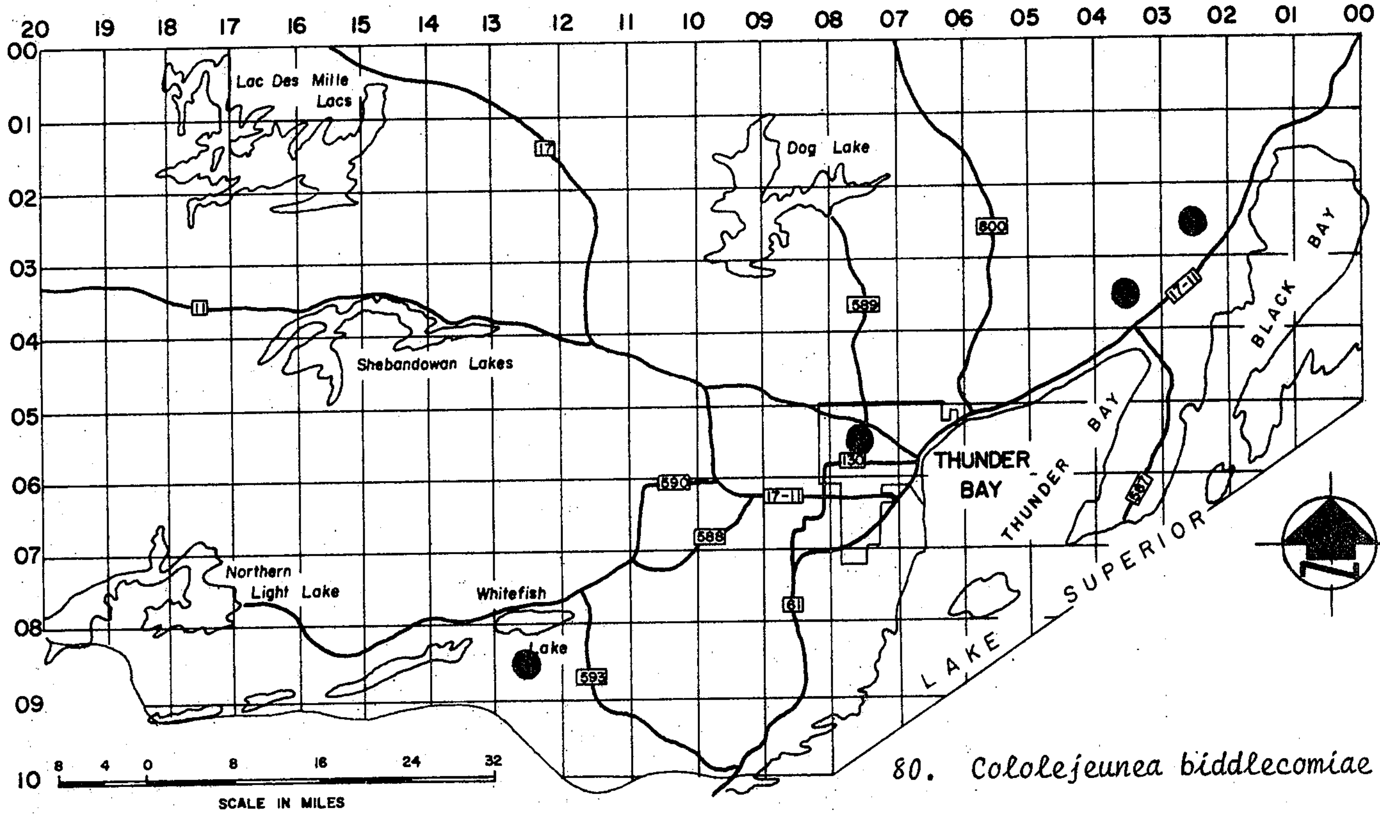
77. *Frullania oakesiana*



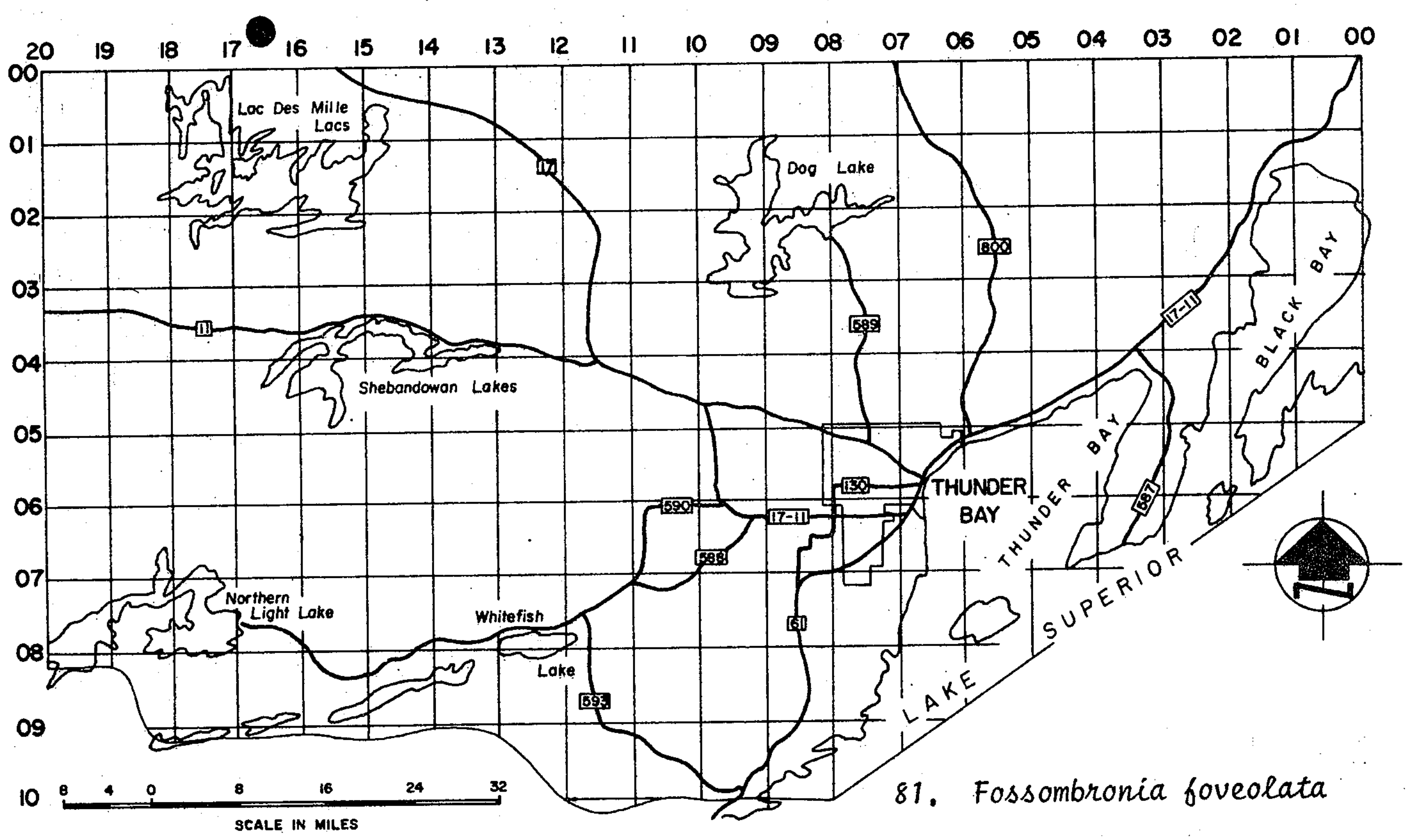
78. *Frullania selwyniana*



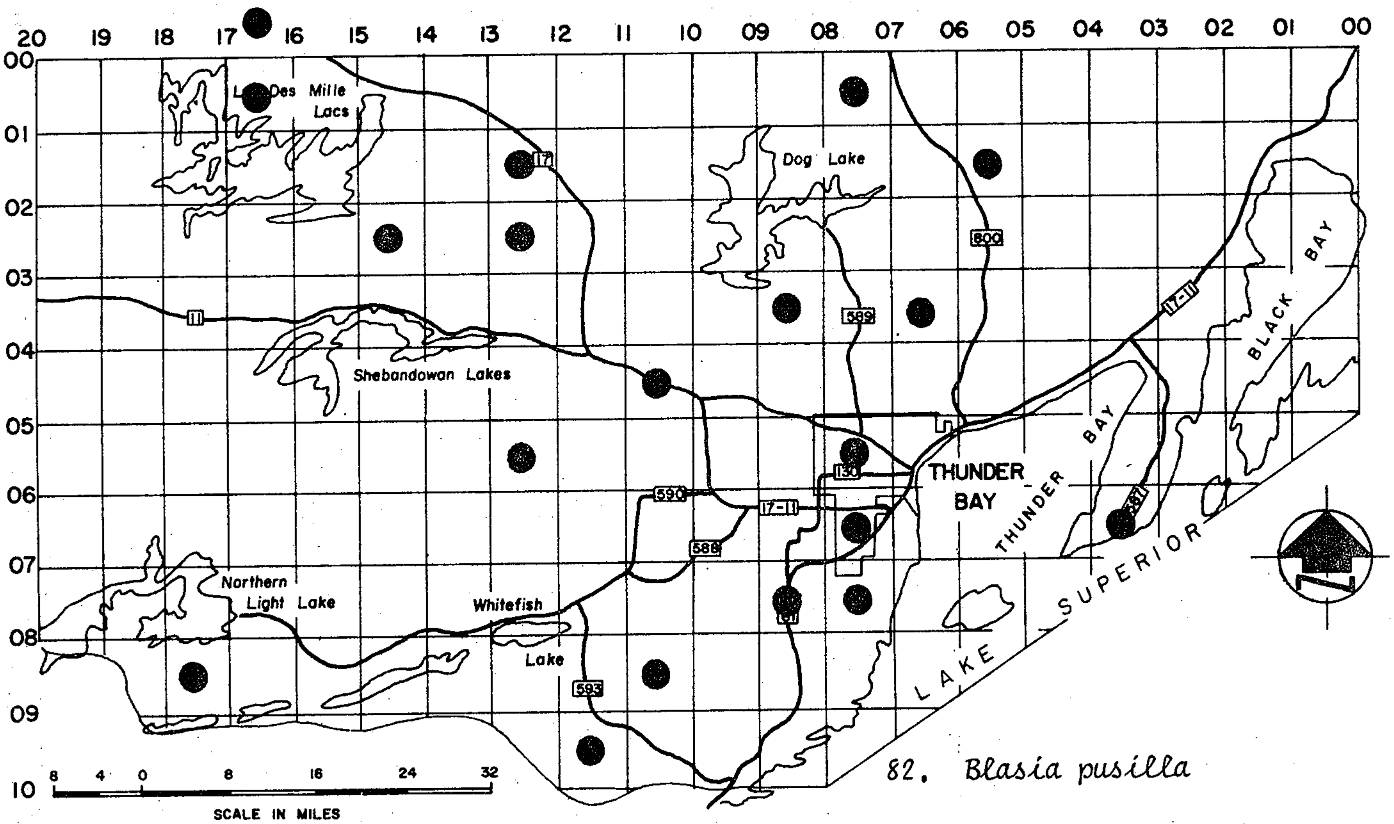
79. *Lejeunea cavifolia*



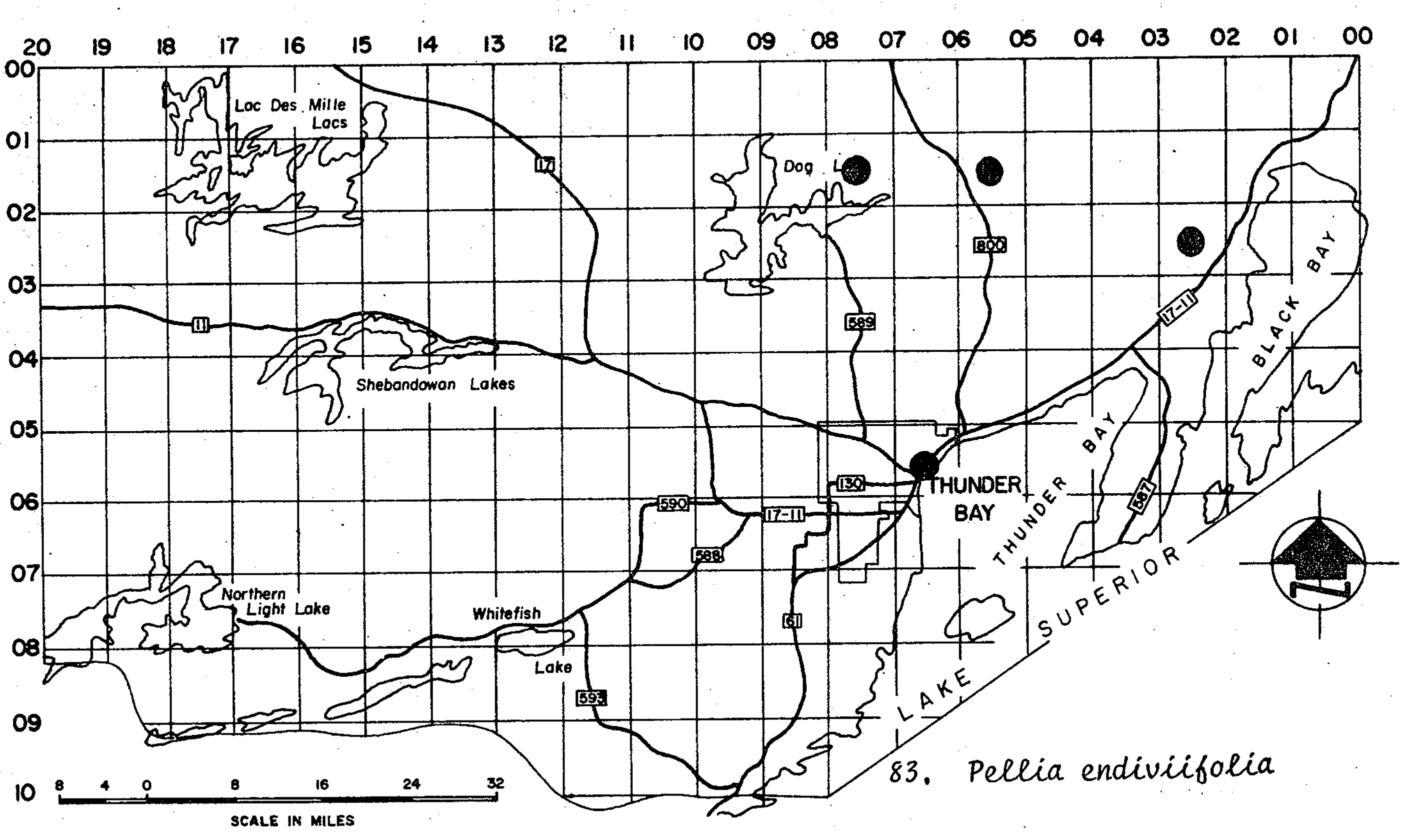
80. *Cololejeunea biddlecomiae*



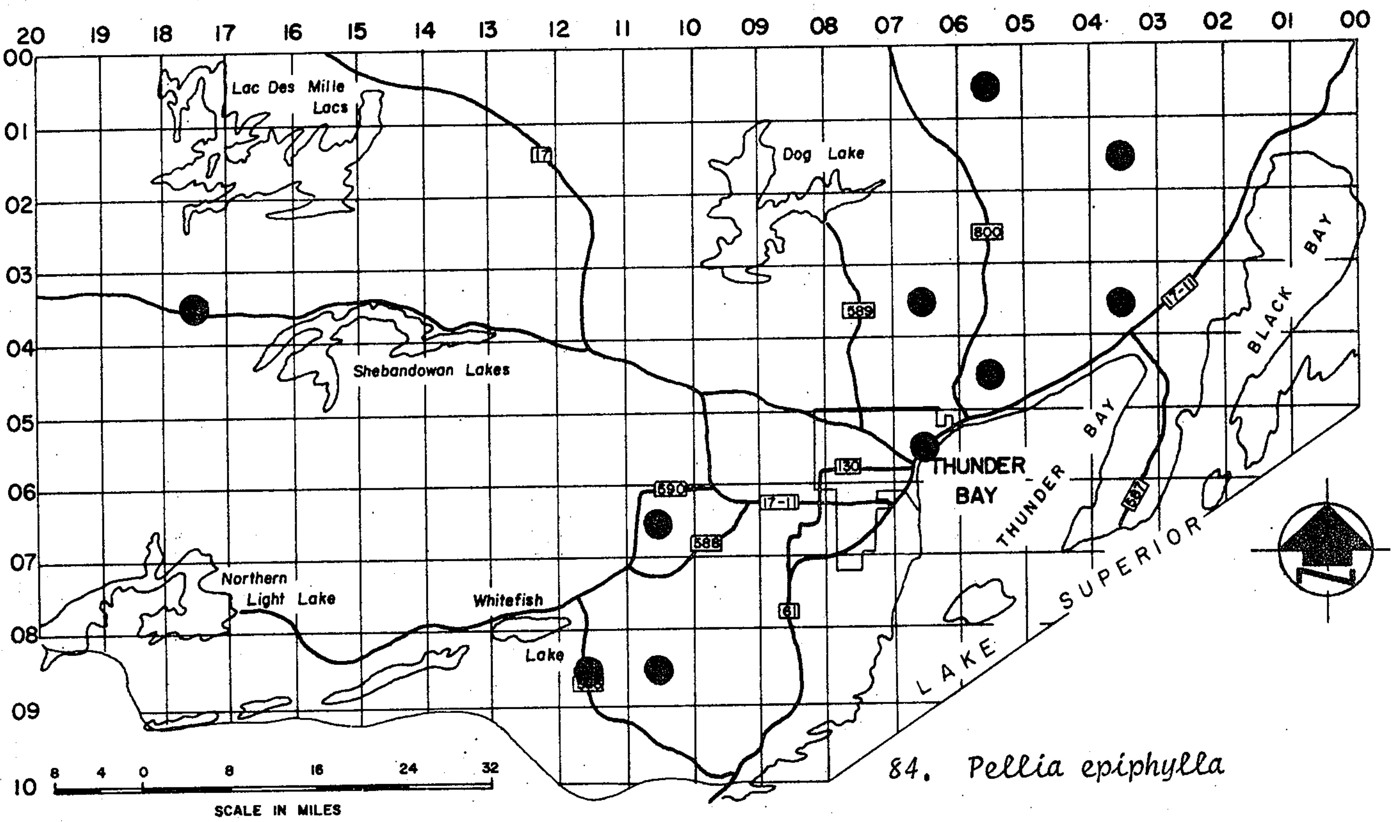
81. *Fossombronia foveolata*



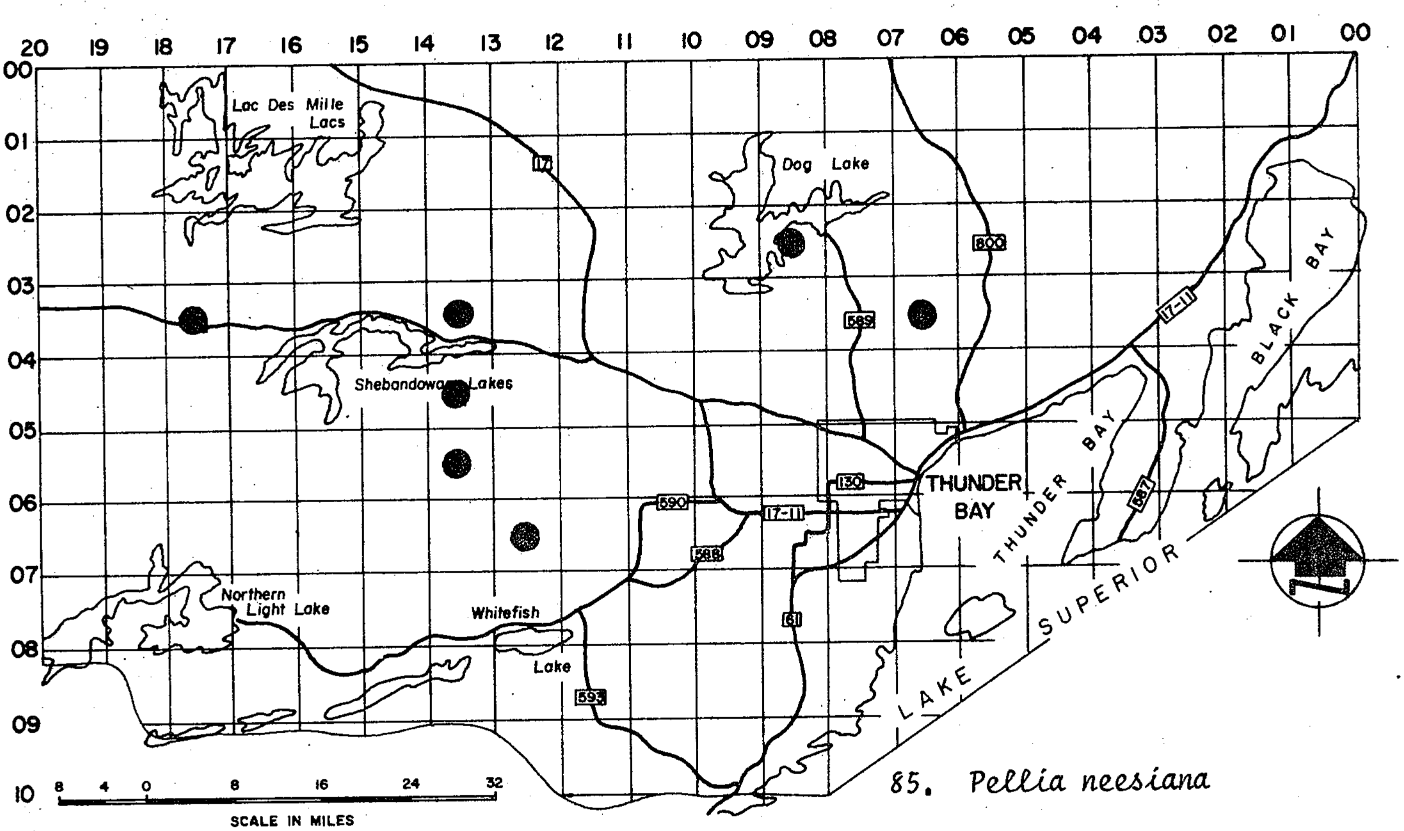
82. *Blasia pusilla*



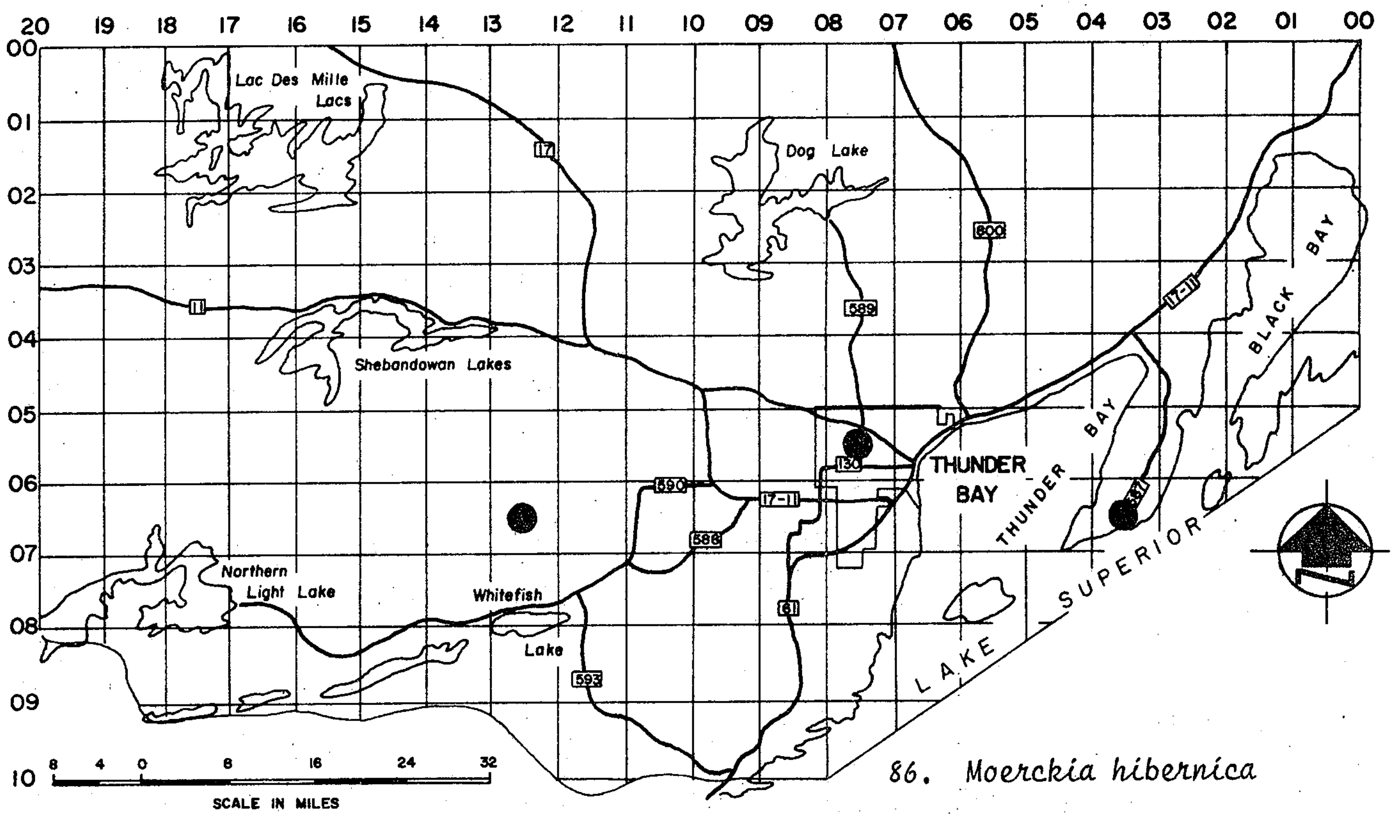
83. *Pellia endiviifolia*



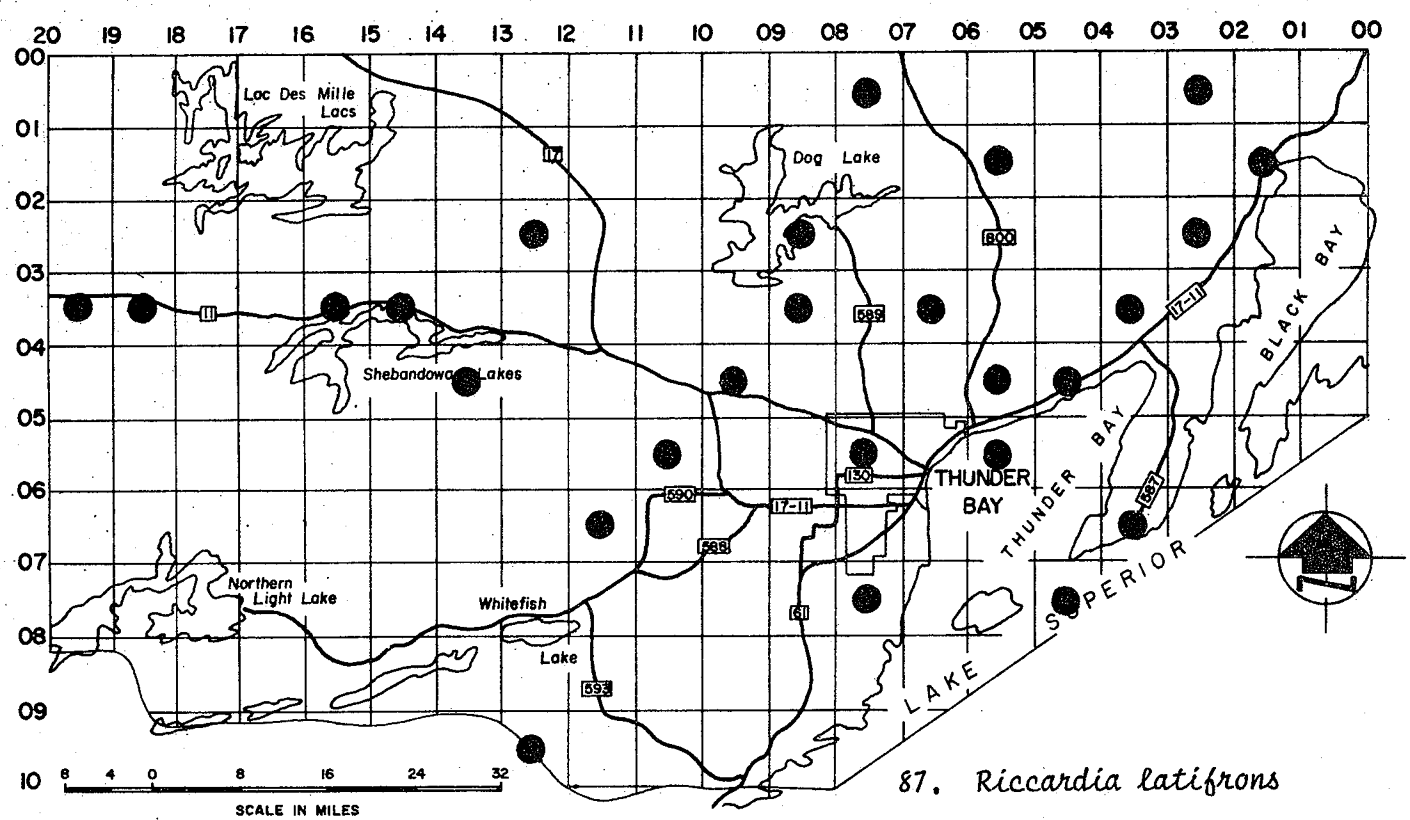
84. *Pellia epiphylla*



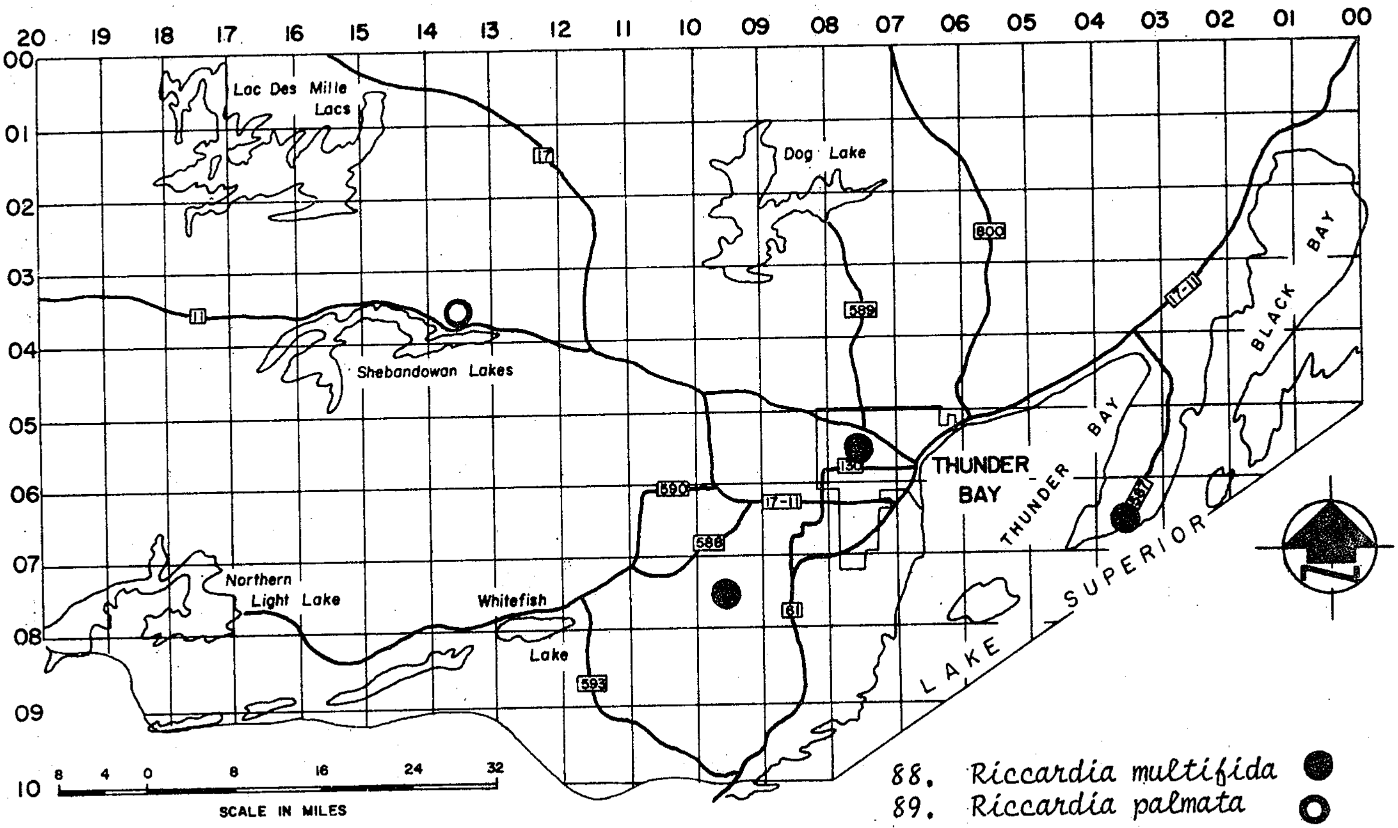
85. *Pellia neesiana*



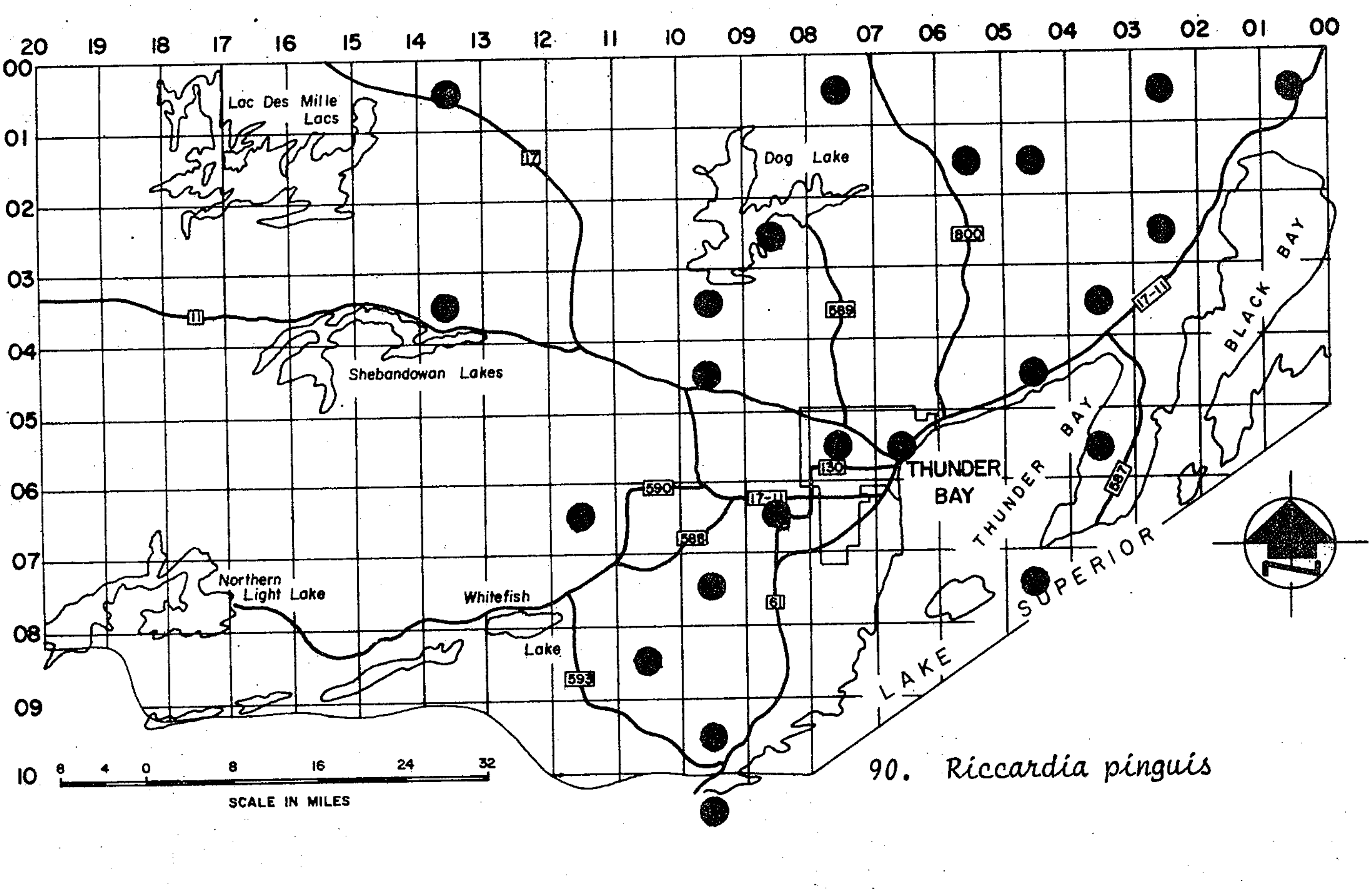
86. *Moerckia hibernica*



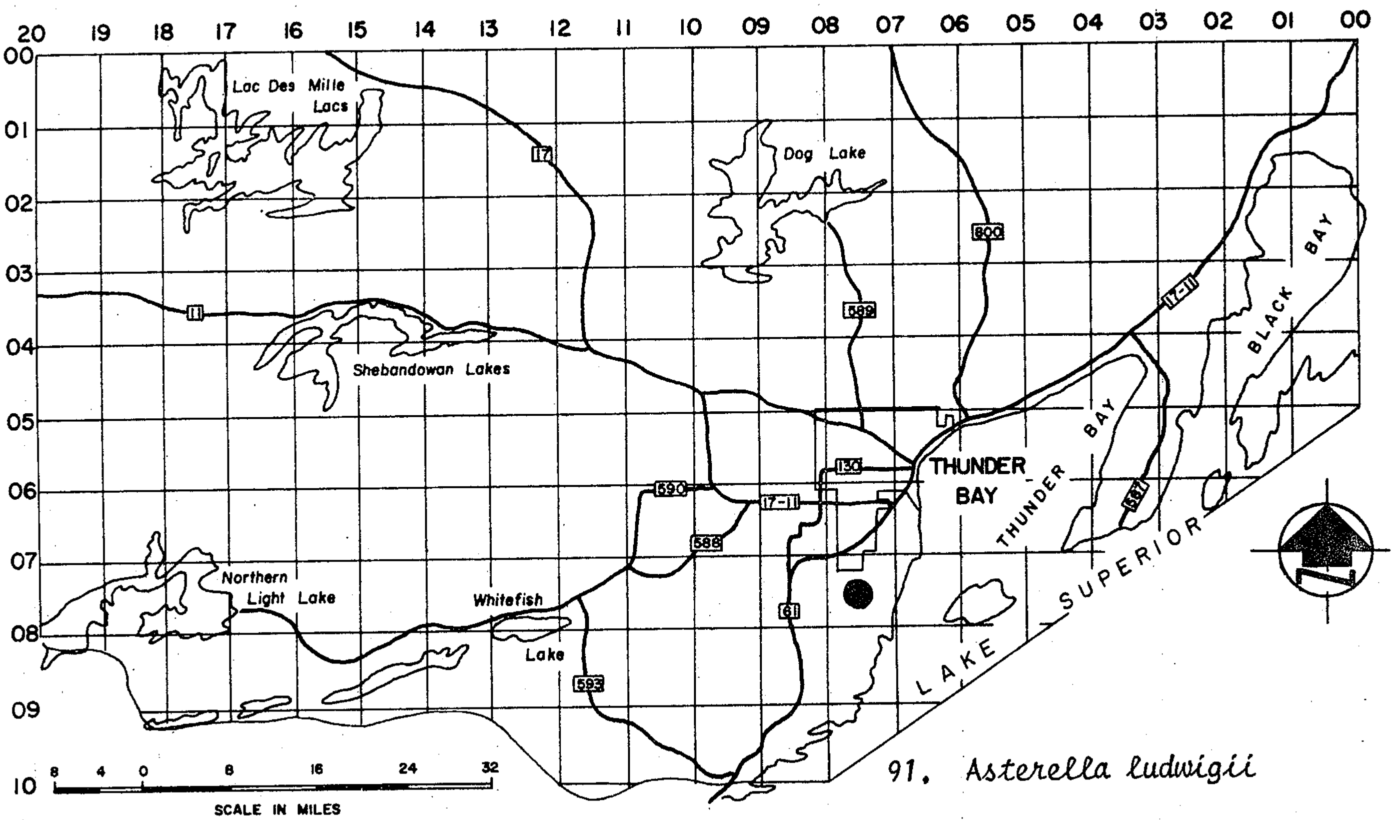
87. *Riccardia latifrons*



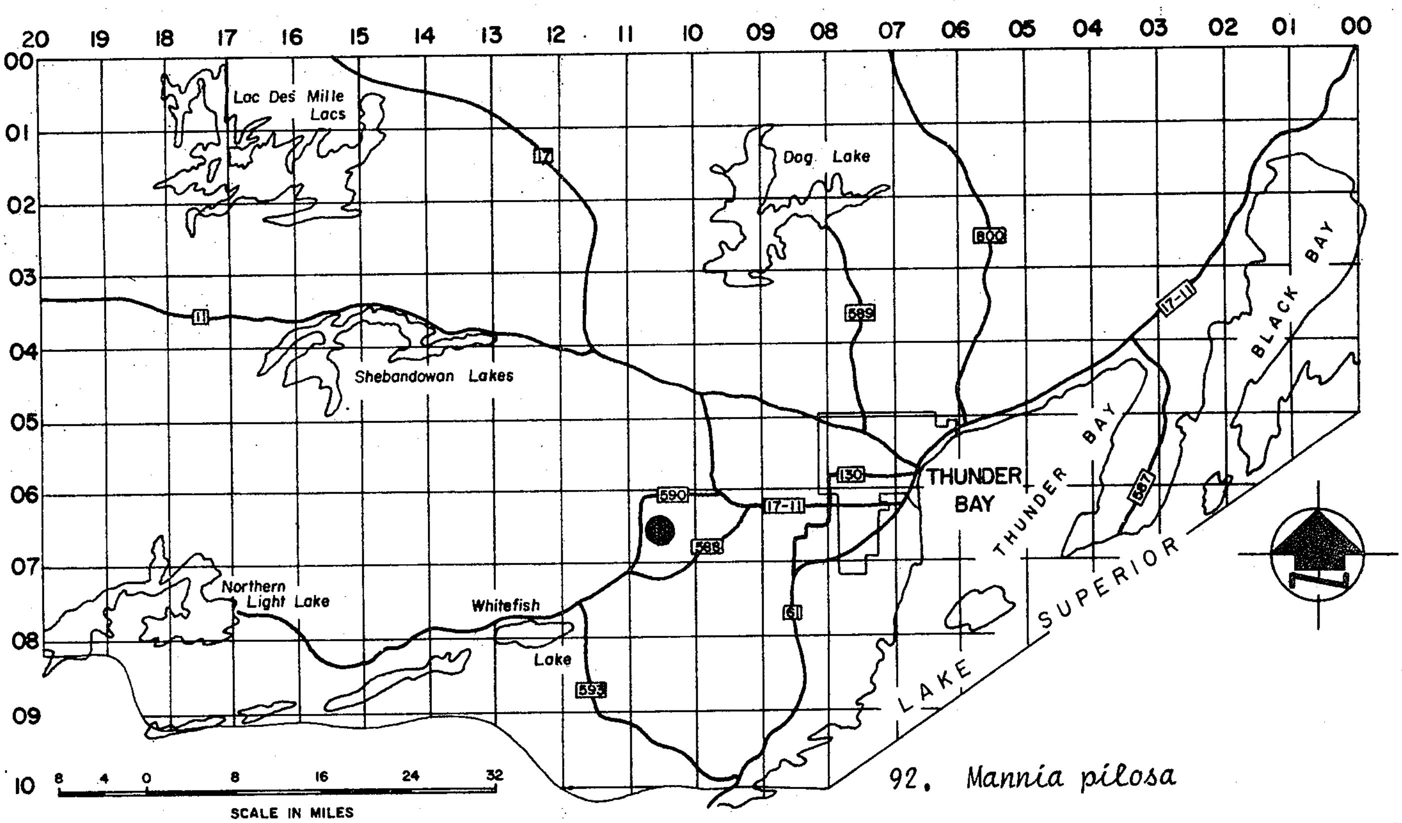
88. *Riccardia multifida* ●
89. *Riccardia palmata* ○



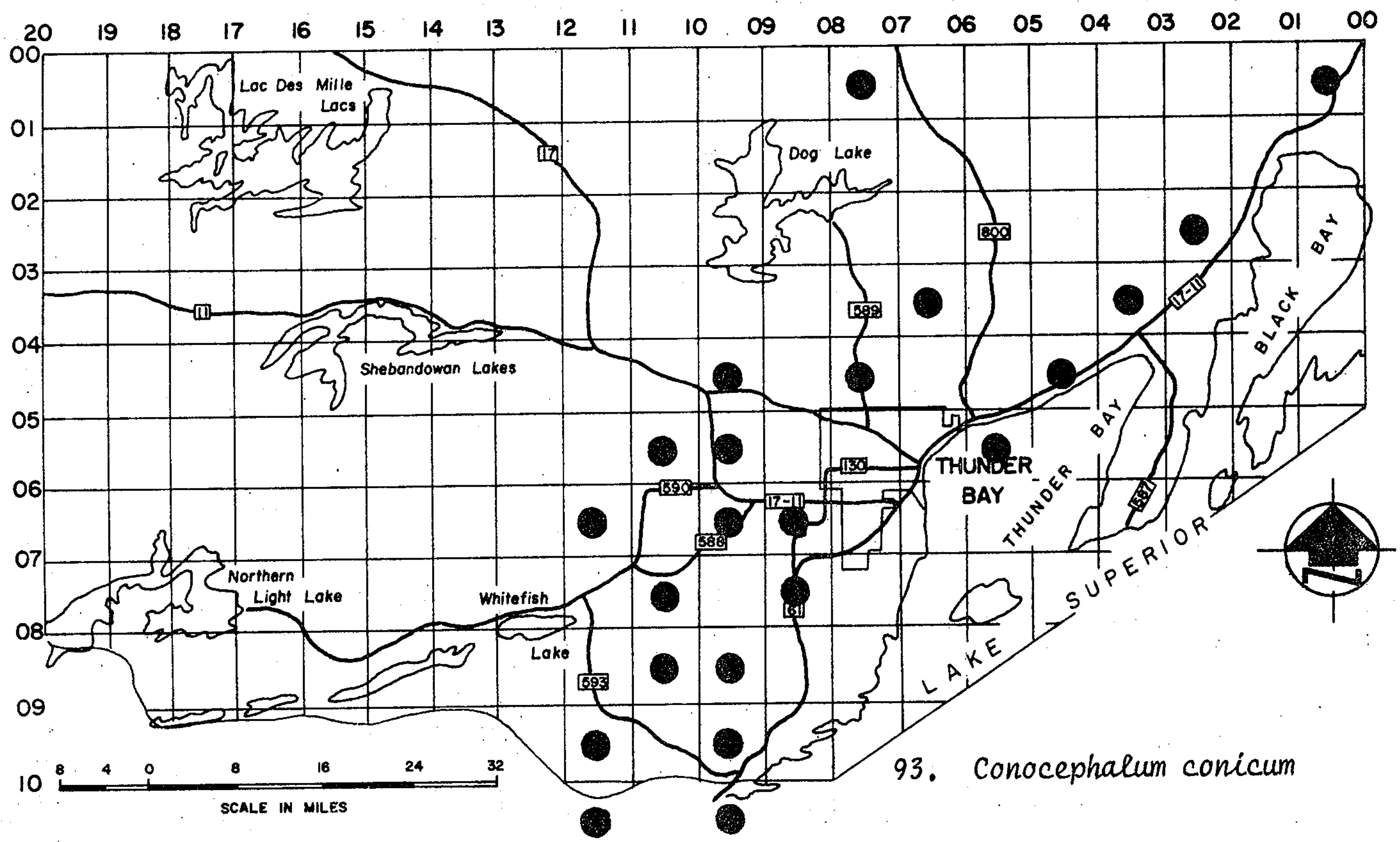
90. *Riccardia pinguis*



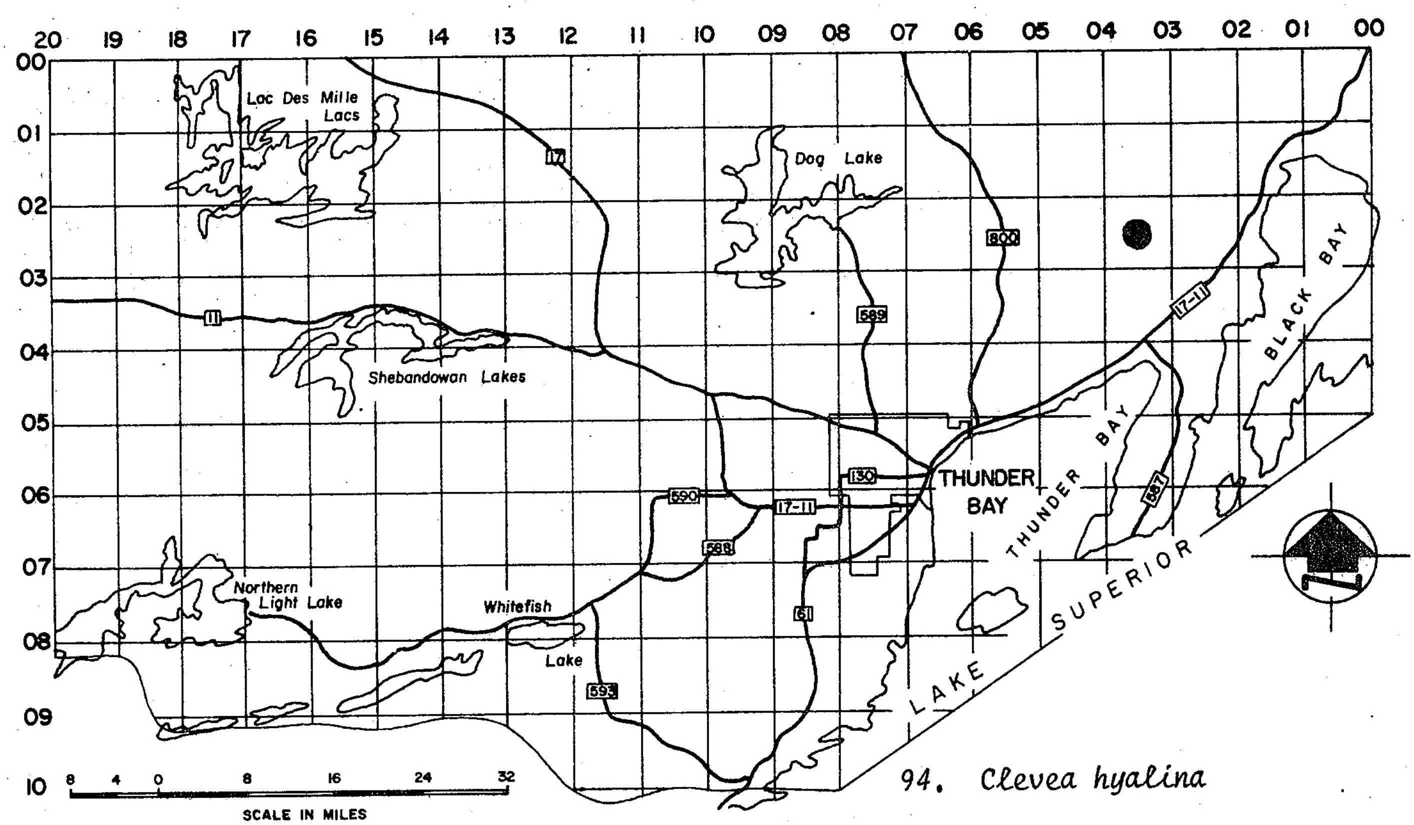
91. *Asterella ludwigii*



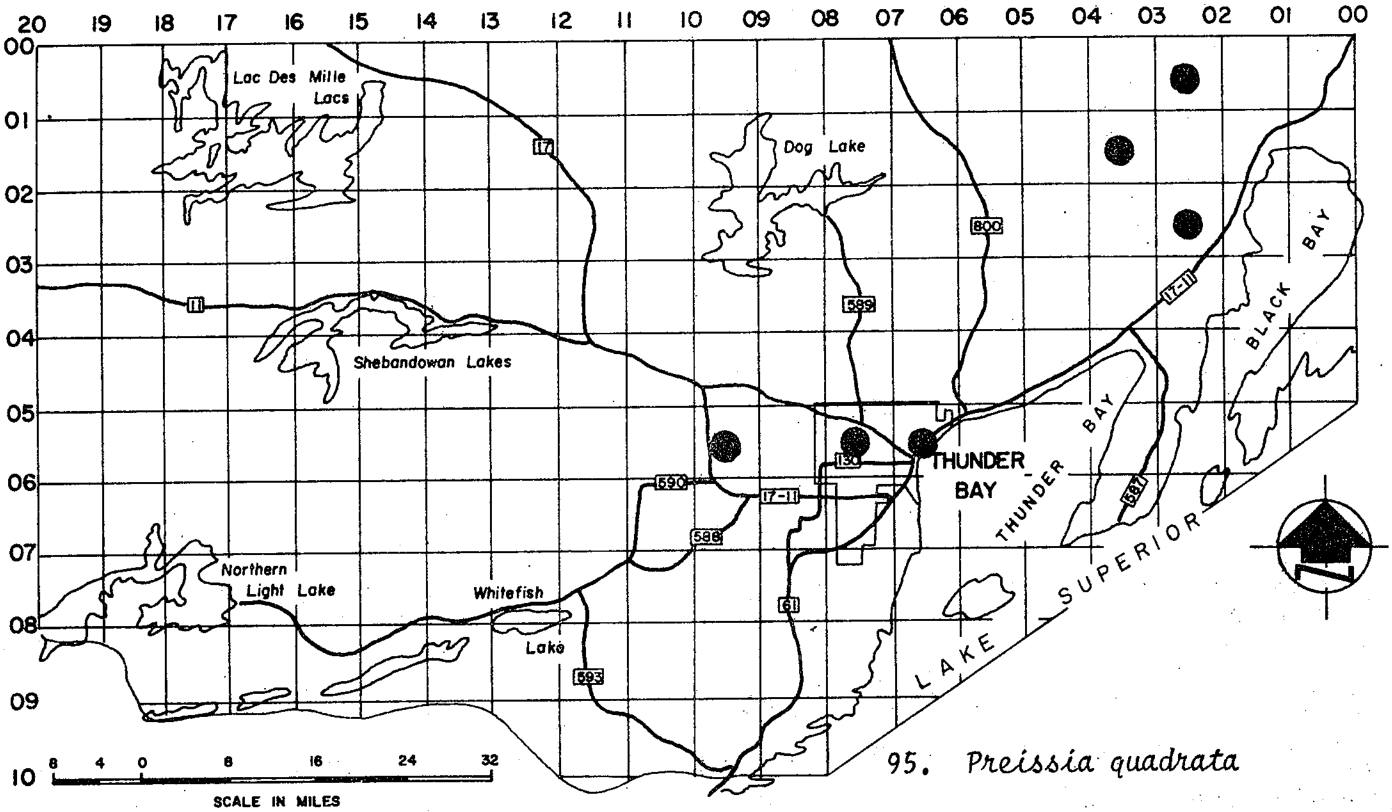
92. *Mannia pilosa*



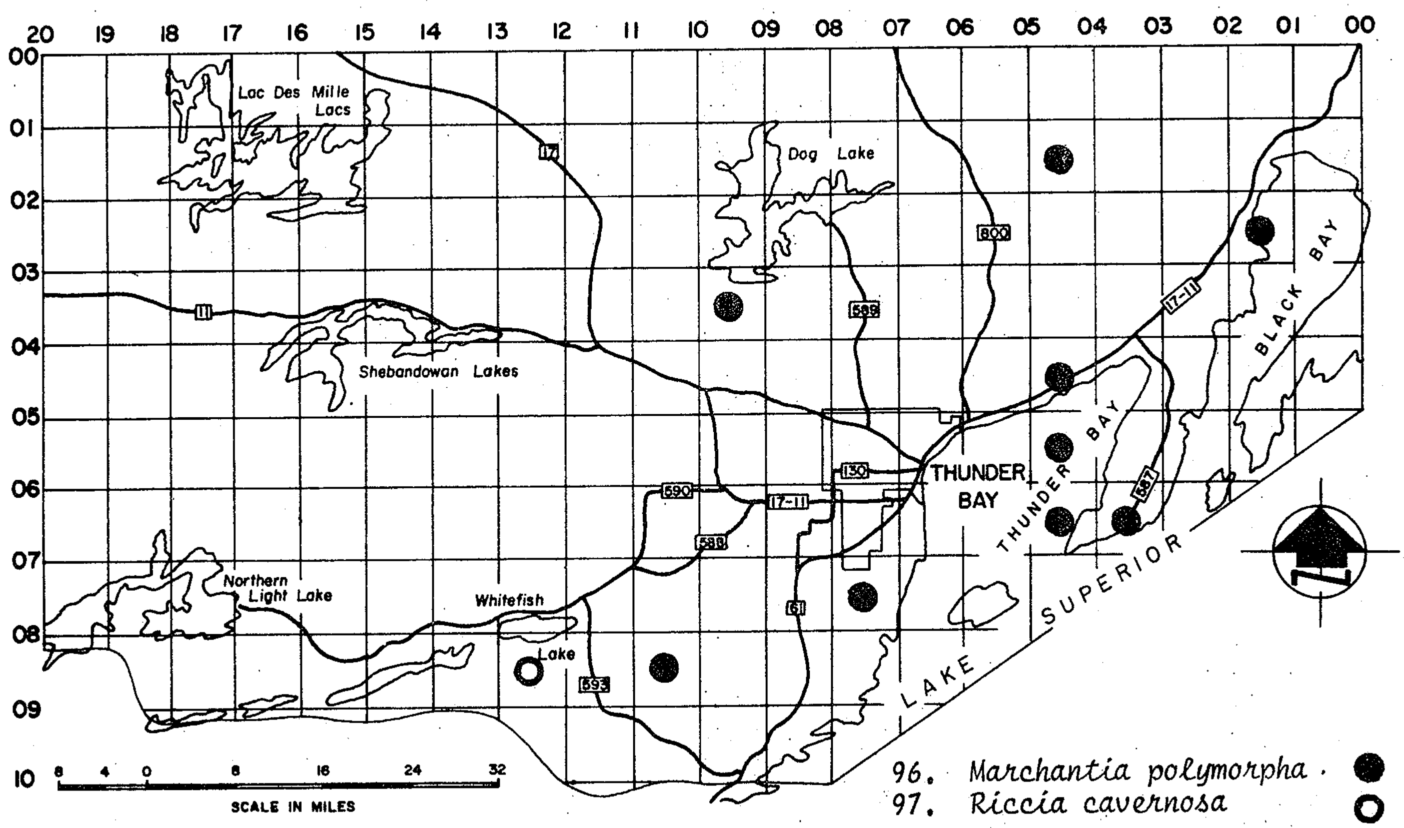
93. *Conocephalum conicum*



94. *Clevea hyalina*



95. *Preissia quadrata*



96. *Marchantia polymorpha* · ●
97. *Riccia cavernosa* ○

APPENDIX V

TOPOGRAPHICAL SURVEY MAPS 52A AND 52B, AND ROAD MAP OF ONTARIO

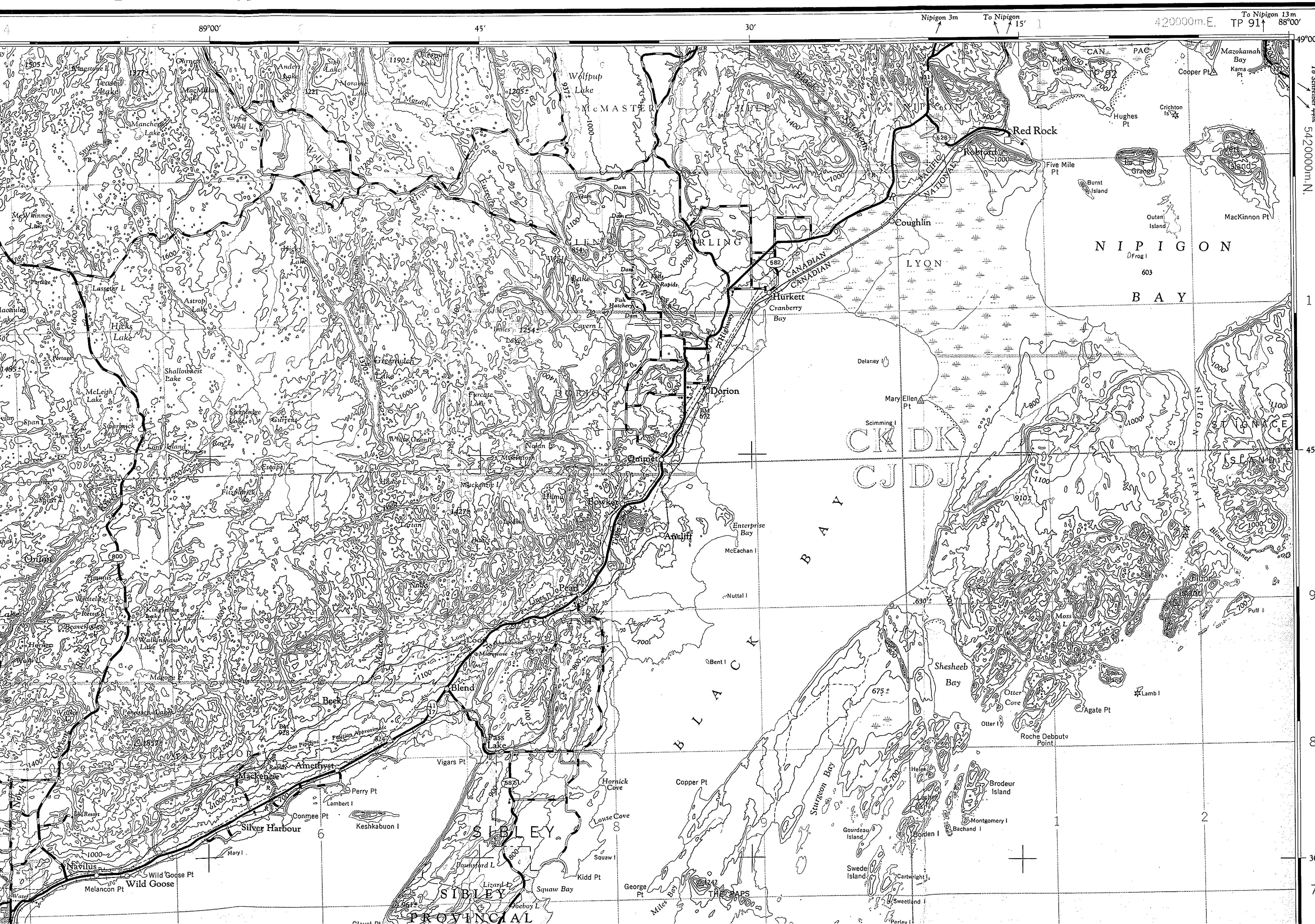
APPENDIX VI

A CHECKLIST OF THE HEPATICS IN THE AREA ADJACENT TO THE CANADIAN LAKEHEAD, BY J. M. CROWE AND P. BARCLAY-ESTRUP. BRYOLOGIST 74: 36-39, 1971.

CANADA

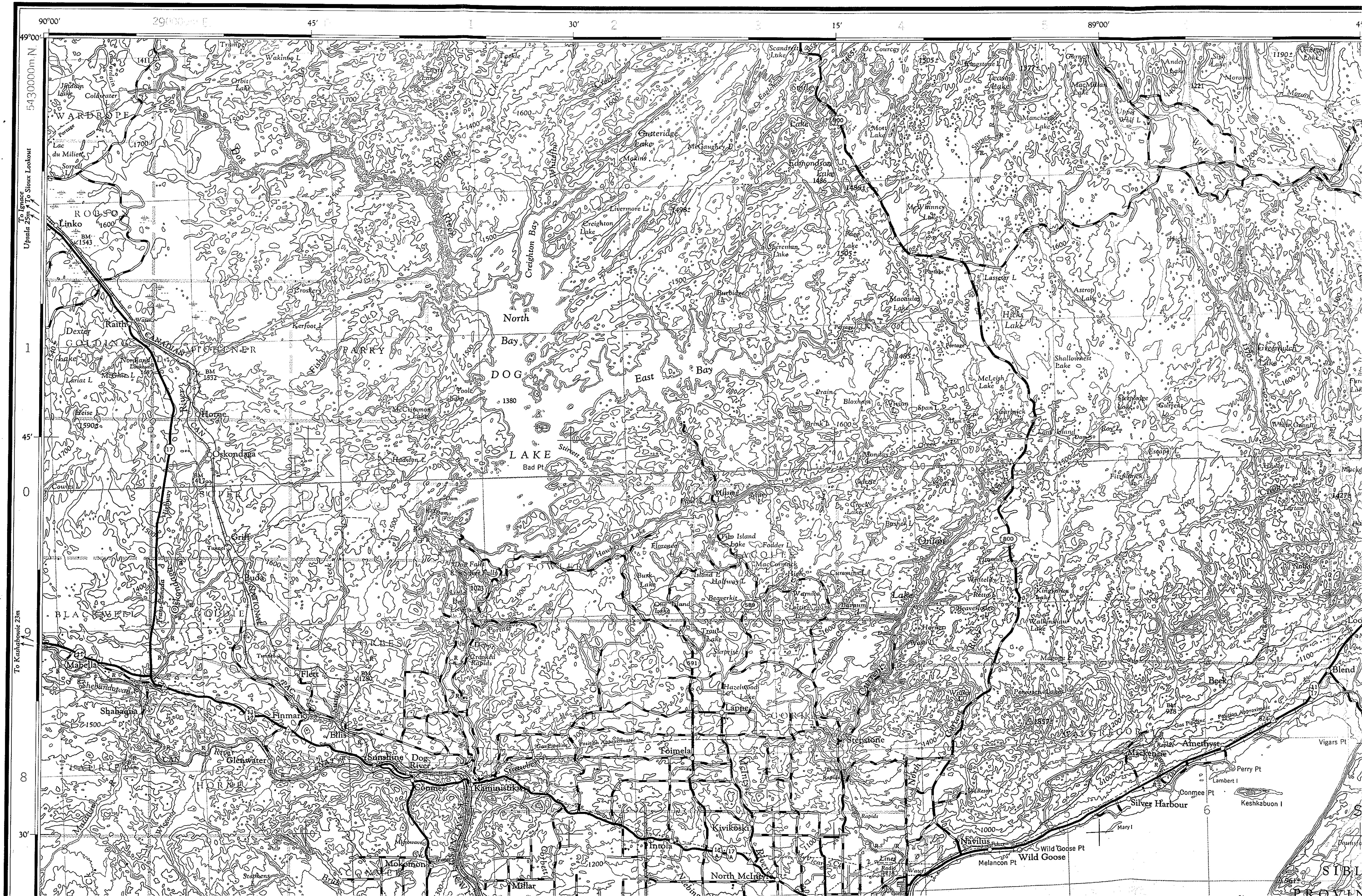
EDITION 1

Refer to this map as: 52 A EDITION 1 ASE SERIES A 501

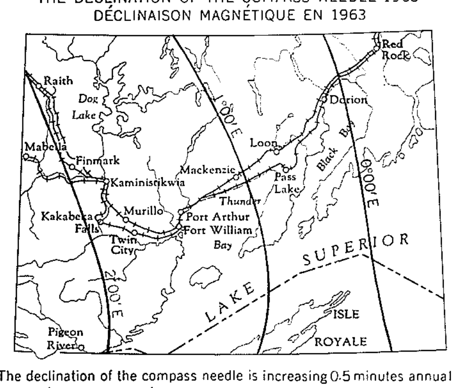


1:250,000

CANADA



THE DECLINATION OF THE COMPASS NEEDLE 1963
DÉCLINAISON MAGNÉTIQUE EN 1963



The declination of the compass needle is increasing 0.5 minutes annually.
La déclinaison magnétique croissante de 0.5 minute annuellement

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FORT WILLIAM

CANADA - UNITED STATES

Scale 1:250,000 Échelle

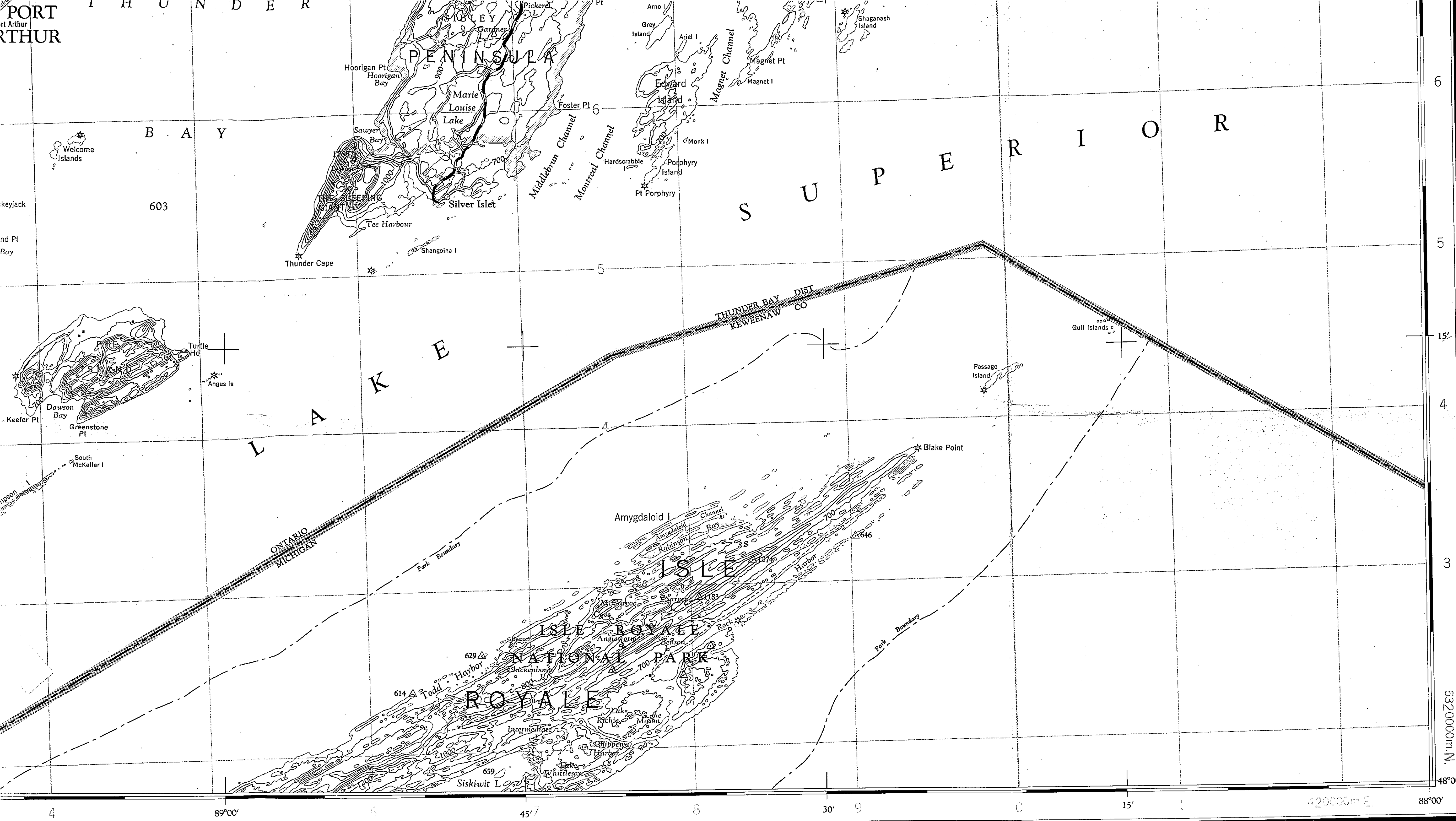
Miles 5 0 5 10 15

Kilometres 5 0 5 10 15 20 25 30

Road	Route			
hard surface, all weather	pavée, toute saison	more than 2 lanes / plus de 2 voies	2 lanes / 2 voies	less than 2 lanes / moins de 2 voies
loose surface, all weather	de gravier, toute saison	2 lanes or more / 2 voies ou plus	less than 2 lanes / moins de 2 voies	dry weather / période sèche
cart track	de terre	trail or portage	sentier ou portage	
Railway, normal gauge	Chemin de fer, écartement normal	station / gare	multiple track / voies multiples	flagstop / arrêt; single track / voie unique; (abandoned) / (abandonné)
Township or Parish	Canton ou Paroisse	surveyed / levée	unsurveyed / non levée	
Depression contours	Courbes de cuvette			
Spot elevation; precise, approximate	Point coté; précis, approximatif	. 950 . 950±		
Power transmission line	Ligne de transport d'énergie			

Transverse Mercator Projection
North American Datum 1927
Contour Interval 100 feet
Elevations in feet above Mean Sea Level

Projection transverse de Mercator
Réseau géodésique nord-américain unifié 1927
Équidistance des courbes 100 pieds
Élévations en pieds au-dessus du niveau moyen de la mer



FORT WILLIAM

CANADA - UNITED STATES

Scale 1:250,000 Échelle

0 5 10 15 20 Milles

0 5 10 15 20 25 30 Kilomètres

Transverse Mercator Projection
North American Datum 1927
Contour Interval 100 feet
Elevations in feet above Mean Sea Level

Projection transverse de Mercator
Réseau géodésique nord-américain unifié 1927
Équidistance des courbes 100 pieds
Élévations en pieds au-dessus du niveau moyen de la mer

Publiée par le SERVICE TOPOGRAPHIQUE DE L'ARMÉE, (G.R.C.) Renseignements à jour en 1959. Imprimée en 1964.
Renseignements relatifs aux É-U fournis par L'ARMY MAP SERVICE, CORPS OF ENGINEERS, ARMÉE DES É.U., valables jusqu'à 1957 seulement.
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Town	Ville	Stream intermittent or dry	Cours d'eau intermittent ou à sec
Village or Settlement	Village ou hameau	Intermittent lake	Lac intermittent
Post Office	Bureau de poste P	Rapids; falls	Rapides; chute R F
Church	Église	Marsh or Swamp	Marais ou marécage
School	École	Lighthouse	Phare
Boundary monument	Borne-frontière	Horizontal control point	Point géodésique
Airport	Aéroport	Landing ground	Piste d'atterrissage
Seaplane base	Base d'hydravions	Seaplane anchorage	Amarrage d'hydravions

100,000 M. SQUARE IDENTIFICATION

GRID ZONE DESIGNATION 16U

BK	CK	DK
BJ	CJ	DJ

54; 3, 4

TO GIVE A REFERENCE TO NEAREST 1000 METRES

EXAMPLE: LIGHTHOUSE

SQUARE: Read letters of 100,000 m. square — CJ

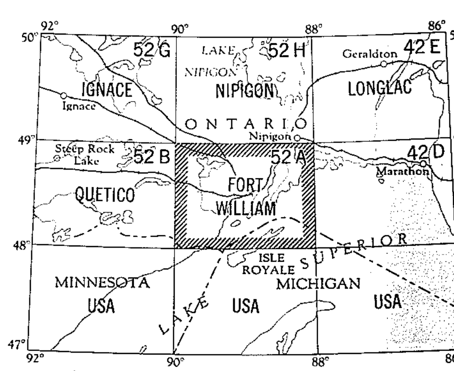
EASTING: Read number on grid line immediately to left of point — 5; Estimate tenths of a square from this line eastward to point — 1; 51

NORTHING: Read number on grid line immediately below point — 4; Estimate tenths of a square from this line northward to point — 4; 44

MILITARY GRID REFERENCE (to nearest 1,000 metres) — CJ5144

If reporting beyond 18° in any direction prefix Grid Zone Designation as — 16UCJ5144

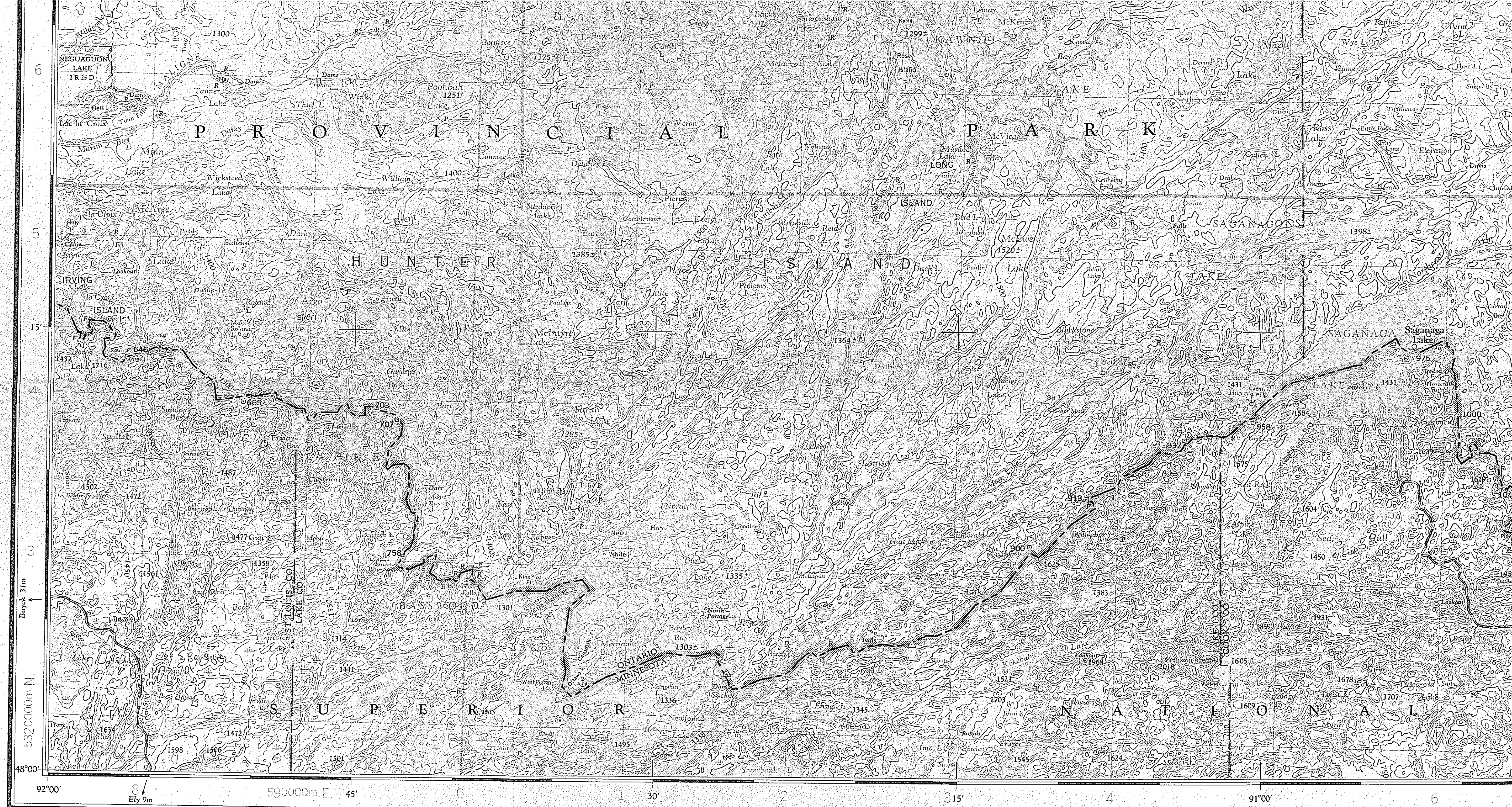
TEN THOUSAND METRE
UNIVERSAL TRANSVERSE MERCATOR GRID
ZONE 16



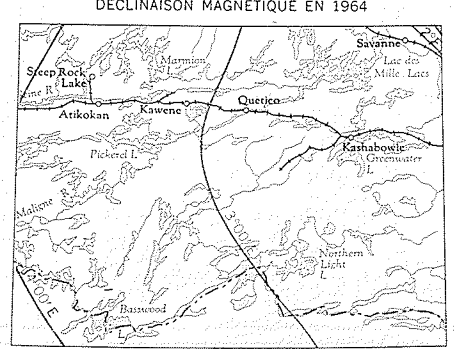
Index to adjoining maps of the National Topographic System
Tableau d'assemblage du Système National de Référence Cartographique

FORT WILLIAM
52 A
EDITION 1

A.M.S. V501
NM 16-10



THE DECLINATION OF THE COMPASS NEEDLE 1964
DÉCLINAISON MAGNÉTIQUE EN 1964



The declination of the compass needle is 0 minutes annually.
La déclinaison magnétique est 0 minute annuellement.

Produced by the ARMY SURVEY ESTABLISHMENT, R.C.E.
Information depicted current as of 1957. Printed 1964.
U.S.A. information supplied by the
UNITED STATES GEOLOGICAL SURVEY.

Copies may be obtained from the Map Distribution Office,
Department of Mines and Technical Surveys, Ottawa.

Reprinted 1969, with minor corrections.

Road — Route
hard surface, all weather .... pavée, toute saison ..... more than 2 lanes / plus de 2 voies — 2 lanes / 2 voies — less than 2 lanes / moins de 2 voies
loose surface, all weather ....de gravier, toute saison .. 2 lanes or more / 2 voies ou plus — less than 2 lanes / moins de 2 voies — dry weather / période sèche
cart track ...... de terre .... trail or portage ... sentier ou portage ...
Railway, normal gauge ..Chemin de fer, écartement normal: station / gare — multiple track / voies multiples — flagstop / arrêt — single track / voie unique — (abandoned) / (abandonné)
Township or Parish .... Canton ou Paroisse ...... surveyed / levée — unsurveyed / non levée
Depression contours .... Courbes de cuvette ...
Spot elevation; precise, approximate ..... Point coté; précis, approximatif ..... . 950 . 950±
Power transmission line ..... Ligne de transport d'énergie ...

QUETICO

CANADA - UNITED STATES

Scale 1:250,000 Échelle

Miles 5 0 5 10 15

Kilometres 5 0 5 10 15 20 25

Transverse Mercator Projection
North American Datum 1927
Contour Interval
100 feet in Canada, 50 feet in U.S.A.
Elevations in feet above Mean Sea Level

Projection transverse de Mercator
Réseau géodésique nord-américain unifié 19
Équidistance des courbes
Au Canada 100 pieds, aux É.-U. 50 pied
Élévations en pieds au-dessus du niveau moyen d

GRID ZONE DESIGNATION	100,000 M. SQUARE IDENTIFICATION
15U	WE XE YE / WD XD YD (54; 6, 7)

TO GIVE A REFERENCE TO NEAREST 1000 METRES	
EXAMPLE	LOOKOUT
SQUARE: Read letters of 100,000 m. square	XD
EASTING: Read number on grid line immediately to left of point	6
Estimate tenths of a square from this line eastward to point	7
	67
NORTHING: Read number on grid line immediately below point	5
Estimate tenths of a square from this line northward to point.	9
	59
MILITARY GRID REFERENCE (to nearest 1,000 metres)	XD6759
If reporting beyond 18° in any direction, prefix Grid Zone Designation as:	15UXD6759

TEN THOUSAND METRE
UNIVERSAL TRANSVERSE MERCATOR GRID
ZONE 15

QUETICO

CANADA - UNITED STATES

Scale 1:250,000 Échelle

0 5 10 15 20 Milles

0 5 10 15 20 25 30 Kilomètres

Transverse Mercator Projection
North American Datum 1927
Contour Interval
0 feet in Canada, 50 feet in U.S.A.
tions in feet above Mean Sea Level

Projection transverse de Mercator
Réseau géodésique nord-américain unifié 1927
Équidistance des courbes
Au Canada 100 pieds, aux É.-U. 50 pieds
Élévations en pieds au-dessus du niveau moyen de la mer

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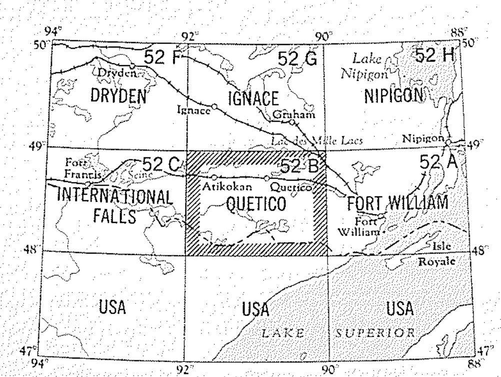
Réimprimée en 1969, avec corrections mineures.

Town	Ville	□	Stream intermittent or dry	Cours d'eau intermittent ou à sec	
Village or Settlement	Village ou hameau	o	Intermittent lake	Lac intermittent	
Post Office	Bureau de poste	P	Rapids; falls	Rapides; chute	R F
Church	Église		Marsh or Swamp	Marais ou marécage	
School	École		Lighthouse	Phare	✡
Boundary monument	Borne-frontière	▫	Horizontal control point	Point géodésique	△
Airport	Aéroport		Landing ground	Piste d'atterrissage	
Seaplane base	Base d'hydravions		Seaplane anchorage	Amarrage d'hydravions	⚓



Index to adjoining maps of the National Topographic System
Tableau d'assemblage du Système National de Référence Cartographique

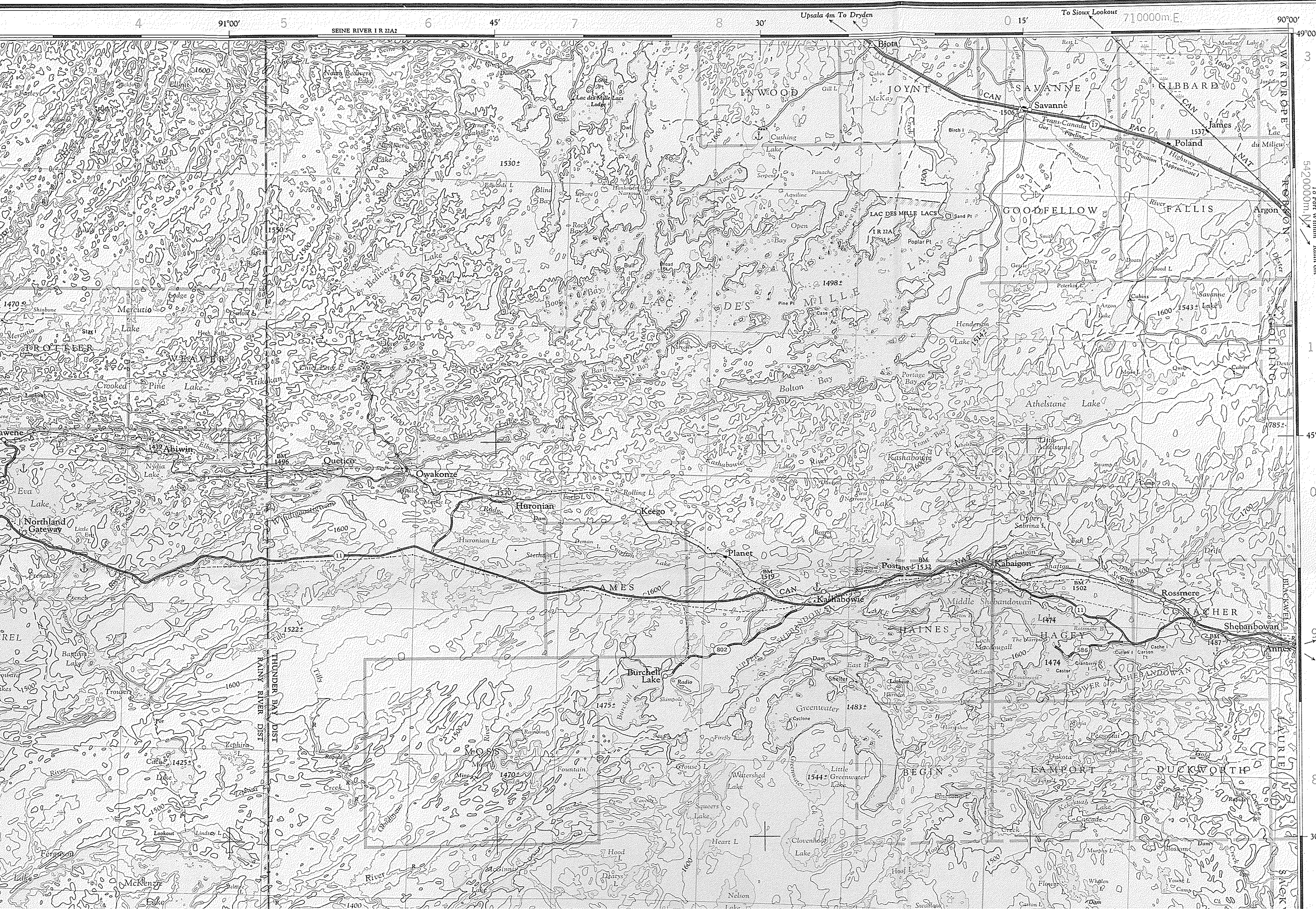
QUETICO
52 B
EDITION 6

A.M.S. V 502
NM 15-12

CANADA

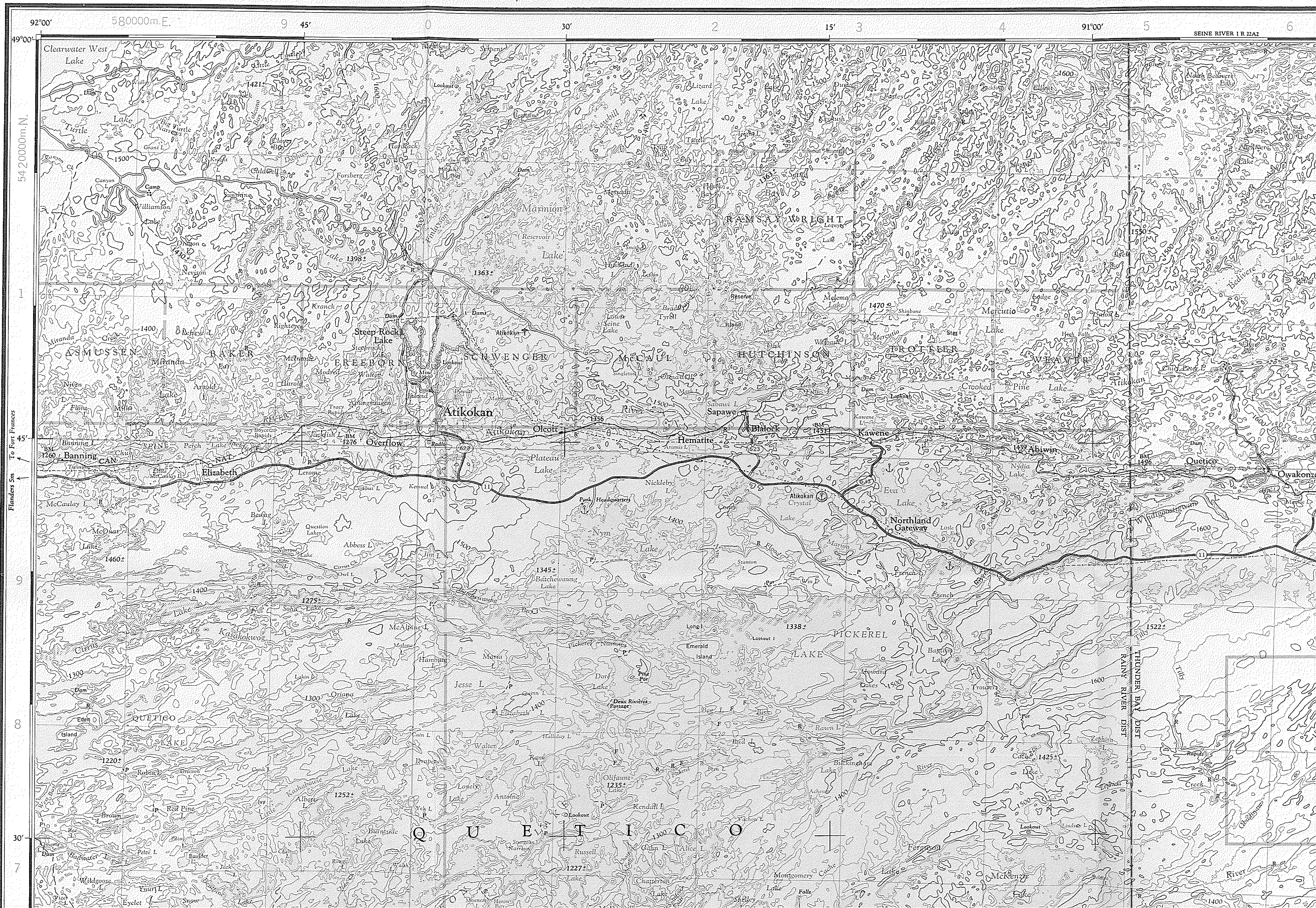
EDITION 6

Refer to this map as:	52B EDITION 6 ASE SERIES A 501



1:250,000

CANADA



A Checklist of the Hepatics in the Area Adjacent to the Canadian Lakehead

JOAN M. CROWE AND P. BARCLAY-ESTRUP

Made in United States of America
Reprinted from THE BRYOLOGIST
Vol. 74, No. 1, Spring 1971
pp. 36–39

A Checklist of the Hepatics in the Area Adjacent to the Canadian Lakehead

Abstract. *Eighty taxa of liverworts, including five not previously reported from the region, are listed from an area of approximately 11,520 km² adjacent to the northwestern end of Lake Superior. The character of the hepatic flora ranges from arctic to temperate, although most of the taxa are typical of the boreal regions of the northern hemisphere.*

This checklist is based on 729 specimens in the Lakehead University Herbarium and includes five species not previously reported from the region. Very little collecting has been done in the checklist area by non-residents and, so far as is known, no checklist specific to this area has been published previously, although material from this area has been cited by other authors (Williams & Cain, 1959).

The checklist area, covering approximately 11,520 km², extends along the northwest coast of Lake Superior from Lake Nipigon in the east to Pigeon River in the south. Most collections were made within a radius of 64 km from the city of Thunder Bay. The rocks underlying this area are all Precambrian, mostly unmetamorphosed sediments or of volcanic character. Glaciation has been important in leaving superficial deposits in many places and exposing bedrock in others. Soils are not well developed. The climate is sub-arctic with a mean daily January maximum of –20°C and a mean daily July maximum of 24.5°C. The mean annual total precipitation is 76.4 cm of which one-third is accounted for by 228.6 cm of snow (Chapman & Thomas, 1968). Ahti (1964) classifies the region as strongly humid but it is not as moist as the area east of Nipigon. However, Lake Superior does have an important modifying effect.

The terrain is rugged and, while no real mountains occur, there are large basalt-capped mesas rising approximately 300 m above lake level (180 m). In contrast, Ouimet canyon is 140 m deep. The predominant vegetation is mixed forest (trembling aspen, white birch, balsam fir, white and black spruce, and jack pine), and the area is largely an ecotone region between the Superior and Nipigon sections of the Boreal Forest and the Quetico section of the Great Lakes-St. Lawrence Forest (Rowe, 1959). There has been some land clearance for farming but the more unsuitable areas are now abandoned and reverting to bush. In addition, the area has been logged at least once and there has been considerable mining activity. Much of the area has been affected by fire within the last century. These environmental factors combine to give considerable local variation in vegetation and provide many suitable habitats for hepatics.

The species listed here are typical of the Taiga areas of the Northern Hemisphere. Only our *Frullanias* and *Cololejeunea biddlecomiae* are confined to North America, and even they are widely distributed on this continent (Bonner, 1963, 1965; Schuster, 1953). There is a small Arctic element; *Chandonanthus setiformis, Lophozia rutheana, Anastrophyllum saxicola, Scapania gymnostophila, Odontoschisma macounii, Mannia pilosa, Asterella ludwigii,* and *Clevea hyalina.* All of these except the first have also been found in neighbouring Minnesota (Schuster, 1953). However, all of these are rare and have only been found in arctic microhabitats, for example Ouimet Canyon. In contrast, the temperate species *Conocephalum conicum* (Schuster, 1953) is common and widely distributed throughout the area.

Phylogenetic arrangement and nomenclature of the following list are according to Schuster (1953, 1966, 1969), except *Pellia endiviifolia* (Dicks.) Dum. (Arnell, 1956). Species not previously reported from the checklist area are indicated by an asterisk (*); the number following the name of each taxon is the total number of specimens of the taxon collected in the checklist area.

BLEPHAROSTOMACEAE

Blepharostoma trichophyllum (L.) Dum. (19)
Ptilidium ciliare (L.) Hampe (20)
P. pulcherrimum (Web.) Hampe (44)

LEPIDOZIACEAE

Lepidozia reptans (L.) Dum. (25)
Bazzania trilobata (L.) S. F. Gray (13)

CALYPOGEIACEAE

Calypogeia integristipula Steph. (10)
C. muelleriana (Schiffn.) K. Müll. (1)
C. neesiana (Mass. & Carest.) K. Müll. (1)
C. sphagnicola (Arn. & Perss.) Warnst. & Loeske (2)
**C. suecica* (Arn. & Perss.) K. Müll. (1)

LOPHOZIACEAE

Chandonanthus setiformis (Ehrh.) Lindb. (2)
Lophozia alpestris (Schleich.) Evans (10)
L. badensis (Gott. *ex* Gott. & Rabenh.) Schiffn. (2)
L. barbata (Schmid.) Dum. (52)
**L. excisa* (Dicks.) Dum. (1)
L. heterocolpa (Thed.) Howe (8)
L. incisa (Schrad.) Dum. (8)
L. longidens (Lindb.) Macoun (7)
L. marchica (Nees) Steph. (2)
L. porphyroleuca (Nees) Schiffn. (1)
**L. rutheana* (Limpr.) Howe (1)
L. ventricosa (Dicks.) Dum. (25)
Tritomaria exsectiformis (Breidl.) Schiffn. (6)
T. quinquedentata (Huds.) Buch. (38)
Anastrophyllum hellerianum (Nees) Schust. (6)
A. michauxii (Web.) Buch. (9)
A. saxicola (Schrad.) Schust. (8)
Gymnocolea inflata (Huds.) Dum. (2)

JUNGERMANNIACEAE

Jamesoniella autumnalis (DC.) Steph. (21)
Jungermannia lanceolata L. (6)
Mylia anomala (Hook.) S. F. Gray (10)

SCAPANIACEAE

Diplophyllum taxifolium (Wahl.) Dum. (4)
Scapania cuspiduligera (Nees) K. Müll. (1)
**S. glaucocephala* (Tayl.) Evans (1)
S. gymnostophila Kaal. (2)
S. irrigua (Nees) Dum. (10)

S. *microphylla* Warnst. (2)
S. *mucronata* Buch. (10)
S. *nemorosa* (L.) Dum. (3)
S. *paludicola* Loeske & K. Müll. (2)
S. *undulata* (L.) Dum. (3)

LOPHOCOLEACEAE

Lophocolea heterophylla (Schrad.) Dum. (17)
L. minor Nees (15)
Chiloscyphus pallescens (Ehrh.) Dum. (2)
C. pallescens var. *fragilis* (Roth.) K. Müll. (9)
Harpanthus scutatus (Web. & Mohr) Spruce (5)
Geocalyx graveolens (Schrad.) Nees (10)

PLAGIOCHILACEAE

Plagiochila asplenioides (L.) Dum. (26)

CEPHALOZIACEAE

Cephalozia connivens (Dicks.) Spruce (2)
**C. media* Lindb. (3)
C. pleniceps (Aust.) Lindb. (4)
Nowellia curvifolia (Dicks.) Mitt. (6)
Cladopodiella fluitans (Nees) Buch. (7)

CEPHALOZIELLACEAE

Cephaloziella elachista (Jack) Schiffn. (2)
C. hampeana (Nees) Buch. (7)

ADELANTHACEAE

Odontoschisma denudatum (Mart.) Dum. (1)
O. macounii (Aust.) Evans (1)

RADULACEAE

Radula complanata (L.) Dum. (34)

PORELLACEAE

Porella platyphylla (L.) Lindb. (10)
P. platyphylloidea (Schwein.) Lindb. (4)

FRULLANIACEAE

Frullania bolanderi Aust. (10)
F. brittoniae Evans (1)
F. eboracensis Gott. (50)
F. oakesiana Aust. (2)
F. selwyniana Pears. (2)

LEJEUNEACEAE

Lejeunea cavifolia (Ehrh.) Lindb. (8)
Cololejeunea biddlecomiae (Aust.) Evans (3)

FOSSOMBRONIACEAE

Fossombronia foveolata Lindb. (2)

BLASIACEAE

Blasia pusilla L. (8)

DILAENACEAE

Pellia endiviifolia (Dicks.) Dum. (3)
P. epiphylla (L.) Corda (10)
Moerckia hibernica (Hook.) Gott. (4)

ANEURACEAE

Riccardia latifrons (Lindb.) Lindb. (6)
R. multifida (L.) S. F. Gray (9)
R. pinguis (L.) S. F. Gray (4)

GRIMALDIACEAE

Asterella ludwigii (Schwaegr.) Underw. (4)
Mannia pilosa (Hornem.) Frye & Clark (2)

CONOCEPHALACEAE

Conocephalum conicum (L.) Dum. (10)

CLEVEACEAE

Clevea hyalina (Sommerf.) Lindb. (1)

MARCHANTIACEAE

Preissia quadrata (Scop.) Nees (19)
Marchantia polymorpha L. (15)

Many thanks to Mr. Claude Garton for his invaluable collections and to Mr. Harry Williams for generously giving up his time to check determinations.

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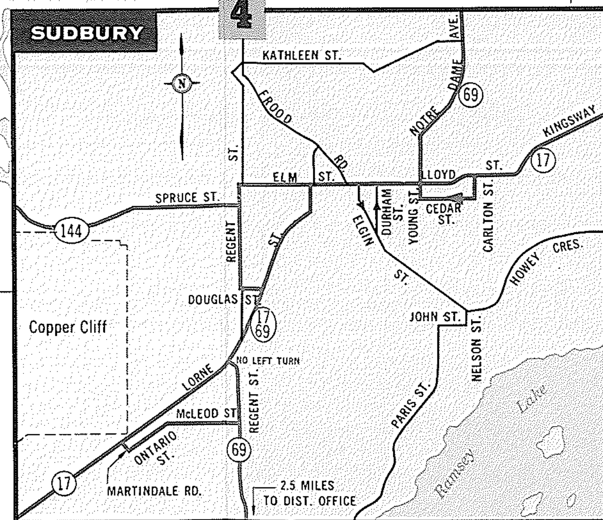
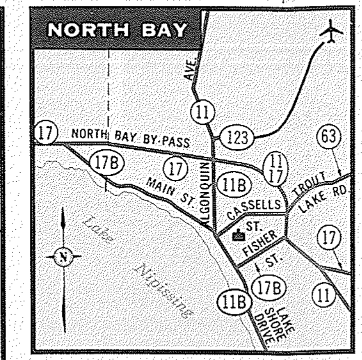
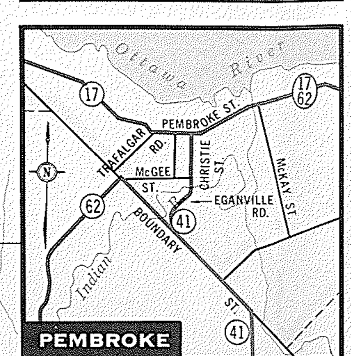
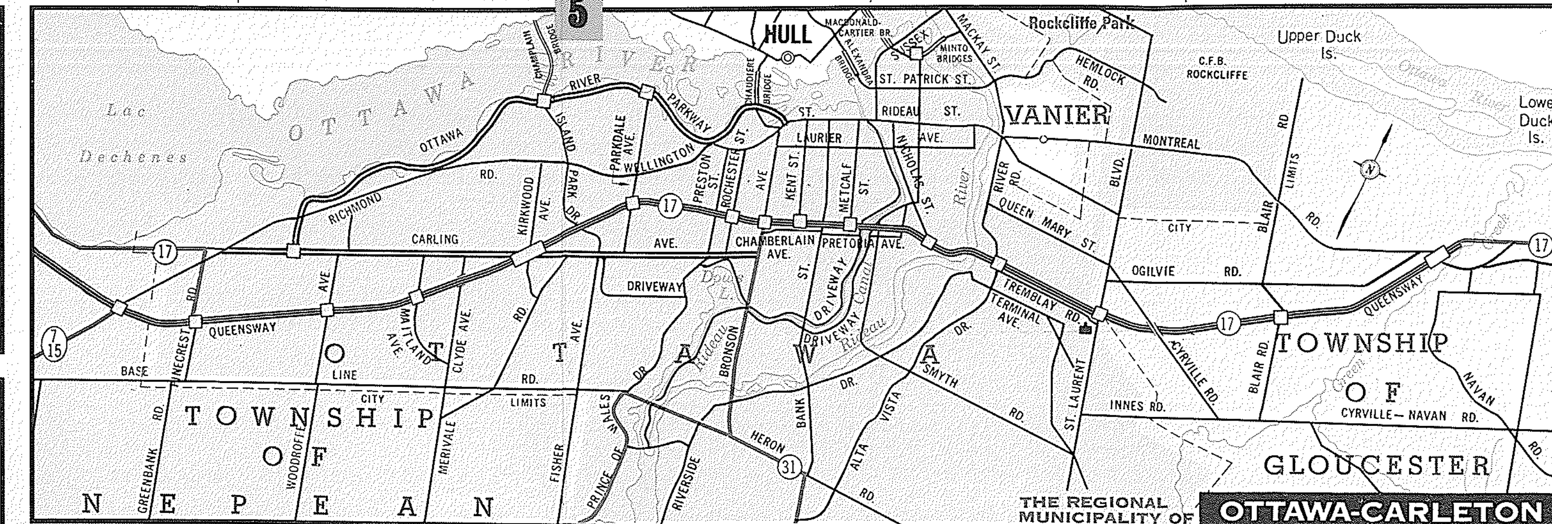
———. 1969. The Hepaticae and Anthocerotae of North America east of the hundredth meridian. II. New York.
WILLIAMS, H. & R. F. CAIN. 1959. Additions to the hepaticae of Ontario. THE BRYOLOGIST 62: 145–148.

JOAN M. CROWE AND P. BARCLAY-ESTRUP, *Department of Biology, Lakehead University, Thunder Bay, Ontario, Canada.*









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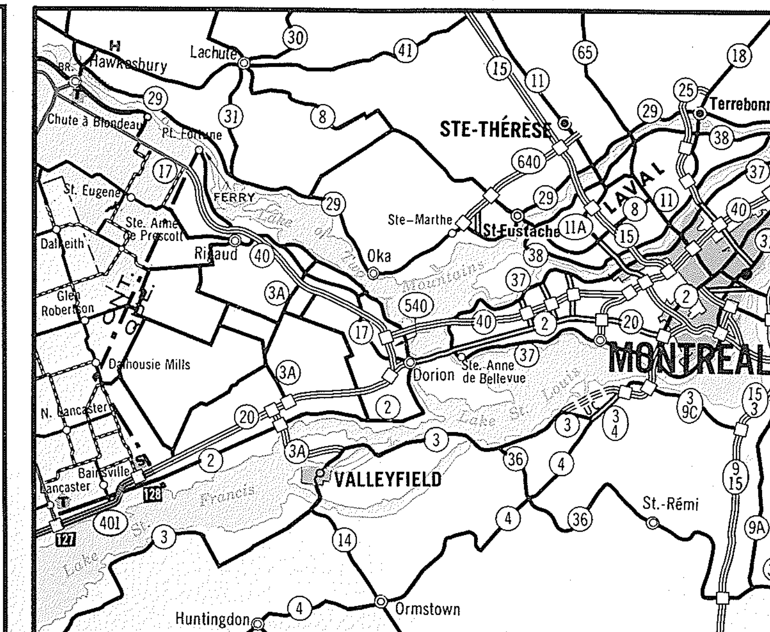
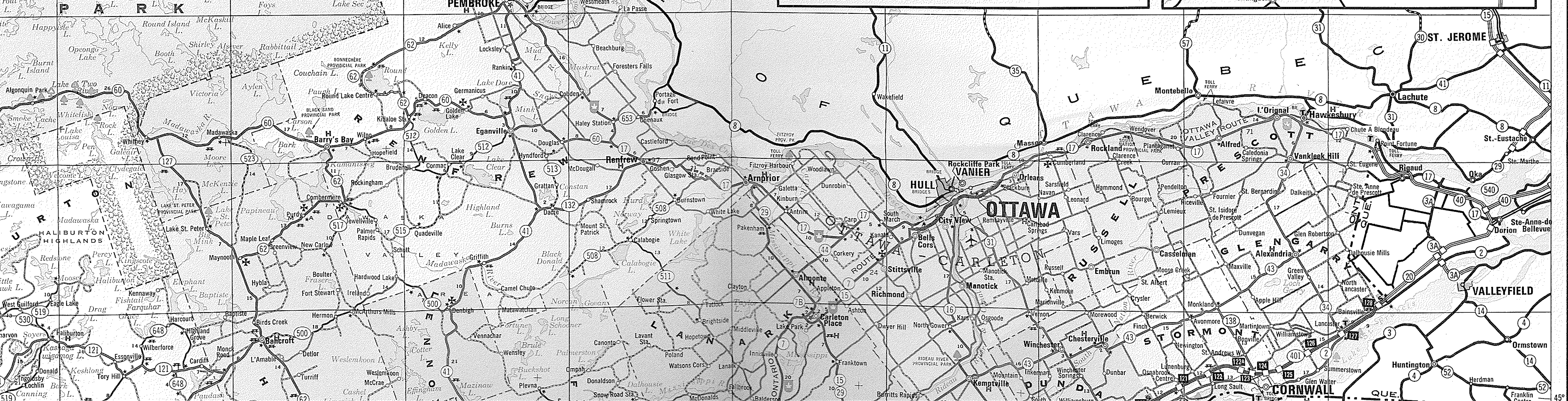
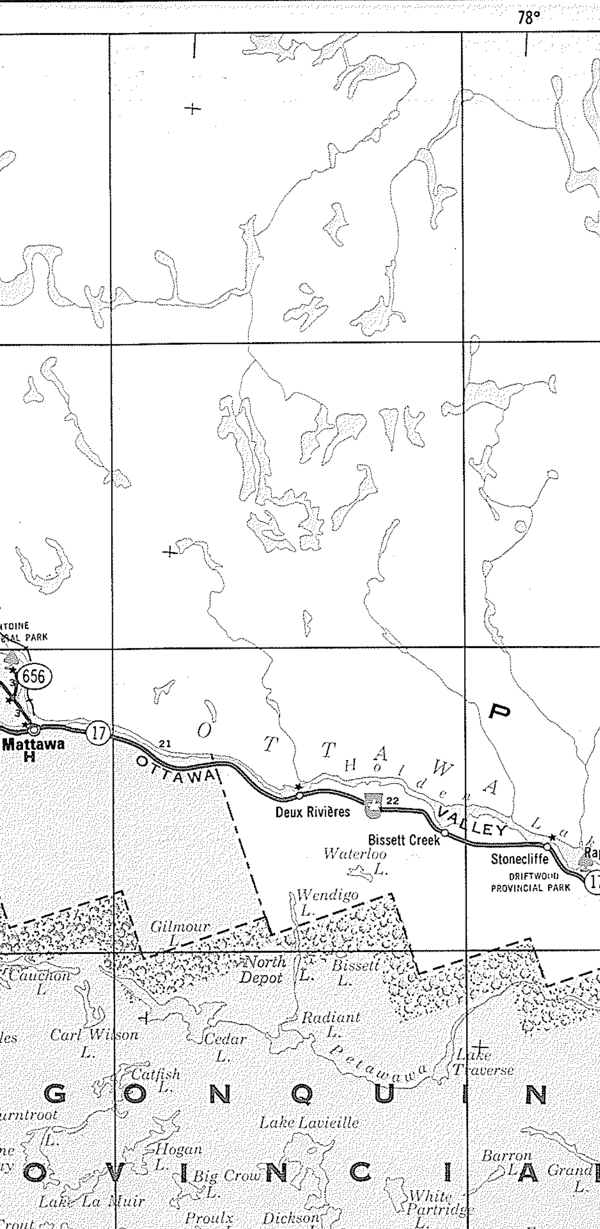
District No. 1, 60 Keil Drive, P.O. Box 910, **CHATHAM, ONT.,** Phone 354-1400
District No. 2, 390 Saskatoon St., P.O. Box 6008, **LONDON, ONT.,** Phone 451-5400
District No. 3, 581 Huron St., P.O. Box 8, **STRATFORD, ONT.,** Phone 271-3550
District No. 4, 1182 North Shore Blvd., P.O. Box 279, **BURLINGTON, ONT.,** Phone 527-9131
District No. 5, 1450 Seventh Avenue East, P.O. Box 520, **OWEN SOUND, ONT.,** Phone 376-7350
District No. 6, Keele St. & Highway 401, **DOWNSVIEW 464, ONT.,** Phone 248-3335
District No. 7, 138 Hope St. North, P.O. Box 150, **PORT HOPE, ONT.,** Phone 885-6381
District No. 8, 355 Counter St., P.O. Box 4000, **KINGSTON, ONT.,** Phone 544-2220
District No. 9, 530 Tremblay Road, **OTTAWA, ONT.,** Phone 745-6841
District No. 10, 64 Monck Rd., P.O. Box 300, **BANCROFT, ONT.,** Phone 320
District No. 11, 207 Main St. West, P.O. Box 790, **HUNTSVILLE, ONT.,** Phone 789-2391
District No. 13, 183 First Ave. West, P.O. Box 240, **NORTH BAY, ONT.,** Phone 474-2640
District No. 14, P.O. Box 390, **NEW LISKEARD, ONT.,** Phone 647-6761
District No. 16, 45 Fourth Avenue, P.O. Box 800, **COCHRANE, ONT.,** Phone 272-4333
District No. 17, Highway No. 69 South, P.O. Box 550, **SUDBURY, ONT.,** Phone 675-8307
District No. 18, 160 MacDougall St., P.O. Box 500, **SAULT STE. MARIE, ONT.,** Phone 256-5682
District No. 19, 1825 Arthur St., P.O. Box 96, **THUNDER BAY, ONT.,** Phone 623-1571
District No. 20, 221 Main St. South, P.O. Box 1070. **KENORA, ONT.,** Phone 468-6494
Road Information Centre, **DOWNSVIEW, ONT.,** Phone 248-3561





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TO CHAPLEAU
83°
82°
81°
80°
TO COCHRANE
79°
2
3
MISSISSAGI PROVINCIAL PARK
Elliot Lake
Thessalon
Iron Bridge
Blind River
Algoma
Spragge
Serpent River
Cutler
Spanish
Walford
Massey
Webbwood
McKerrow
Espanola
Nairn Centre
Whitefish
Lively
Naughton
Creighton
Copper Cliff
SUDBURY
Azilda
Chelmsford
Dowling
Onaping
Levack
Blezard Valley
Val Caron
Hanmer
Capreol
Milnet
Sellwood
Falconbridge
Garson
Coniston
Wahnapitae
Wanup
Estaire
Markstay
Hagar
Warren
Verner
Field
River Valley
Desaulniers
Lavigne
Cache Bay
Sturgeon Falls
Garden Village
NORTH BAY
Callander
Corbeil
Bonfield
Rutherglen
Mattawa
Calvin
Eau Claire
Astorville
Nipissing
Powassan
Alderdale
Chiswick
Restoule
Trout Creek
Commanda
Golden Valley
Arnstein
Port Loring
Loring
Sundridge
South River
Burk's Falls
Sand Lake
Katrine
Emsdale
Scotia
Kearney
Sprucedale
Novar
Melissa
Huntsville
Dwight
Dorset
Baysville
Bracebridge
Gravenhurst
Port Sydney
Utterson
Ullswater
Rosseau
Windermere
Port Carling
Milford Bay
Port Sandfield
Bala
Torrance
Parry Sound
Nobel
McKellar
Waubamik
Hurdville
Broadbent
Seguin Falls
Orrville
Shawanaga
Pointe au Baril Sta.
Byng Inlet
Britt
French River
Alban
Noelville
Monetville
Wolseley Bay
Temiscaming
Thorne
Eldee
Tomiko
Redbridge
Balsam Creek
LAKE NIPISSING
GEORGIAN BAY
THIRTY THOUSAND ISLANDS
NORTH CHANNEL
MANITOULIN IS.
Little Current
Sheguiandah
Manitowaning
Wikwemikong
Mindemoya
Providence Bay
South Baymouth
Tehkummah
Gore Bay
Kagawong
Spring Bay
Evansville
Silver Water
Meldrum Bay
COCKBURN ISLAND
Cockburn Island
JOHN ISLAND
AIRD ISLAND
LARCH ISLAND
INNES ISLAND
CLAPPERTON IS.
BARRIE IS.
GREENE IS.
WESTERN DUCK ISLAND
GREAT DUCK ISLAND
OUTER DUCK ISLAND
KILLARNEY PROVINCIAL PARK
Killarney
PHILIP EDWARD IS.
GRUNDY LAKE PROVINCIAL PARK
STURGEON BAY PROVINCIAL PARK
KILLBEAR POINT PROVINCIAL PARK
LONELY ISLAND
FITZWILLIAM ISLAND
COVE ISLAND
FLOWERPOT IS.
GEORGIAN BAY ISLANDS NAT'L PARK
Tobermory
Cape Hurd
Cabot Head
Dyer Bay
Cape Chin
Miller Lake
Pine Tree Harbour
Stokes Bay
Lion's Head
Barrow Bay
Cape Croker
Ferndale
Pike Bay
Howdenvale
Red Bay
Purple Valley
LYAL ISLAND
CHRISTIAN IS.
HOPE ISLAND
GIANTS TOMB
BEAUSOLEIL IS.
MIDLAND
ORILLIA
UNITED STATES
CANADA
ALGONQUIN PROVINCIAL PARK
MUSKOKA
PARRY SOUND
SUDBURY
NIPISSING
ALGOMA
MANITOULIN
N

15
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2
L
M
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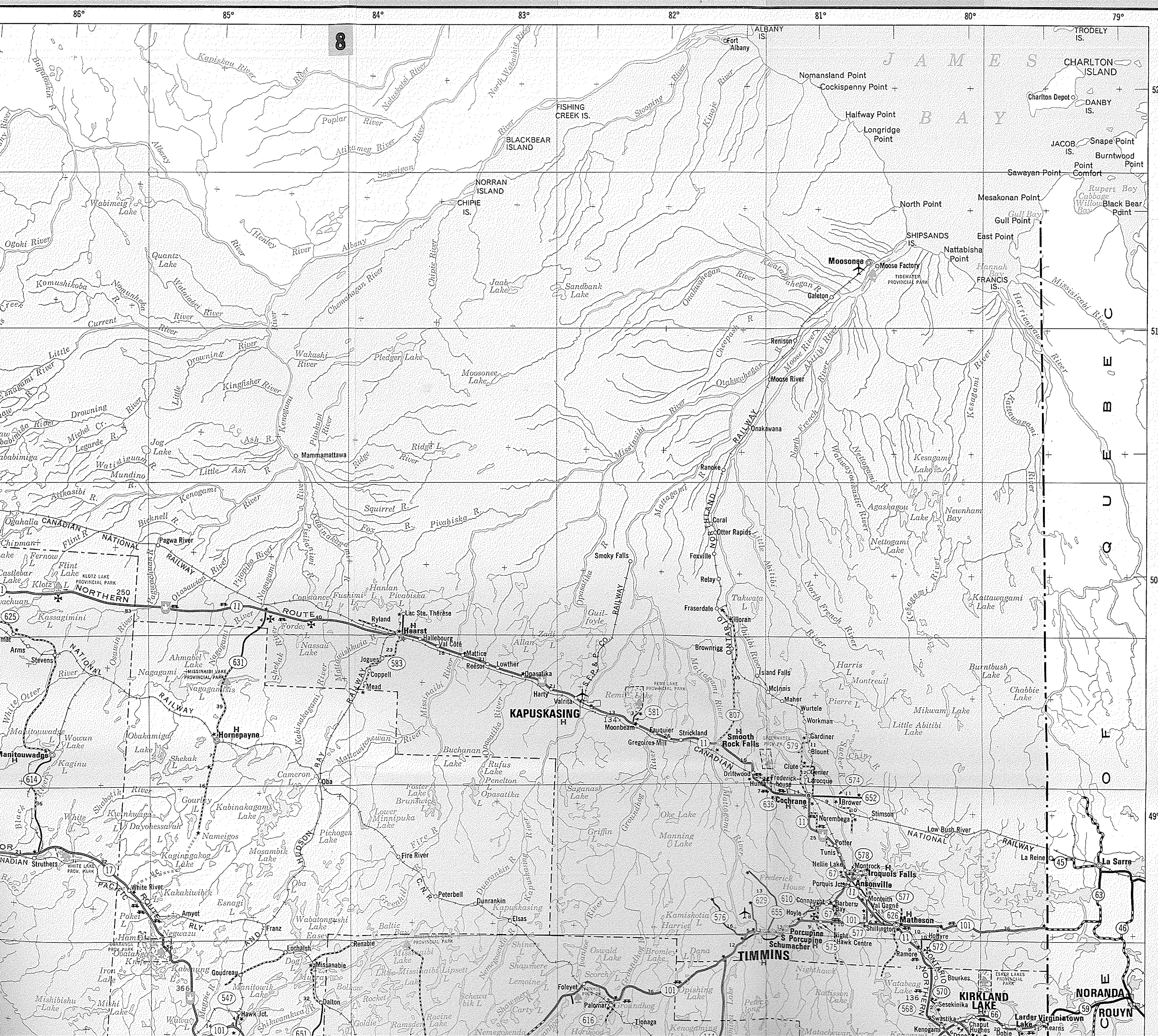
O
P
Q
R
TO CHAPLEAU
SAULT STE. MARIE
LAKE SUPERIOR
SUGAR ISLAND
STATE OF MICHIGAN
NEEBISH IS.
ST. JOSEPH IS.
DRUMMOND ISLAND
MACKINAC IS.
St. Ignace
BOIS BLANC ISLAND
Cheboygan
MICH.
Cedarville
De Tour Village
Echo Bay
Bar River
Desbarats
Richards Ldg.
Hilton Beach
Bruce Mines
Thessalon
Iron Bridge
Dean Lake
Blind River
Algoma
Spragge
Serpent River
Cutler
Spanish
Walford
Massey
Elliot Lake
MISSISSAGI PROVINCIAL PARK
ALGOMA
CHAPLEAU ROUTE
SUDBURY
Levack
Onaping
Chelmsford
Azilda
Copper Cliff
Creighton
Lively
Naughton
Whitefish
Worthington
Capreol
Hanmer
Val Caron
Blezard Valley
Garson
Falconbridge
Coniston
Wahnapitae
Markstay
Hagar
Warren
Verner
St. Charles
Wanup
Estaire
Espanola
McKerrow
Webbwood
Nairn Centre
SUPERIOR ROUTE
NORTH CHANNEL
JOHN ISLAND
AIRD ISLAND
LARCH ISLAND
INNES ISLAND
CLAPPERTON IS.
Cape Robert
COCKBURN ISLAND
Meldrum Bay
Sheshegwaning
Silver Water
BARRIE IS.
Gore Bay
Kagawong
Little Current
Sheguiandah
Whitefish Falls
Birch Island
KILLARNEY PROVINCIAL PARK
Killarney
PHILIP EDWARD IS.
GEORGE IS.
MANITOULIN IS.
Evansville
Elizabeth Bay
Poplar
Mindemoya
Providence Bay
Spring Bay
Tehkummah
Sandfield
Wikwemikong
Manitowaning
South Baymouth
Cape Smith
GREENE IS.
WESTERN DUCK ISLAND
GREAT DUCK ISLAND
OUTER DUCK ISLAND
CANADA
UNITED STATES
SQUAW IS.
BUSTARD IS
GEORGIAN BAY
THIRTY THOUSAND ISLANDS
LONELY ISLAND
FITZWILLIAM ISLAND
COVE ISLAND
FLOWERPOT IS.
GEORGIAN BAY ISLANDS NAT'L PARK
Tobermory
Cape Hurd
Dyer Bay
Cape Chin
Miller Lake
Pine Tree Harbour
Stokes Bay
Lion's Head
Barrow Bay
Cape Croker
LYAL ISLAND
HAY ISLAND
WHITE CLOUD IS.
GRIFFITH ISLAND
Cape Commodore
Pike Bay
Howdenvale
Red Bay
Cabot Head
Alban
Rutter
Noelville
Monetville
Wolseley Bay
EIGHTEEN MILE IS.
Bigwood
French River
GRUNDY LAKE PROVINCIAL PARK
Britt
Byng Inlet
Bayfield Wharf
Pointe au Baril
Shawanaga
Nobel
Waubamik
Parry Sound
PARRY ISLAND
Depot Harbour
KILLBEAR POINT PROVINCIAL PARK
SANDY IS
Brooks Landing
FRANKLIN IS.
Snug Harbour
HOPE ISLAND
GIANTS TOMB
BEAUSOLEIL
BECKWITH IS.
CHRISTIAN IS.
Christian Island
Loring
Port Loring
Ardbeg
Whitestone
Dunchurch
PARRY
LAKE
SAULT STE. MARIE
MIDLAND
BARRIE
ORILLIA
Kempenfelt Bay (Lake Simcoe)
Lake Couchiching
Lake Simcoe
Midland Bay
Little Lake

GALT
WATERLOO
KITCHENER
LONDON
SARNIA
WINDSOR
CHATHAM
PELEE IS.
WOODSTOCK
BRANTFORD
DETROIT
PONTIAC
LIVONIA
MONROE
Mount Clemens
PORT HURON
SARNIA
WALLACEBURG
CHATHAM
WINDSOR
LONDON
STRATFORD
WATERLOO
KITCHENER
GUELPH
GALT
PRESTON
BRAMPTON
GEORGETOWN
WOODSTOCK
BRANTFORD
HAMILTON
BURLINGTON
ST. THOMAS
SIMCOE
TILLSONBURG
LAKE ST. CLAIR
LAKE ERIE
MICHIGAN
MACDONALD-CARTIER FREEWAY
MICH. ONT.
43°
42°
83°
82°
81°
80°
15
16
17
18
19
20
21
22


PETERBOROUGH
BELLEVILLE
TRENTON
KINGSTON
WATERTOWN
TORONTO
MISSISSAUGA
OAKVILLE
BURLINGTON
HAMILTON
ST. CATHARINES
NIAGARA FALLS
LOCKPORT
WELLAND
BUFFALO
BRAMPTON
GEORGETOWN
RICHMOND HILL
AURORA
OSHAWA
WHITBY
AJAX
COBOURG
LAKE ONTARIO
CANADA
UNITED STATES
LINDSAY
TRENTON
OAKVILLE
ST. CATHARINES
OSHAWA
PORT COLBORNE
PETERBOROUGH
BURLINGTON
HAMILTON
METROPOLITAN TORONTO
WELLAND
NIAGARA FALLS
79°
78°
77°
76°
22
23
24
25
26
27
28
29
30

DEPARTMENT OF HIGHWAYS ONTARIO
PROVINCE OF
ONTARIO
SOUTHERN PORTION
LEGEND
THE KING'S HIGHWAY
Freeway with interchange and number
Multilane, Divided
Multilane, Undivided
Two-Lane, Paved
Gravel or Crushed Stone
Under Construction
SECONDARY HIGHWAYS
Paved
Gravel or Crushed Stone
Under Construction
OTHER ROADS
Freeway with interchange
Multilane, Divided
Two-Lane, Paved
Gravel or Crushed Stone
U.S. Interstate Route Number
International Boundary
Provincial Boundary
County and District Boundary
Park Boundary
Steamship Routes
Canal Routes
Lake Elevations EL 246
D.H.O. District Offices (on city enlargements only)
Commercial Airports (having scheduled flights)
Tourist Reception Centres
Service Centres
Government Camp Sites
Government Park Sites (no camping)
St. John Ambulance First Aid Posts
Hospitals
Local Mileage
Accumulated Mileage
D.H.O. Picnic Areas
POPULATIONS
Under 1000
1000–5000
5000–10,000
10,000–25,000
25,000–100,000
100,000–200,000
over–200,000
All municipalities with populations of 10,000 or more have their built-up areas shown by solid yellow and limits shown by a yellow shaded line.
SCALE OF MILES
SYSTEM OF NUMBERING THE KING'S HIGHWAY
A Freeway is a multilane divided controlled-access highway
The 400 Series are Freeways of the most modern design.
Nos. 2 to 144 are two- to four-lane undivided highways.
The 500 and 600 series are Secondary Highways, usually local or access roads, and are also under the full jurisdiction of the Dept. of Highways.
The suffix "B" after a highway no. indicates the highway route through a business district.
The Trans-Canada Highway routes are named thus: NORTHERN ROUTE, and marked on the map thus:
12 LANE FREEWAY
LINDSAY
KINGSTON
BROCKVILLE
CORNWALL
TRENTON
BELLEVILLE
OAKVILLE
ST. CATHARINES
OSHAWA
PORT COLBORNE
PETERBOROUGH
BURLINGTON
HAMILTON
METROPOLITAN TORONTO
BOROUGH OF NORTH YORK
BOROUGH OF SCARBOROUGH
BOROUGH OF YORK
BOROUGH OF ETOBICOKE
BOROUGH OF EAST YORK
TORONTO
LAKE ONTARIO
PETERBOROUGH
BELLEVILLE
TRENTON
KINGSTON
WATERTOWN
COBOURG
PRINCE EDWARD
NORTHUMBERLAND



ONTARIO

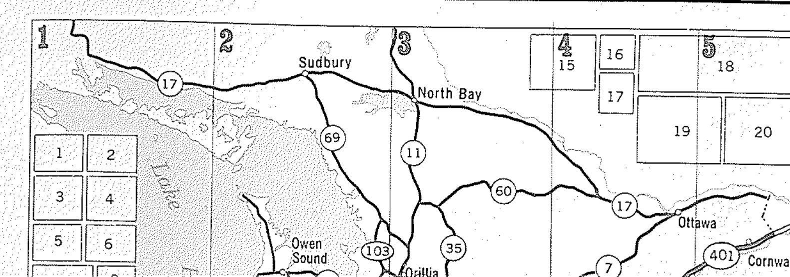
1970 Official Road Map

Hon. John P. Robarts Prime Minister
Hon. George E. Gomme Minister
A.T.C. McNab Deputy Minister

Department of Highways, Ontario

INSTRUCTIONS FOR USE OF MAP

Open the three sections of this panel to its fullest extent. Find the city enlargement or other area to which you wish to refer on the Key maps below and note the panel number. The corresponding panel numbers on the large maps are shown at the top of the reverse side of this panel. Open map as you would the pages of a book to the required area—To find exact location of cities, towns, villages and lakes refer to index with example on reverse side of this panel.



DEPARTMENT OF HIGHWAYS, ONTARIO
NORTHERN PORTION
PROVINCE OF

INDEX OF CITIES, TOWNS AND VILLAGES (SOUTHERN ONTARIO)

Example: To find Huntsville 3-Q-23

1. Open the map as you would the pages of a book to panel "3".
2. Refer to the large letter "Q" on the vertical edge of the map.
3. Refer to the large figure "23" on the horizontal edge of the map.
4. Huntsville will be found in the rectangle formed by the guide lines from "Q" and "23".

POPULATIONS SHOWN THUS (14112)

VILLAGES (NORTHERN ONTARIO)

POPULATIONS SHOWN THUS (23457)

POPULATIONS

Under 1000 — 1000–5000 — 5000–10,000 — 10,000–25,000 — 25,000–100,000 — 100,000–200,000 — over–200,000

All municipalities with populations of 10,000 or more have their built-up areas shown by solid yellow and limits shown by a yellow shaded line.

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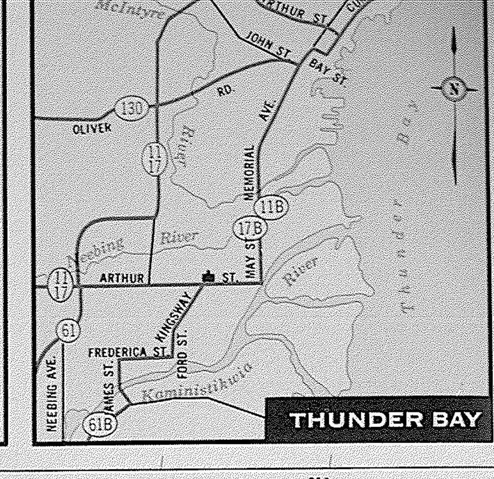
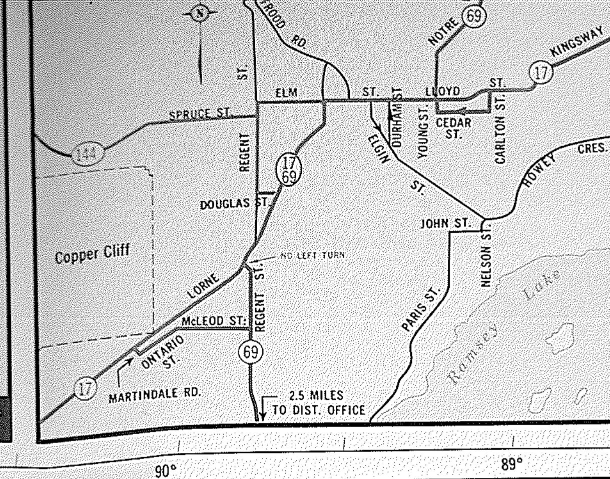




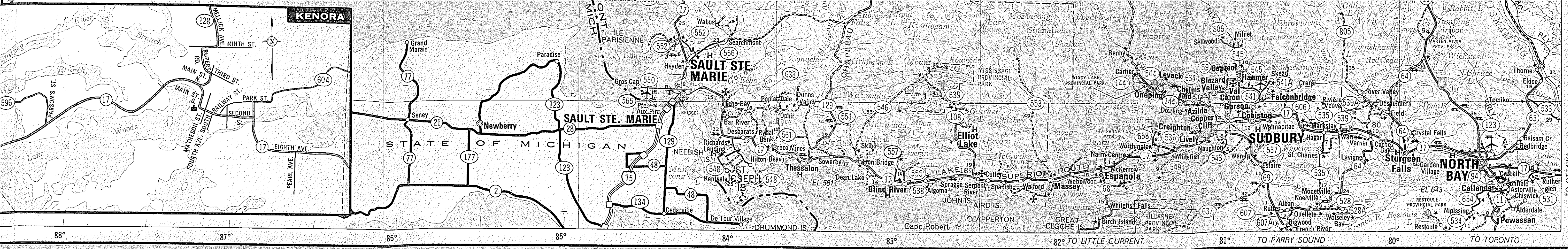
INDEX OF LAKES (SOUTHERN ONTARIO)

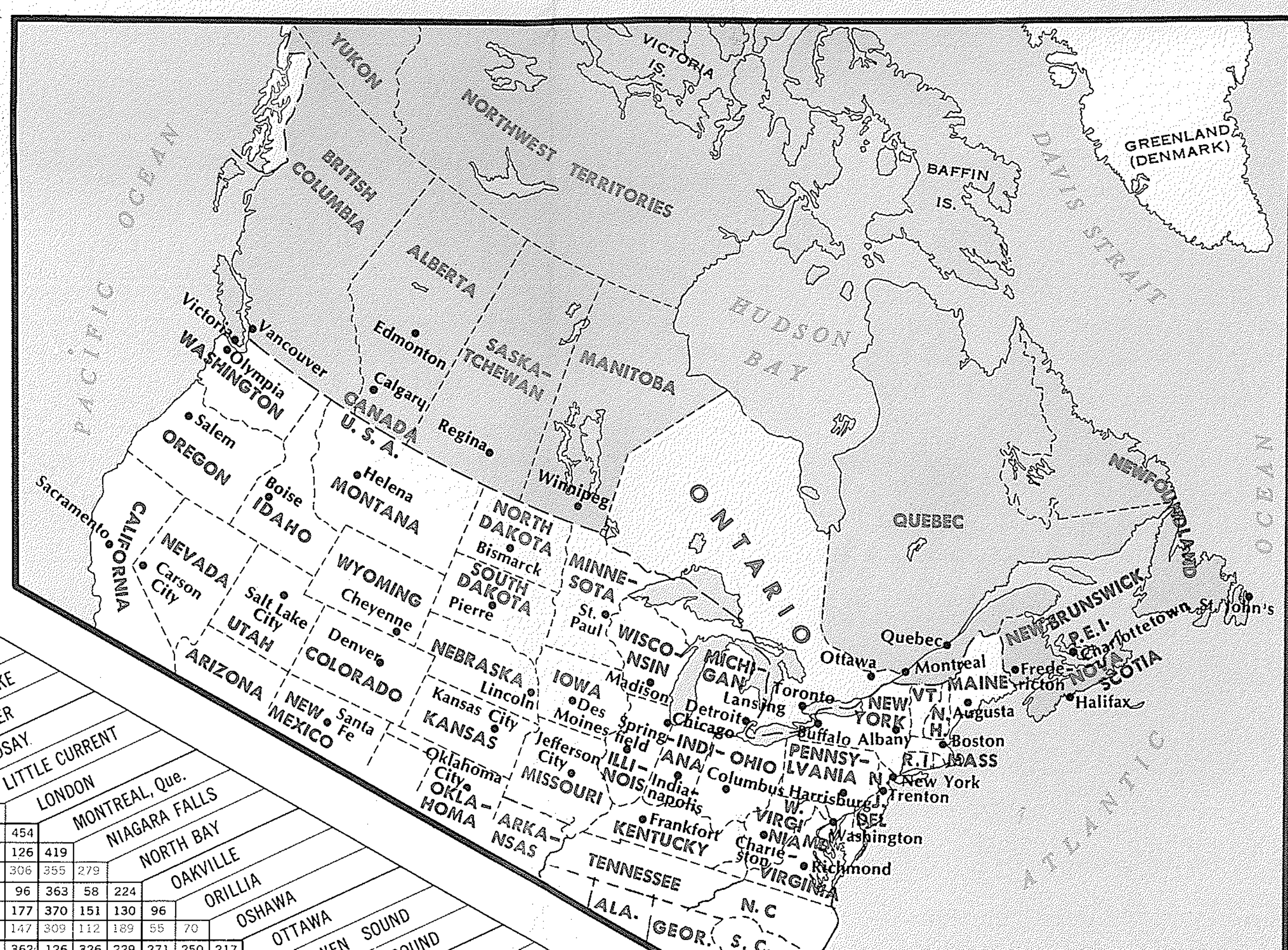
ALTITUDES SHOWN THUS (970)

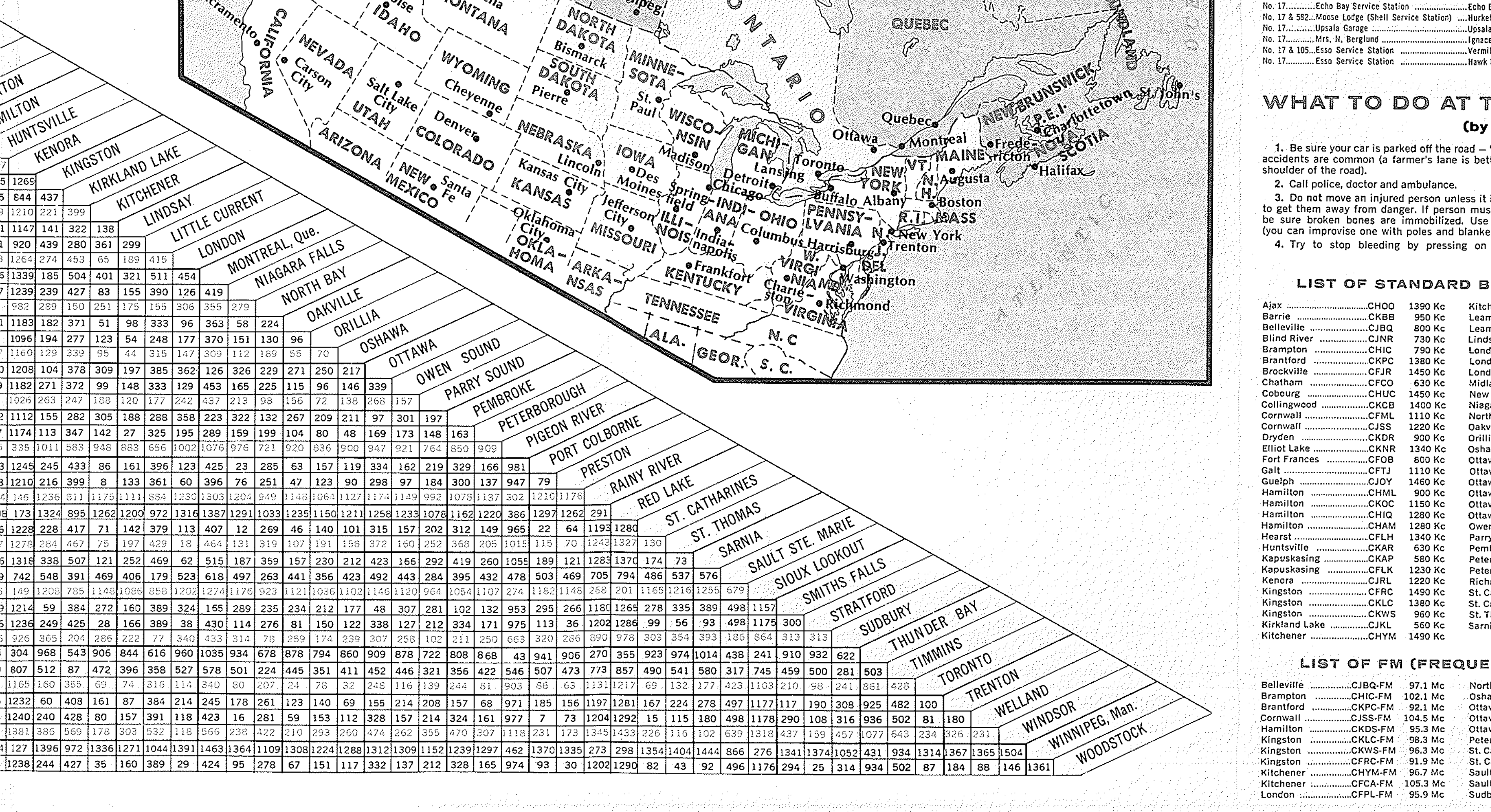
INDEX OF LAKES (NORTHERN ONTARIO)

ALTITUDES SHOWN THUS (930)

BANCROFT
BARRIE
BELLEVILLE
BRACEBRIDGE
BRAMPTON
BRANTFORD
BROCKVILLE
BURLINGTON
CHAPLEAU
CHATHAM
CORNWALL
ELLIOT LAKE
FORT ERIE
FORT FRANCES
GALT
GRAVENHURST
GUELPH
HALIBURTON
HAMILTON
HUNTSVILLE
KENORA
KINGSTON







ONTARIO HIGHWAY FIRST AID POSTS

This system is maintained jointly by the St. John Ambulance and Ontario Motor League

HIGHWAY	NAME	VICINITY
No. 2	Bernard's Garage	Newcastle
No. 3	Supertest Station	Cottam
No. 3 & 59	Dell Motel	Delhi
No. 4 & 22	Supertest Service Centre	London
No. 5 & 6	Tiny Hick's Towing Service	Waterdown
No. 6	Handicraft House	Wiarton
No. 6	Fire Station	Tobermory
No. 7	Nixon's Garage	Manilla
No. 7 & 15	Stittsville Garage	Stittsville
No. 7 & 41	Fina Service Station	Kaladar
No. 11	Sign of the Elk	Guthrie
No. 11	White Rose Service Station	Latchford
No. 11 & 572	Esso Service Station	Ramore
No. 11	Trans Canada Lodge	Ford Lake
No. 11 & 631	Mooseland Esso Service Station	Nagagami
No. 11	Klotz Lake Camp	Klotz Lake
No. 11	Colimar Lodge	Jellicoe
No. 11	Forest Inn Motel	Kashabowie
No. 11	Mine Centre Resort	Mine Centre
No. 11	Windy Point Resort	Fort Francis
No. 12	Wood's Tractor Sales	Orillia
No. 15	Lakeview Garage	Portland
No. 15 & 32	Sly's Texaco Station	Seeley's Bay
No. 17	Mrs. R. J. Kennedy	Cumberland
No. 17	Champagne's Texaco Service Station	Walford
No. 17	Kennebec Motel	Cutler
No. 17	Echo Bay Service Station	Echo Bay
No. 17 & 582	Moose Lodge (Shell Service Station)	Hurkett
No. 17	Upsala Garage	Upsala
No. 17	Mrs. N. Berglund	Ignace
No. 17 & 105	Esso Service Station	Vermilion Bay
No. 17	Esso Service Station	Hawk Lake
No. 18A	Holiday Beach Provincial Park	Colchester
No. 21 & 81	Sunoco Service Station	Grand Bend
No. 21	Tennyson's Store & Post Office	Underwood P.O.
No. 24	B.A. Service Station	Duntroon
No. 24A	Lang Trim Hall	Galt
No. 28 & 115	Hawson's Esso Service Station	Peterborough
No. 35	Barry's Garage	Dorset
No. 41	Inwood Supertest Service Station	Denbigh
No. 60	Esso Service Station	Golden Lake
No. 60	Ashbury Motor Court	Oxtongue Lake
No. 62 & 127	Peter's Garage	Maynooth
No. 62	St. Joseph House	Combermere
No. 62	Purdy's Post	Combermere
No. 69 & 545	Carol Richard Park Community Assoc.	Hanmer
No. 69	Wing's Car Storage	Pointe au Baril
No. 69	Elsasser's Store	Horseshoe Lake
No. 71	Johnson's Stores	Sioux Narrows
No. 71	Jim's Food Market	Nestor Falls
No. 101 & 575	Parnell's Fina Service Station	Night Hawk Centre
No. 103	M & M Motel	MacTier
No. 124	B.A. Service Station	McKellar
No. 400 & 89	B.A. Service Station	Cookstown
No. 400 & 90	Continental Motor Inn	Barrie
No. 401	Supertest Service Station	Tilbury
No. 401	White Rose Service Station	Dutton
No. 401	B.A. Service Station	Dutton
No. 401	Dave's Texaco Super Service Station	Beachville
No. 401	Esso Service Centre	Beachville
No. 401	B.A. Service Centre	Brighton
No. 516	Mary Lake Motors	Utterson
No. 532	Swift's Boat Livery	Rosseau
No. 592	Leigh's Store & Post Office	Scotia

WHAT TO DO AT THE SCENE OF AN ACCIDENT

(by St. John Ambulance)

1. Be sure your car is parked off the road — "secondary" accidents are common (a farmer's lane is better than the shoulder of the road).
2. Call police, doctor and ambulance.
3. Do not move an injured person unless it is necessary to get them away from danger. If person must be moved, be sure broken bones are immobilized. Use a stretcher (you can improvise one with poles and blankets or coats).
4. Try to stop bleeding by pressing on the wound through a clean pad.
5. For shock: lay patient on back, head and shoulders low, face to one side; loosen clothing; keep warm but don't overheat.
6. To be prepared; carry a first aid kit; take a course in first aid.
7. When handling an unconscious patient, make sure the air passages are kept clear and fluids allowed to drain from the mouth and nose.

LIST OF STANDARD BROADCASTING STATIONS IN ONTARIO

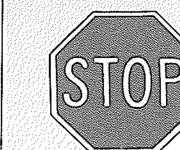
Ajax	CHOO	1390 Kc
Barrie	CKBB	950 Kc
Belleville	CJBQ	800 Kc
Blind River	CJNR	730 Kc
Brampton	CHIC	790 Kc
Brantford	CKPC	1380 Kc
Brockville	CFJR	1450 Kc
Chatham	CFCO	630 Kc
Cobourg	CHUC	1450 Kc
Collingwood	CKCB	1400 Kc
Cornwall	CFML	1110 Kc
Cornwall	CJSS	1220 Kc
Dryden	CKDR	900 Kc
Elliot Lake	CKNR	1340 Kc
Fort Frances	CFOB	800 Kc
Galt	CFTJ	1110 Kc
Guelph	CJOY	1460 Kc
Hamilton	CHML	900 Kc
Hamilton	CKOC	1150 Kc
Hamilton	CHIQ	1280 Kc
Hamilton	CHAM	1280 Kc
Hearst	CFLH	1340 Kc
Huntsville	CKAR	630 Kc
Kapuskasing	CKAP	580 Kc
Kapuskasing	CFLK	1230 Kc
Kenora	CJRL	1220 Kc
Kingston	CFRC	1490 Kc
Kingston	CKLC	1380 Kc
Kingston	CKWS	960 Kc
Kirkland Lake	CJKL	560 Kc
Kitchener	CHYM	1490 Kc
Kitchener	CKKW	1320 Kc
Leamington	CHIR	730 Kc
Leamington	CHYR	710 Kc
Lindsay	CKLY	910 Kc
London	CFPL	980 Kc
London	CKSL	1410 Kc
London	CJOE	1290 Kc
Midland	CKMP	1230 Kc
New Liskeard	CJTT	1230 Kc
Niagara Falls	CJRN	1600 Kc
North Bay	CFCH	600 Kc
Oakville	CHWO	1250 Kc
Orillia	CFOR	1570 Kc
Oshawa	CKLB	1350 Kc
Ottawa	CBO	910 Kc
Ottawa	CBOF	1250 Kc
Ottawa	CFRA	580 Kc
Ottawa	CKOY	1310 Kc
Ottawa	CKPM	1440 Kc
Ottawa	CJRC	1150 Kc
Owen Sound	CFOS	560 Kc
Parry Sound	CKAR-1	1340 Kc
Pembroke	CHOV	1350 Kc
Peterborough	CHEX	980 Kc
Peterborough	CKPT	1420 Kc
Richmond Hill	CFGM	1310 Kc
St. Catharines	CKTB	610 Kc
St. Catharines	CHSC	1220 Kc
St. Thomas	CHLO	680 Kc
Sarnia	CKJD	1250 Kc
Sarnia	CHOK	1070 Kc
Sault Ste. Marie	CJIC	1050 Kc
Sault Ste. Marie	CKCY	920 Kc
Simcoe	CFRS	1560 Kc
Smiths Falls	CJET	630 Kc
Stratford	CJCS	1240 Kc
Sudbury	CFBR	550 Kc
Sudbury	CHNO	900 Kc
Sudbury	CKSO	790 Kc
Thunder Bay	CJLX	800 Kc
Thunder Bay	CFPA	1230 Kc
Thunder Bay	CKPR	580 Kc
Tillsonburg	CKOT	1510 Kc
Timmins	CFCL	620 Kc
Timmins	CKGB	680 Kc
Toronto	CBL	740 Kc
Toronto	CFRB	1010 Kc
Toronto	CHFI	680 Kc
Toronto	CHIN	1540 Kc
Toronto	CHUM	1050 Kc
Toronto	CJBC	860 Kc
Toronto	CKEY	590 Kc
Toronto	CKFH	1430 Kc
Wawa	CJWA	1240 Kc
Welland	CHOW	1470 Kc
Windsor	CBE	1550 Kc
Windsor	CKLW	800 Kc
Windsor	CKWW	580 Kc
Wingham	CKNX	920 Kc
Woodstock	CKOX	1340 Kc

LIST OF FM (FREQUENCY MODULATION) RADIO STATIONS

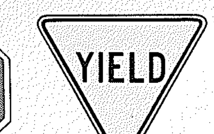
Belleville	CJBQ-FM	97.1 Mc
Brampton	CHIC-FM	102.1 Mc
Brantford	CKPC-FM	92.1 Mc
Cornwall	CJSS-FM	104.5 Mc
Hamilton	CKDS-FM	95.3 Mc
Kingston	CKLC-FM	98.3 Mc
Kingston	CKWS-FM	96.3 Mc
Kingston	CFRC-FM	91.9 Mc
Kitchener	CHYM-FM	96.7 Mc
Kitchener	CFCA-FM	105.3 Mc
London	CFPL-FM	95.9 Mc
North Bay	CKAT-FM	93.7 Mc
Oshawa	CKQS-FM	94.9 Mc
Ottawa	CBO-FM	103.3 Mc
Ottawa	CFMO-FM	93.9 Mc
Ottawa	CKBY-FM	105.3 Mc
Peterborough	CHEX-FM	101.5 Mc
St. Catharines	CKTB-FM	97.7 Mc
St. Catharines	CHSC-FM	105.7 Mc
Sault Ste. Marie	CJIC-FM	100.5 Mc
Sault Ste. Marie	CKCY-FM	104.3 Mc
Sudbury	CKSO-FM	92.7 Mc
Thunder Bay	CKPR-FM	94.3 Mc
Tillsonburg	CKOT-FM	100.5 Mc
Timmins	CKGB-FM	94.5 Mc
Toronto	CBC-FM	94.1 Mc
Toronto	CJRT-FM	91.1 Mc
Toronto	CHFI-FM	98.1 Mc
Toronto	CHUM-FM	104.5 Mc
Toronto	CKFM-FM	99.9 Mc
Toronto	CHIN-FM	100.7 Mc
Windsor	CKLW-FM	93.9 Mc
Windsor	CKWW-FM	88.7 Mc

REGULATORY SIGNS

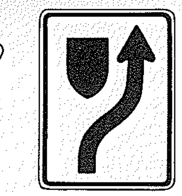
Maximum Speed Sign



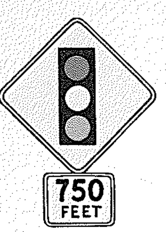
Stop Sign



Yield Sign

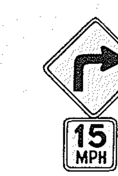

Keep Right Sign

WARNING SIGNS

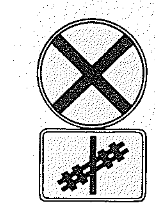


Signals 750 ft.

Stop 500 Ft.



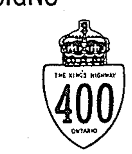
Curve Warning and Advisory Speed


Advance Railway Crossing Signs

GUIDE SIGNS

Provincial Park Marker

Trans-Canada Highway Marker

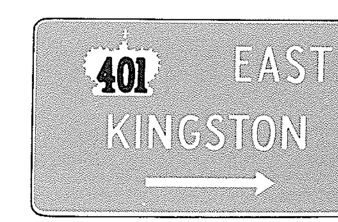


King's Highway Marker

Secondary Highway Marker

Picnic Area Sign

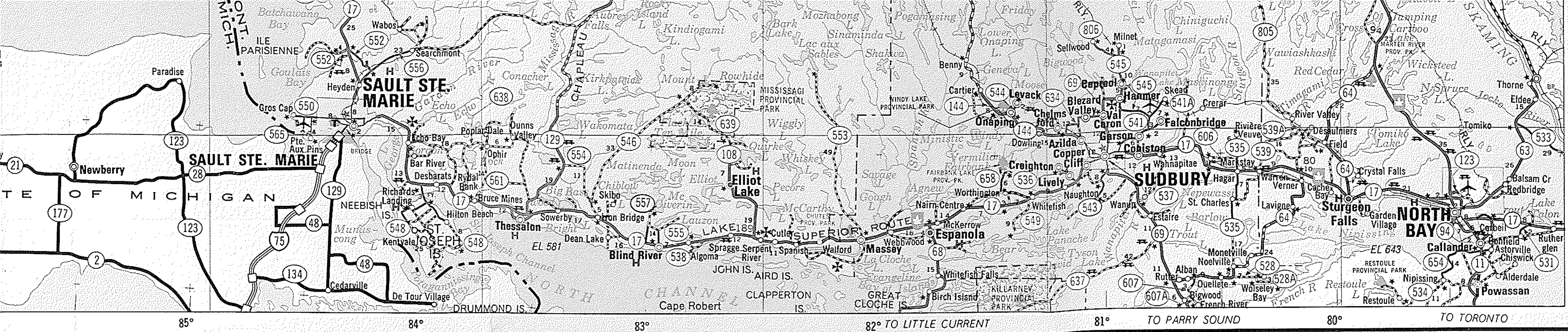
Hospital Marker

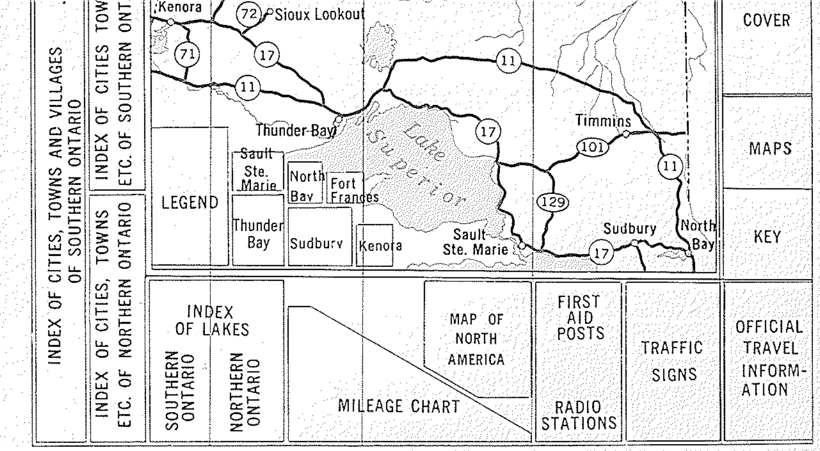


Turn-off Sign

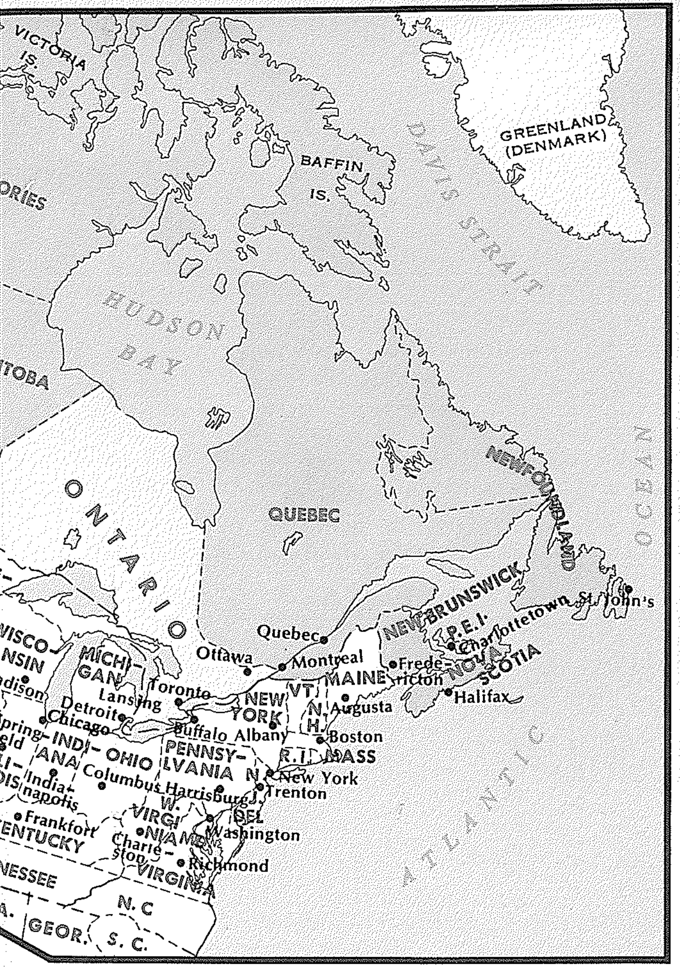
SOURCES OF INFORMATION

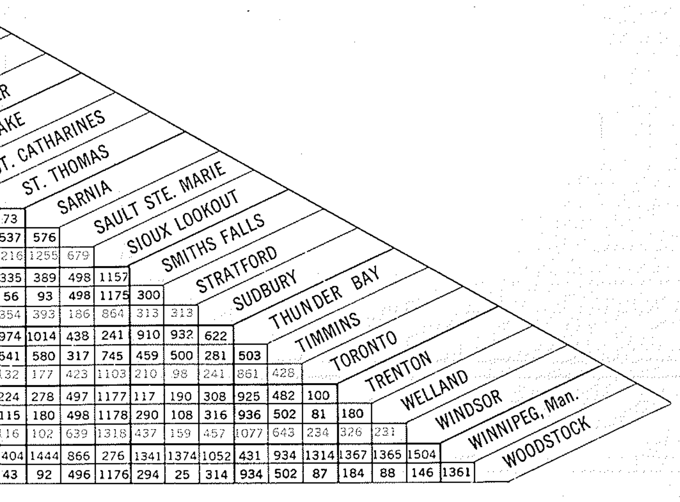
Maps from Department of Lands and Forests, Ontario.
Plans on record in Department of Highways, Ontario.
Camp Sites — Department of Lands and Forests, Ontario.
Highway Map — Department of Roads, Quebec.
U.S.A. State Highway Maps.
Department of Municipal Affairs, Ontario.
Compiled by Photogrammetry Office D.H.O.





KEY MAP OF NORTHERN ONTARIO





ONTARIO HIGHWAY FIRST AID POSTS

This system is maintained jointly by the St. John Ambulance and Ontario Motor League

HIGHWAY	NAME	VICINITY
No. 2	Bernard's Garage	Newcastle
No. 3	Supertest Station	Cottam
No. 3 & 59	Dell Motel	Delhi
No. 4 & 22	Supertest Service Centre	London
No. 5 & 6	Tiny Hick's Towing Service	Waterdown
No. 6	Handicraft House	Wiarton
No. 6	Fire Station	Tobermory
No. 7	Nixon's Garage	Manilla
No. 7 & 15	Stittsville Garage	Stittsville
No. 7 & 41	Fina Service Station	Kaladar
No. 11	Sign of the Elk	Guthrie
No. 11	White Rose Service Station	Latchford
No. 11 & 572	Esso Service Station	Ramore
No. 11	Trans Canada Lodge	Ford Lake
No. 11 & 631	Mooseland Esso Service Station	Nagagami
No. 11	Klotz Lake Camp	Klotz Lake
No. 11	Colimar Lodge	Jellicoe
No. 11	Forest Inn Motel	Kashabowie
No. 11	Mine Centre Resort	Mine Centre
No. 11	Windy Point Resort	Fort Francis
No. 12	Wood's Tractor Sales	Orillia
No. 15	Lakeview Garage	Portland
No. 15 & 32	Sly's Texaco Station	Seeley's Bay
No. 17	Mrs. R. J. Kennedy	Cumberland
No. 17	Champagne's Texaco Service Station	Walford
No. 17	Kennebec Motel	Cutler
No. 17	Echo Bay Service Station	Echo Bay
No. 17 & 582	Moose Lodge (Shell Service Station)	Hurkett
No. 17	Upsala Garage	Upsala
No. 17	Mrs. N. Berglund	Ignace
No. 17 & 105	Esso Service Station	Vermilion Bay
No. 17	Esso Service Station	Hawk Lake

HIGHWAY	NAME	VICINITY
No. 18A	Holiday Beach Provincial Park	Colchester
No. 21 & 81	Sunoco Service Station	Grand Bend
No. 21	Tennyson's Store & Post Office	Underwood P.O.
No. 24	B.A. Service Station	Duntroon
No. 24A	Lang Trim Hall	Galt
No. 28 & 115	Hawson's Esso Service Station	Peterborough
No. 35	Barry's Garage	Dorset
No. 41	Inwood Supertest Service Station	Denbigh
No. 60	Esso Service Station	Golden Lake
No. 60	Ashbury Motor Court	Oxtongue Lake
No. 62 & 127	Peter's Garage	Maynooth
No. 62	St. Joseph House	Combermere
No. 62	Purdy's Post	Combermere
No. 69 & 545	Carol Richard Park Community Assoc.	Hanmer
No. 69	Wing's Car Storage	Pointe au Baril
No. 69	Elsasser's Store	Horseshoe Lake
No. 71	Johnson's Stores	Sioux Narrows
No. 71	Jim's Food Market	Nestor Falls
No. 101 & 575	Parnell's Fina Service Station	Night Hawk Centre
No. 103	M & M Motel	MacTier
No. 124	B.A. Service Station	McKellar
No. 400 & 89	B.A. Service Station	Cookstown
No. 400 & 90	Continental Motor Inn	Barrie
No. 401	Supertest Service Station	Tilbury
No. 401	White Rose Service Station	Dutton
No. 401	B.A. Service Station	Dutton
No. 401	Dave's Texaco Super Service Station	Beachville
No. 401	Esso Service Centre	Beachville
No. 401	B.A. Service Centre	Brighton
No. 516	Mary Lake Motors	Utterson
No. 532	Swift's Boat Livery	Rosseau
No. 592	Leigh's Store & Post Office	Scotia

WHAT TO DO AT THE SCENE OF AN ACCIDENT

(by St. John Ambulance)

1. Be sure your car is parked off the road — "secondary" accidents are common (a farmer's lane is better than the shoulder of the road).
2. Call police, doctor and ambulance.
3. Do not move an injured person unless it is necessary to get them away from danger. If person must be moved, be sure broken bones are immobilized. Use a stretcher (you can improvise one with poles and blankets or coats).
4. Try to stop bleeding by pressing on the wound through a clean pad.
5. For shock: lay patient on back, head and shoulders low, face to one side; loosen clothing; keep warm but don't overheat.
6. To be prepared; carry a first aid kit; take a course in first aid.
7. When handling an unconscious patient, make sure the air passages are kept clear and fluids allowed to drain from the mouth and nose.

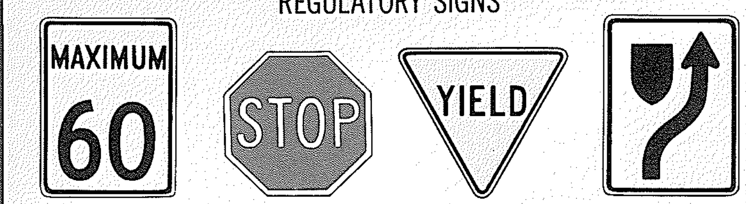
LIST OF STANDARD BROADCASTING STATIONS IN ONTARIO

Ajax	CHOO	1390 Kc
Barrie	CKBB	950 Kc
Belleville	CJBQ	800 Kc
Blind River	CJNR	730 Kc
Brampton	CHIC	790 Kc
Brantford	CKPC	1380 Kc
Brockville	CFJR	1450 Kc
Chatham	CFCO	630 Kc
Cobourg	CHUC	1450 Kc
Collingwood	CKCB	1400 Kc
Cornwall	CFML	1110 Kc
Cornwall	CJSS	1220 Kc
Dryden	CKDR	900 Kc
Elliot Lake	CKNR	1340 Kc
Fort Frances	CFOB	800 Kc
Galt	CFTJ	1110 Kc
Guelph	CJOY	1460 Kc
Hamilton	CHML	900 Kc
Hamilton	CKOC	1150 Kc
Hamilton	CHIQ	1280 Kc
Hamilton	CHAM	1280 Kc
Hearst	CFLH	1340 Kc
Huntsville	CKAR	630 Kc
Kapuskasing	CKAP	580 Kc
Kapuskasing	CFLK	1230 Kc
Kenora	CJRL	1220 Kc
Kingston	CFRC	1490 Kc
Kingston	CKLC	1380 Kc
Kingston	CKWS	960 Kc
Kirkland Lake	CJKL	560 Kc
Kitchener	CHYM	1490 Kc
Kitchener	CKKW	1320 Kc
Leamington	CHIR	730 Kc
Leamington	CHYR	710 Kc
Lindsay	CKLY	910 Kc
London	CFPL	980 Kc
London	CKSL	1410 Kc
London	CJOE	1290 Kc
Midland	CKMP	1230 Kc
New Liskeard	CJTT	1230 Kc
Niagara Falls	CJRN	1600 Kc
North Bay	CFCH	600 Kc
Oakville	CHWO	1250 Kc
Orillia	CFOR	1570 Kc
Oshawa	CKLB	1350 Kc
Ottawa	CBO	910 Kc
Ottawa	CBOF	1250 Kc
Ottawa	CFRA	580 Kc
Ottawa	CKOY	1310 Kc
Ottawa	CKPM	1440 Kc
Ottawa	CJRC	1150 Kc
Owen Sound	CFOS	560 Kc
Parry Sound	CKAR-1	1340 Kc
Pembroke	CHOV	1350 Kc
Peterborough	CHEX	980 Kc
Peterborough	CKPT	1420 Kc
Richmond Hill	CFGM	1310 Kc
St. Catharines	CKTB	610 Kc
St. Catharines	CHSC	1220 Kc
St. Thomas	CHLO	680 Kc
Sarnia	CKJD	1250 Kc
Sarnia	CHOK	1070 Kc
Sault Ste. Marie	CJIC	1050 Kc
Sault Ste. Marie	CKCY	920 Kc
Simcoe	CFRS	1560 Kc
Smiths Falls	CJET	630 Kc
Stratford	CJCS	1240 Kc
Sudbury	CFBR	550 Kc
Sudbury	CHNO	900 Kc
Sudbury	CKSO	790 Kc
Thunder Bay	CJLX	800 Kc
Thunder Bay	CFPA	1230 Kc
Thunder Bay	CKPR	580 Kc
Tillsonburg	CKOT	1510 Kc
Timmins	CFCL	620 Kc
Timmins	CKGB	680 Kc
Toronto	CBL	740 Kc
Toronto	CFRB	1010 Kc
Toronto	CHFI	680 Kc
Toronto	CHIN	1540 Kc
Toronto	CHUM	1050 Kc
Toronto	CJBC	860 Kc
Toronto	CKEY	590 Kc
Toronto	CKFH	1430 Kc
Wawa	CJWA	1240 Kc
Welland	CHOW	1470 Kc
Windsor	CBE	1550 Kc
Windsor	CKLW	800 Kc
Windsor	CKWW	580 Kc
Wingham	CKNX	920 Kc
Woodstock	CKOX	1340 Kc

LIST OF FM (FREQUENCY MODULATION) RADIO STATIONS

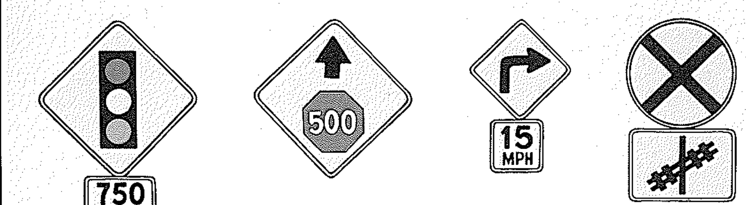
Belleville	CJBQ-FM	97.1 Mc
Brampton	CHIC-FM	102.1 Mc
Brantford	CKPC-FM	92.1 Mc
Cornwall	CJSS-FM	104.5 Mc
Hamilton	CKDS-FM	95.3 Mc
Kingston	CKLC-FM	98.3 Mc
Kingston	CKWS-FM	96.3 Mc
Kingston	CFRC-FM	91.9 Mc
Kitchener	CHYM-FM	96.7 Mc
Kitchener	CFCA-FM	105.3 Mc
London	CFPL-FM	95.9 Mc
North Bay	CKAT-FM	93.7 Mc
Oshawa	CKQS-FM	94.9 Mc
Ottawa	CBO-FM	103.3 Mc
Ottawa	CFMO-FM	93.9 Mc
Ottawa	CKBY-FM	105.3 Mc
Peterborough	CHEX-FM	101.5 Mc
St. Catharines	CKTB-FM	97.7 Mc
St. Catharines	CHSC-FM	105.7 Mc
Sault Ste. Marie	CJIC-FM	100.5 Mc
Sault Ste. Marie	CKCY-FM	104.3 Mc
Sudbury	CKSO-FM	92.7 Mc
Thunder Bay	CKPR-FM	94.3 Mc
Tillsonburg	CKOT-FM	100.5 Mc
Timmins	CKGB-FM	94.5 Mc
Toronto	CBC-FM	94.1 Mc
Toronto	CJRT-FM	91.1 Mc
Toronto	CHFI-FM	98.1 Mc
Toronto	CHUM-FM	104.5 Mc
Toronto	CKFM-FM	99.9 Mc
Toronto	CHIN-FM	100.7 Mc
Windsor	CKLW-FM	93.9 Mc
Windsor	CKWW-FM	88.7 Mc

REGULATORY SIGNS



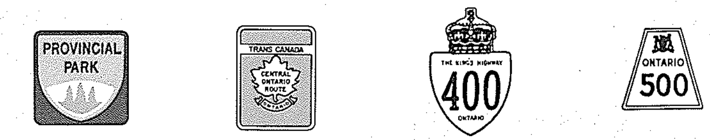
Maximum Speed Sign — Stop Sign — Yield Sign — Keep Right Sign

WARNING SIGNS

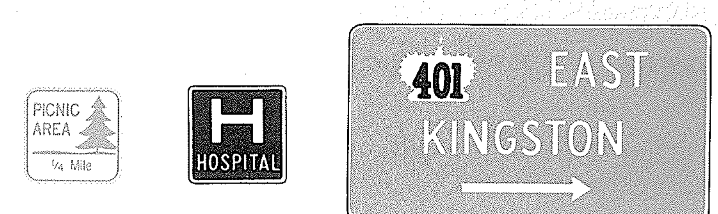


Signals 750 ft. — Stop 500 Ft. — Curve Warning and Advisory Speed — Advance Railway Crossing Signs

GUIDE SIGNS



Provincial Park Marker — Trans-Canada Highway Marker — King's Highway Marker — Secondary Highway Marker



Picnic Area Sign — Hospital Marker — Turn-off Sign

SOURCES OF INFORMATION

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Highway Map — Department of Roads, Quebec.
U.S.A. State Highway Maps.
Department of Municipal Affairs, Ontario.
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Printed in Ontario.

OFFICIAL TRAVEL INFORMATION

is available from: THE DEPARTMENT OF TOURISM AND INFORMATION
10A Parliament Bldgs., Toronto, Ont.

HON. JAMES A. C. AULD, Minister
A. S. BRAY, Deputy Minister

A complete travel counselling service for visitors and residents is maintained in the Department's office, 185 Bloor Street East, Toronto, and travel information services are found at the following official Government Reception Centres:

SOUTHERN ONTARIO

Windsor — Ambassador Bridge; Windsor-Detroit Tunnel
Sarnia — Blue Water Bridge
Niagara Falls — Niagara Falls, Ont., Rainbow Bridge Exit
Fort Erie — Peace Bridge Exit
Barrie — Hwy. No. 400, north of Hwy. 27 Interchange
Queen Elizabeth Way — Garden City Skyway & Hwy. No. 8
Thousand Islands Bridge — Hwy. No. 401 west from Bridge
Thousand Islands Bridge — Hwy. No. 137 Hill Is.
Prescott — (Johnstown) — Prescott-Ogdensburg Bridge
Cornwall — Seaway International Bridge Exit
Hawkesbury — Hawkesbury Bridge
Point Fortune — At Quebec Boundary
Lancaster — 2 miles east on Highway No. 2

NORTHERN ONTARIO

Sault Ste. Marie
Sault Ste. Marie International Bridge Exit

Pigeon River
Bridge Exit

Fort Frances
Church St.

Kenora-Keewatin
Highway No. 17

Rainy River
Opposite Bridge Plaza

Tourist Reception Centres are shown on face of Map, thus

ONTARIO PROVINCIAL POLICE

District Headquarters' Addresses and Telephone Numbers

District No. 1, 317 Queen St., **CHATHAM, ONT.**, Phone 352-1122
District No. 2, Highway 401 & Wellington Rd., **LONDON, ONT.**, Phone 438-1746
District No. 3, Queen Elizabeth Way & Highway No. 2, **BURLINGTON, ONT.**, Phone 528-0666
District No. 4, Queen Elizabeth Way & Stanley Ave., **NIAGARA FALLS, ONT.**, Phone 356-1311
District No. 5, Highway 401 & Keele St., **DOWNSVIEW, ONT.**, Phone 248-3151
District No. 6, No. 6 Highway North, **MOUNT FOREST, ONT.**, Phone 323-3130
District No. 7, Highway 400 at Highway No. 26, **BARRIE, ONT.**, Phone 726-6484
District No. 8, Jct. 7 & 7A Highways, **PETERBOROUGH, ONT.**, Phone 742-0401
District No. 9, Highway 401 at Highway No. 14, **BELLEVILLE, ONT.**, Phone 968-5507
District No. 10, 12 Victoria St., **PERTH, ONT.**, Phone 267-2626
District No. 11, Highway No. 2, **LONG SAULT, ONT.**, Phone 534-2223
District No. 12, 489 McIntyre St. West, **NORTH BAY, ONT.**, Phone 472-4343
District No. 13, 20 Young St. South, **SUDBURY, ONT.**, Phone 675-1361
District No. 14, No. 17 Highway, North City Limits, **SAULT STE. MARIE, ONT.**, Phone 254-1415
District No. 15, Highway 101, **SOUTH PORCUPINE, ONT.**, Phone 235-3345
District No. 16, 489 North Algoma St., **PORT ARTHUR, ONT.**, Phone 344-8421
District No. 17, Water Street South, **KENORA, ONT.**, Phone 468-8971

This **ROAD MAP** and the following maps are prepared for free distribution by the Department of Highways, Ontario.

MAP OF NORTHERN ONTARIO
An enlarged map that shows more detail about Northern Ontario.

Copies of the above maps may be obtained by writing to the Map Office, Department of Highways, Downsview, Ontario, or Department of Tourism and Information, Parliament Buildings, Toronto 5, Ontario.

THE "ROAD BULLETIN" issued every two weeks from May to November, lists sections of King's Highway and Secondary Highways under construction. This bulletin is available, free of charge, from: Information Section, Department of Highways, Downsview, Ontario.

LARGE SCALE COUNTY MAPS OF SOUTHERN ONTARIO priced at a nominal sum, each may be obtained from the Map Office, Department of Highways, Downsview, Ontario, upon request.