A CLASSIFICATION OF PEATLANDS IN EASTERN NEWFOUNDLAND

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IN
EASTERN NEWFOUNDLAND

by

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A Thesis submitted in partial fulfillment
of the requirements for the degree of
Master of Science

Department of Biology
Memorial University of Newfoundland

May 1976

St. John's Newfoundland

ABSTRACT

The peatlands of eastern Newfoundland have been classified into six morphological types. The separation of types is based on peat depth, botanical constituents and degree of humification of the different peat strata, surface vegetation, and surface contours relative to the surrounding topography.

The following peatland types are described:

1. Raised Bog
2. Blanket Bog
3. Slope Bog
4. Basin Bog
5. Patterned Fen
6. Flat Fen

The vegetation of these morphological peatland types has been classified into seven plant associations and four communities using the methods of the Zurich-Montpellier School of Phytosociology. These floristic units are listed below in their approximate order of minerotrophy:

1. Cladonio-Vaccinietum vitis-idaea -- characteristic of dry heath-like conditions on raised, blanket, slope and basin bog.

2. Kalmio-Sphagnetum fusci -- characteristic of drier areas of raised, blanket, basin and slope bogs.

3. Calamagrostio-Sphagnetum fusci -- represents the Sphagnum fuscum hummocks of fens.

4. Scirpo-Sphagnetum tenelli -- represents the wet flats and hollows of raised, blanket, slope and basin bogs.

5. Scirpo-Sphagnetum subniti -- this is the dominant vegetation type of slope bogs and occurs only on that morphological peatland type.

6. Betulo-Sphagnetum stricti -- the dominant vegetation type of patterned fens and occurs only on that morphological peatland type.

7. Betulo-Thalictretum polygoni -- represents the minerotrophic flat fens.

8. Nuphar variegatum Community -- represents the deep, open pools of raised, blanket and basin bogs.

9. *Sphagnum torreyanum* Community -- represents the shallow pools of raised, blanket and basin bogs.

10. *Utricularia cornuta* Community -- represents the shallow mudflats of raised, blanket and basin bogs.

11. *Drosera intermedia* Community -- represents the more nutrient-enriched pools of patterned and flat fens.

Water samples from a bog pool, characterized by the *Nuphar variegatum* community, and from a fen pool within a *Drosera intermedia* community site, were analysed for comparative assessment of algal species composition. The fen pool algal populations included 41 species; the bog pool had 22 species. This result is indicative of differences in nutritive conditions between bog and fen habitats.

The morphological and phytosociological classifications presented were prepared on basis of independent sets of criteria. Nevertheless, it was found that the two systems were complementary and that particular phytosociological units were characteristic of particular morphological peatland types as listed above. To further test the validity of the proposed phytosociological classification a series of nutrient analysis, soil thaw rates and soil pH determinations were obtained for selected peat soils underlying the major floristic units. Results of these analyses strengthened the validity of the classification.

ACKNOWLEDGEMENTS

I am very grateful to Dr. W.J. Carroll, Director, Newfoundland Forest Research Centre (NFRC), for provision of working facilities within that department. I am especially indebted to Dr. F.C. Pollett, Research Scientist, NFRC, for his encouragement, supervision, and helpful advice in the collection of data and the final compilation of this thesis.

I wish to thank Mr. Roy Ficken, Department of Biology, Memorial University, for technical advice in the printing of photographs, and to Mr. Eugene Mercer, Newfoundland and Labrador Wildlife Service, for providing the opportunity to take aerial photographs of the different peatland types in eastern Newfoundland. Special thanks to Mr. E. Dawe, NFRC, for his assistance in determining pH and nutrient contents of selected peatland soils; to Mrs. E. Quick for typing the vegetation tables; and to Mr. L. May, NFRC, for assistance in the selection and sampling of morphological peatland types in eastern Newfoundland.

I am also grateful to Mr. W. Meades, NFRC, for his time freely given in reading much of this manuscript, and for his helpful suggestions in the final writing and compilation.

TABLE OF CONTENTS

Page

LIST OF TABLES

Page

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER I. INTRODUCTION

Newfoundland forms part of the world's 'boreal zone' which is defined by Sjors (1961a) as "...the almost circumpolar zone in the north where drained grounds are covered by prevailing coniferous forests". Sjors further states that "...the greater part of the total peat area of the world is within the boreal zone .... and the most common type of unwooded areas are bogs and fens". Because of climatic and hydro-topographic conditions the Island of Newfoundland does not exactly fit the above description. It is a mixture of scrub- and heath-covered barrens admixed with shallow fens on the exposed uplands, and of coniferous forest interspersed with fen and deep bog on the lowlands.

The peatlands of Newfoundland cover about 17-20% of the land area, or 5-6 million acres (Pollett, 1968a) and, with few exceptions, they are non-forested. In recent years evaluation of this land area has focused on the multiple-use resource potential of peatlands. At present, the peatlands are being assessed for their forestry and agricultural potentials. Inventories of their peat moss and peat fuel volumes are being calculated. Some areas are being utilized in park recreational programs while others have been checklisted through the International Biological Program. Also, peatlands are being investigated to determine their productivity rating and assess their carrying capacity for wildlife.

However, even with this scale of activity there is no integrated program of peatland management undertaken in the province.

If such an integrated program of peatland development is to occur, it should be based on interpretive sets of baseline information obtained for each of the major wetland types. One type of information is a site classification by which any peatland can be readily identified according to its ecological characteristics. If this classification were available, areas could be selected on an ecological basis for purposes of industrial or recreational use or for purpose of conservation.

The need for a peatland classification in Newfoundland led to the establishment of an in-depth research program in peatland ecology by the Federal Department of the Environment. These studies emphasized and resulted in the determination of a phytosociological classification of bog and fen throughout central, western and northern Newfoundland. (e.g. Pollett, 1968a, 1968b, 1968c, 1972a, 1972b, 1972c). However, no attempt was made to prepare a detailed classification based on morphological site criteria. Furthermore, none of the investigations were undertaken in eastern Newfoundland. Because of this lack of information and the present need for ecological data in peatland resource development, this study of the peatlands in eastern Newfoundland was undertaken.

The objectives of the study were:

1. To establish a phytosociological classification of peatlands in eastern Newfoundland and to compare this classification with existing works completed for other regions of the Island.

2. To develop a morphological classification of peatlands for eastern Newfoundland and to determine distributions of phyto-sociological units in relation to site morphology.

Previous Peatland Research in Newfoundland

Many of the peatlands of Newfoundland have already been classified using criteria such as composition of plant communities, nutrient status, site morphology, physical peat characteristics and to a much lesser degree, hydrology. These studies include the works of Damman (1964), Heikurainen (1968), Pollett (1968a, 1968b, 1968c, 1972a, 1972b, 1972c) and Pollett and Bridgewater (1973).

Damman (1964) first developed the classification framework on which all subsequent peatland ecological studies undertaken in Newfoundland have been based. His classification is as follows:

1. Dwarf shrub bog (dry, nutrient poor; vegetation dominated by ericaceous shrubs);

2. Oligotrophic bog (wet, very nutrient poor);

3. Mesotrophic bog (moderately poor, wet);

4. Mesotrophic fen (moderately poor, with meadow-like vegetation);

5. Eutrophic fen (nutrient-rich; vegetation with more exacting nutrient requirements);

6. Marsh (nutrient-rich vegetation composed of sedges and grasses; vegetation of periodically flooded alluvial soils).

Pollett (1968b) utilized this approach in describing the peat resources of Newfoundland. However, dominant species comprising the surface vegetation were also described.

A modified peatland classification was developed by Heikurainen (1968) who described the species composition of the site and the relationship of species groups to nutrient status. Six main bog and fen types were described:

1. Dwarf shrub bog (*Kalmia*-*Sphagnum fuscum* bog);

2. Small sedge bog (*Sphagnum*-*Scirpus cespitosus* bog);

3. Sedge bog (*Carex oligosperma* bog)

4. Herb-rich sedge bog (Sphagnum recurvum-Carex-Herbaceae bog);

5. Sphagnum fen (Sphagnum warnstorfii fen);

6. Brown moss fen (Campylium stellatum-Scirpus fen).

A later approach (Pollett, 1972b), based on morphological and floristic criteria, was used to classify the Newfoundland peatlands into three general types:

1. Ombrotrophic peatlands - separated into three geographically distinct types.

   a. raised bogs of the central ecoregion,

   b. blanket bogs of the eastern and western ecoregions,

   c. blanket bogs of the northern coastal ecoregion.

2. Weakly minerotrophic peatlands - peatlands that have developed under a slight to moderate minerotrophic influence; e.g. thin blanket peats, fen hummocks, mud bottoms, sloping fens, and particular marsh varieties.

3. Euminerotrophic peatlands - includes rich fens.

All three types have been classified phytosociologically with either plant communities or associations described for each. The six major plant associations listed below characterize most of the bogs and fens surveyed in Newfoundland.

1. Kalmio-Sphagnetum fusci - represents the drier hummocks and all but the wettest hollows of both raised bogs and western-eastern blanket bogs.

2. Rubo-Empetrum nigri - sites similar to those of Number 1, but occurring in the northern coastal regions of Newfoundland.

3. Scirpo-Sphagnetum papillosi - represents the poor fens concentrated in central Newfoundland.

4. Potentillo-Campylietum stellati - characterizes the majority of rich (euminerotrophic) fens throughout the central-western regions of Newfoundland.

5. Thalictro-Potentilletum fruticosae - represents the very rich, moist, meadow-like fens of the northern peninsula limestone barrens.

6. Betulo-Vaccinietum uliginosi - represents the drier, more heterogeneous fens of the northern peninsula limestone barrens.

Site parameters, including nutrient contents and pH of the peat soils have been correlated with the peatland units (Pollett, 1972c).

Geographic Setting

Study Area

The study area comprised a large part of the Forest Section B30 within the Boreal Forest Region (Rowe, 1972) including the Avalon, Burin and Bonavista peninsulas (Figure 1-1).

Topography

The Avalon and Burin peninsulas are characterized by a flat to gently rolling topography which seldom exceeds 200 m in elevation. Extensive areas of ericaceous heath barrens occur, especially in the central and northern regions of the Avalon peninsula. Many of the hills are severely exposed and alpine heath is not uncommon. The topography of the Bonavista peninsula is relatively flat, however, it rises toward the north reaching a maximum of 150 m above sea level.

Coniferous forests occur throughout most of the Bonavista peninsula and the lowlands of the central and eastern sections of the Avalon peninsula. Deep, ombrotrophic *Sphagnum* bogs occur in poorly-drained depressions of the more sheltered forested regions. Small

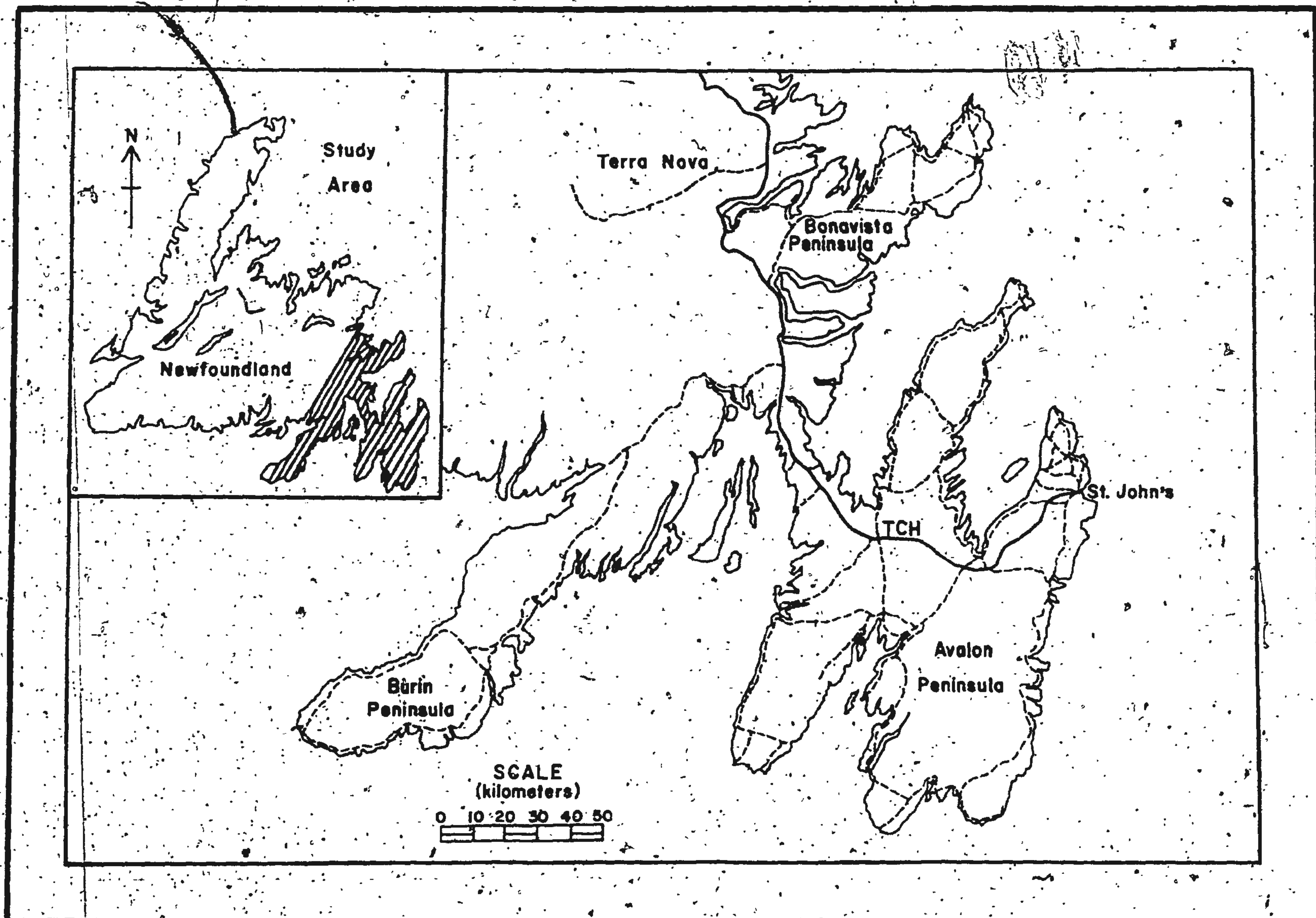

Figure 1-1: Map of Eastern Newfoundland showing study area.

topographically confined slope bogs are numerous throughout eastern Newfoundland, whereas larger blanket bogs characterize the extreme southern coastal regions.

Geology and Soils

Eastern Newfoundland is underlain by a basement of Precambrian rock. The Burin peninsula is dominated by acidic to mafic volcanic rocks whereas the Bonavista and Avalon peninsulas are characterized mostly by siltstone, slate, conglomerate, and acidic to minor volcanic rocks. Pockets of Cambrian shales are also frequent.

Humo-ferric podzol is the predominant soil type in the study area. However, ferro-humic podzols are common on the Avalon and Burin peninsulas, the Isthmus of the Avalon and the northern tip of the Bonavista peninsula. Placic ferro-humic podzols are more common along the coastline. Organic deposits, some extensive, are scattered throughout the whole region. In general the eastern portion of Newfoundland lacks base-rich rocks, and the soils, both organic and mineral, are quite acid (Heringa, pers. comm.).

Climate

Mean annual precipitation of the study area is generally greater than elsewhere in Newfoundland. It varies from 135 cm for the Avalon and southern Burin peninsulas, to 127 cm for the northern Burin peninsula, and 102 cm for the Bonavista peninsula. Similarly, moisture surpluses vary from about 50 cm in the more northerly regions of the Bonavista peninsula to 90 cm for most areas of the Avalon and Burin peninsulas. Moisture surpluses as high as 110 cm have also been recorded for certain areas of the Avalon peninsula (Pollett, 1968b).

The development of most peatlands is related to climatic conditions. Granlund (1932) reports that raised bogs in Sweden are concentrated primarily in areas with precipitation between 62 cm and 100 cm. Where precipitation is greater than 100 cm blanket bogs are dominant. Extensive blanket bog development occurs even over sloping ground in the humid southern regions of the Avalon and Burin peninsulas. Furthermore, Auer (1930) states that although it is the existence of depressions or other favouring topographic features that brings about the local growth of peat bogs, a "generous" rainfall favours their formation.

The mean air temperature for January is $4^{\circ}C$ and for July is $12^{\circ}-15^{\circ}C$, Pollett (1968b). The coolness of the summer temperatures is attributed to influences of the cold Labrador current. These cool temperatures in combination with a moisture surplus, high humidity, and a frost-free season of about 120-150 days, reduce the rate of evaporation and further promote bog development in eastern Newfoundland.

Peatland Classification Systems

Peatlands comprise about 150 million hectares (375 million acres) of the world's land surface (Tibbett's, 1968), and, in recent years have been the focus of attention of many researchers (ecologists, botanists, foresters, engineers, etc.). Consequently, many peatland classification systems have been developed, independent of one another, to satisfy the needs of particular disciplines. These multifarious approaches to the classification problem have led to almost insurmountable difficulties in efforts to produce a universal classification.

The practicality and applicability of any classification system depends mainly upon its purpose (e.g. forestry, agriculture, commercial, etc.). Most approaches to peatland classification comprise external features of the peatlands (e.g. vegetation, morphology, physiognomy) or internal physico-chemical features (e.g. peat chemistry, structure, hydrology, degree of humification), or a combination of both.

The internal properties of peatlands generally involve environmental gradients, nutrient status, and origin and structure of the organic soils. Nutrient status has been used successfully as a basis for peatland classification in Europe (DuRietz, 1949; Bellamy, 1968) and in North America (Sjors, 1959, 1963; Heinselman, 1963). Similarly, classification systems based on structure, degree of decomposition and floristic origin of peat have been described (Day, 1968; Farnham, 1963, 1968; MacFarlane and Radforth, 1968; Moore, 1973; Puustjarvi, 1973).

The external features of peatland classification are generally emphasized in a landform approach (Dachnowski, 1921; Drury, 1956; Radforth, 1969; Bellamy, 1972; Ruuhijarvi, 1972). However, some approaches stress either features of plant physiognomy and dominance (Whittaker, 1962; Penfound, 1967; Jeglum, Boissoneau and Haavisto, 1973), or floristics (Duvigneaud, 1949; Pollett and Bridgewater, 1973).

Most modern-day approaches to peatland classification incorporate both internal and external features of peatlands. For example, Heinselman (1963, 1970) in Minnesota and Tarnocai (1970) in Manitoba describe water regime, physical characteristics, ecology and natural vegetation as defining criteria of peatlands. Other approaches involve hydro-morphological factors (Goode, 1973; Malmer, 1973), nutritional status and plant communities (Pollett, 1972a, 1972b, 1972c; Toleman, 1973); vegetation, peat and sub-soil (McEwen, 1967).

Three major categories of peatland classification that underlie much of current peatland research are outlined by Pollett (1972b):

1. Morphological - involving the peatland complex
2. Phytosociological - involving sub-units of the complex
3. Ecological - the linking theme, involving ecological parameters.

The first wetland classification involving aspects of all three approaches has been developed in Canada by Zoltai, et al. (1975). The four classificatory levels listed below are heirarchical in structure, descending from the generalized levels to the specific levels.

Level 1: - most generalized; based on site features which either constitute or contribute to the physiognomy of the wetlands. The major wetland classes are:

a) bog
b) fen
c) marsh
d) swamp
e) shallow open water

Level 2: - based primarily on surface morphology of the wetland; e.g., raised, or level surfaces, patterns or ridges, depressions or pools.

Level 3: - the wetlands defined in Level 2 are here defined on the basis of their vegetation characteristics.

Level 4: - the most detailed level of the classification where the specialized needs of disciplines are recognized.

Methods

The peatlands of eastern Newfoundland have been classified according to morphological and phytosociological criteria and supplemented by ecological data. The methods used in the classification are presented below.

A. Morphological

A total of 156 peat profiles were described from peat cores sampled from 47 selected sites (Figure 1-2). A Hillier peat sampler was used to obtain the profiles and depths of the peat deposit. Cores were taken at every 50 cm depth until bottom was reached. The peat texture, botanical constituents (Sphagnum, sedge, woody, etc.) and degree of humification (Table 1-1) were determined and recorded for each core depth. Not less than three such profiles were taken on each of the different peatland sites investigated (locations in Appendix I).

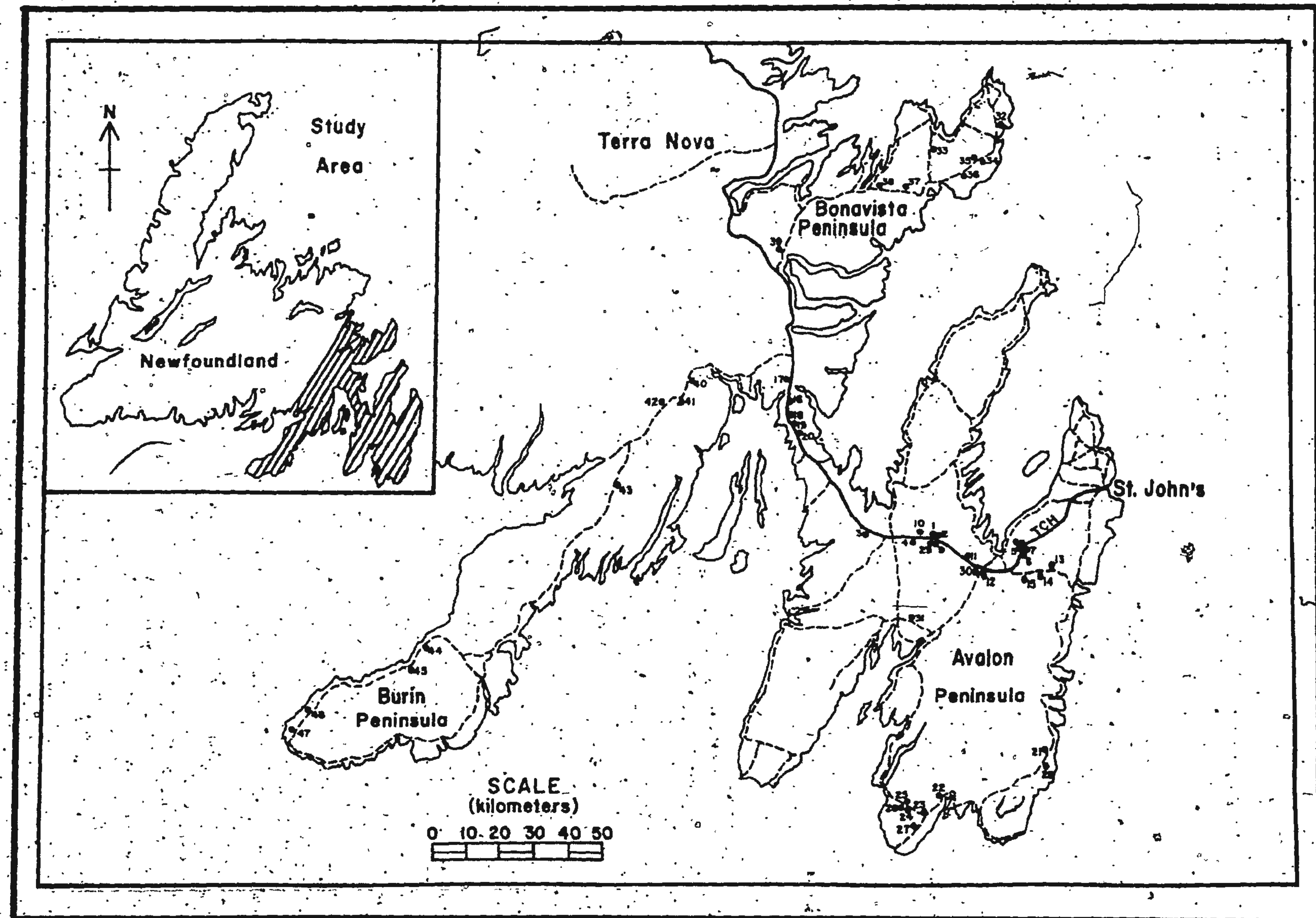

Figure 1-2: Map of study area showing morphological sample sites.

TABLE 1-1: METHOD FOR DETERMINATION OF HUMIFICATION OF PEAT SAMPLES (From von Post, 1926)

Humification Scale	Evidence of Degree of Decomposition	Plant Structure	Mud Present	Water Passing	Upon squeezing through fingers, amount of peat substance passing	Residue
1	nil	recognizable	nil	yes. clear and colourless	none	none
2	almost nil	recognizable	nil	yes. clear but yellow brown	none	none
3	very little	recognizable	little	yes. distinctly turbid	none	none
4	little	mostly recognizable	some	yes. very turbid	none	some. somewhat pulpy
5	fairly evident	barely recognizable	moderate amount	yes. moderate amount	some	very pulpy
6	evident	indistinct less in residue	moderate amount	yes. moderate amount	one-third	very pulpy
7	strong	fairly recognizable	much	yes, some. dark in colour	one-half	very pulpy
8	strong	very indistinct	much	yes, some. dark in colour	two-thirds	greasy
9	almost fully decomposed	almost unrecognizable	very much	very little; very dark in colour	almost all	greasy
10	completely decomposed	entirely without plant structure	entirely muddy	no free water	all	greasy

After the different peatland types were determined (e.g. raised bog, slope bog, aapa fen, etc.), a representative peat deposit of each type was selected (locations in Appendix II) for more intensive morphological studies. At least 6-7 profiles were taken and degree of slope per unit distance was recorded using an Abney hand level and a chain measure. These peat deposits are illustrated in Figures 2-1 to 2-6.

B. Phytosociology

The phytosociological methods of the Zurich-Montpellier School of Phytosociology (Braun-Blanquet, 1932, 1951) were used in the description of 248 relevés from 128 peatland sites (Figure 1-3) and the subsequent delineation of 11 vegetative units. Although this method has been criticized as being subjective, it has successfully been applied to classify forests, heath, peatlands and grasslands throughout the world (e.g. Duvigneaud, 1949; Damman, 1964; Williams and Varley, 1967; Bridgewater, 1970; Pollett, 1972a, 1972b; and Meades, 1973). It is probably the most universally adopted phytosociological method presently used in wide-scale vegetation surveys. According to Poore (1955):

> "The techniques of describing vegetation practiced by the Braun-Blanquet School offer a happy mean between time-consuming statistical methods and the rather slipshod description of large areas practiced by many English-speaking workers. Furthermore, Anglo-American ecologists tend to over-estimate the importance of dominance; they are thus prone to overlook well-defined communities occurring within vegetation dominated by the same species."

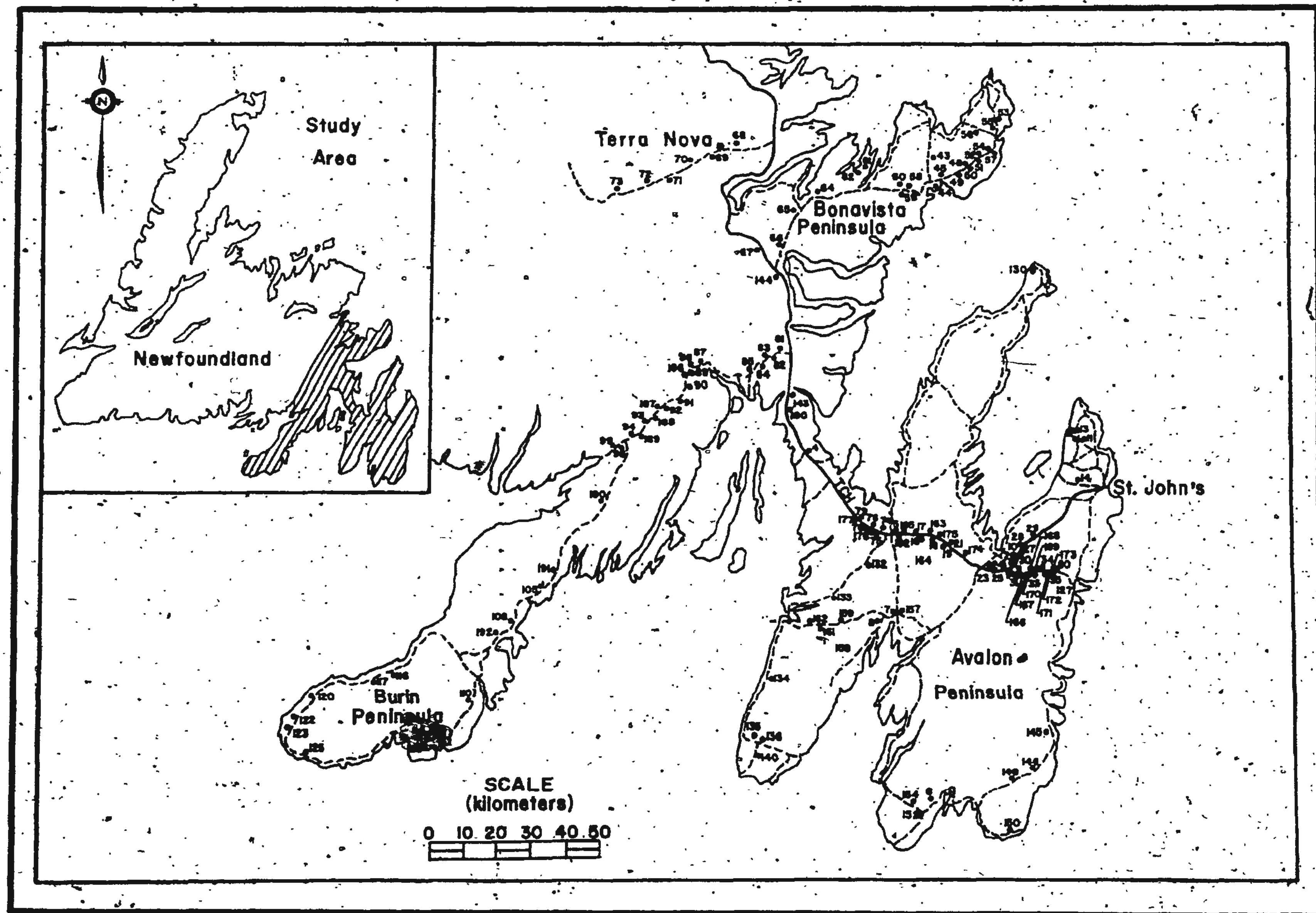

Figure 1-3: Map of study area showing phytosociological sample sites.

In an effort to compare and evaluate certain phytosociological techniques, Moore, et al (1970) described three areas of vegetation (dune, mountain heath, and salt-marsh) in Ireland using the following techniques:

1. The Braun-Blanquet method
2. Association and inverse analysis of Williams and Lambert (1959, 1961)
3. Cluster analysis based on different coefficients of similarity, and
4. Ordination or principal component analysis performed on matrices of different coefficients.

The overall results indicated that the Braun-Blanquet method is considered to combine several advantages of the other methods and to be the most economical in terms of "efficiency" (ratio of time input to information emerging). Further, Shimwell (1971) states that:

> "The results of comparative studies and studies on the best method for a particular problem have shown: (a) that there is no general 'best method', and (b) with respect to time involved and information obtained, the methods of the so-called traditional schools of phytosociology present a better over-all understanding of the complexity of the nature of the vegetation."

Since its creation about 50 years ago, the Z-M approach to vegetation classification has undergone only minor changes in methodology. The works of Braun-Blanquet (1932), Poore (1955, 1956), Ellenberg (1956) and Becking (1957) form the basis of the Zurich-Montpellier approach today, but contains remnants of outmoded terminology. The most recent, and more reliable, accounts of the Z-M methodology are presented by Westhoff and Den Held (1969), Bridgewater (1970), Pollett (1972a), Shimwell (1971) and Meades (1973).

The techniques of the Zurich-Montpellier school of phytosociology can be divided into two phases: (a) analytic phase, concerned with selection and sampling of plant communities; and (b) synthesis phase, concerned with the synthesis of field data into a heirarchical phytosociological classification system. In the following summary, the analytic phase follows Bridgewater (1970), Moore, et al. (1970) and Shimwell (1972), whereas synthesis follows Shimwell (1972).

1) Analysis

The analytic phase of the Z-M methodology involved the collection of field data, denoted by relevés throughout the text. This sampling procedure has been termed very subjective since it allows the investigator freedom to choose the most representative uniform sampling areas. At first glance, the approach appears to be very biased and selective. However, the phytosociologist with his knowledge of the study area -- climate, topography, pedology, flora -- will, with a little experience, be able to detect different floristic combinations within different habitats, thereby enabling him to sample plant communities selectively, but also representatively. Becking (1957) describes this as a "phytosociological view" of vegetation by the investigator.

One of the major sampling problems associated with the Z-M method was selection of a uniform or homogenous area. Poore (1955a) defined it as "...the essential prerequisite of all phytosociological systems, but it is unfortunate that one cannot define with precision what is meant by uniformity". A statistical method of determining homogeneity of a vegetational area involves the concept of 'minimal area' (Hopkins, 1957; Bridgewater, 1970). This concept was used in the study of Newfoundland bogs and fens in central, western, and northern Newfoundland (Pollett, Bridgewater and Wells, 1970). The minimal sizes of sampling area established for uniform homogeneous mats within bog and fen were 1/16 sq. m. and 1 sq. m. respectively. As the sample area increased beyond this size, the numbers of additional species were almost negligible. Closed vegetation units (e.g. hummocks, hollows, pools, etc.) were sampled within their complete boundaries regardless of size. This method of determining minimal area is appropriate for sampling relatively few sites, but is too time consuming for large-scale surveys.

An alternative approach to determining homogeneity, and one that was used in this study, was visual assessment as advocated by Moore, et al. (1970) who stated:

> "A properly trained field worker in the Braun-Blanquet school will choose areas for description on the basis of two criteria:
>
> 1) that the main physiognomic and floristic types of the vegetation seen in the area being studied are reasonably sampled, and;
>
> 2) that the sample plots seem uniform in regard to vegetation and to obvious features; this is aimed at avoiding the inclusion of two vegetation types within one relevé."

The collection of field data will, in most instances, contain some "unhomogeneous" relevés. However, synthesis of the vegetation table serves as a quasi-objective test for homogeneity. A relevé consisting of plants from two different communities will contain a large number of species -- often twice the mean value for the community. In addition, the relevé will include a long list of isolated occurrences of plants.

After selection of a uniform sample area, all plant species within that area were listed and given a combined value on the scales of cover/abundance and sociability. Also included were the relevé number, locality, grid reference, altitude, date, and other obvious ecological, pedological, hydrological and topographic features.

The Scales used in Describing the Vegetation:

Abundance/Cover

+ - one occurrence

1 - covering up to 5%

2 - covering 6-25%

3 - covering 26-50%

4 - covering 51-75%

5 - coverage greater than 75%

r - present in close proximity, but not in the sample site

Sociability

1 - growing singly (k = seedling)

2 - growing in tufts or trailing

3 - large groups or patches

4 - extensive patches covering greater than 50% of the sample area

5 - forming extensive carpets over 75% of the sample area

2) Synthesis

Upon completion of field work, the relevés were aggregated in a 'raw' table. To facilitate this procedure, squared paper was used with the species names written at the left side of the table and each relevé assigned a vertical column. Species are sometimes arranged under the separate headings of trees, herbs, mosses, lichens, etc. This approach, however, is more convenient than valid and can be very time-consuming.

Regardless of the species arrangement, it is apparent, even to the unskilled eye, that certain species combinations recur, and that these species groups may be mutually exclusive.

The species groups, as well as species having a restricted occurrence in the raw table, were then transferred to a partial table, with the aid of transfer slips (see Shimwell, 1972, pp. 191-194). Such species were then re-arranged vertically and horizontally into definite groups of mutually exclusive species, or groups of "differential species". Finally, the differentiating species were written on the left of the table in groups and the relevés were rearranged vertically into a new order to give a progression of species groups from left to right of the table. Repeated sorting resulted in an association synthesis table (e.g. Table 3-1).

The concept of "characteristic" or "faithful" species was once widely used to define vegetation units within a synthesis table. Originally, it was defined as a species which would occur more frequently or exclusively in one particular community than in all other communities of an area under study. However, it is obvious that only species with narrow ecological amplitudes suited this purpose and the number of such species decreased proportionately with an increase in the size of the study area.

This ultimately led to the concept of differential species which is used to differentiate one vegetation unit from several other vegetation units but not with respect to all other units considered within an area. Thus, the "characteristic" or "faithful" species is only a special case of the differential species; i.e., the characteristic species is a differential species with respect to all vegetation units considered.

The concept of "differential species groups" was used to define phytosociological units in this study of eastern Newfoundland peatlands. Since the ecological amplitude of a differential species tends to vary considerably throughout its geographical range, inherent difficulties result in classification over a large area. As a result, such species cannot be used alone to describe a vegetation type. However, their repeated occurrence within a group of species constitutes a "differential species group" which differentiates a vegetation type from all other vegetation types.

Differential species groups are related to site factors as defining units. These groups of species are referred to as sociological species if they consistently occur together but do not necessarily have the same ecological amplitude. If they all possess narrow ecological tolerances related to sharply defined site factors, they are termed "ecological species groups".

Presence values were listed on the right-hand side of the synthesis tables for each of the plant species. These values range from I to V and denote the percentage of occurrence of a particular plant species in the table. For example, the differential species, Cladonia rangiferina, occurred in all the sites recorded in Table 3-1. It was therefore assigned a presence value of V (81-100%). Cetraria islandica, on the other hand, occurred in seven of the recorded sites or 58% of the sites. It was assigned a presence value of III (41-60%). Presence values of 1-5 were assigned to species where the number of recorded tests in a synthesis table (e.g. Table 3-10) was five or less. The presence values of the differential species were summarized in tabular form (e.g. Table 3-13) to comparatively assess the floristic variation within the vegetation presently under study.

The association or community tables group species along a gradient of ecological amplitude resulting in a heirarchical classification system consisting of classes, orders, alliances, associations, sub-associations, and variants. Specific endings are given to community names, which indicate the rank of the community in the system as shown below:

Rank	Ending
Class	-etea
Order	-etalia
Alliance	-ion
Association	-etum
Sub-Association	-etosum
Variant	------

The naming of community rank followed that of Bach, Kuoch, and Moore (1962). All synthesis tables in this text have been classified in the association level.

3) Algae: Bog Pool vs. Fen Pool

Water samples containing organic matter were collected from two different aquatic peatland communities -- a bog pool and a fen pool -- to record the different species of algae that grow in each of the different habitats. Although the collection and synthesis of data did not involve phytosociological methods, the final results complemented the phytosociological units defined for these habitats.

To facilitate sampling, a large dip net with a fine mesh was used to scoop up the "muddy" decomposed peat from the bottom of each habitat. This material was then transferred to quart-size sample bottles comprising four replicas from each habitat.

The eight sample bottles consisting of approximately 2/3 organic material and 1/3 water from the sample sites, were placed in an environmental chamber at a temperature of 15^{o}C. Samples for microscopic examination were pipetted off from the surface of the water and from the top of the settled organic material every 7-10 days for 6-7 weeks. The sample slides were then qualitatively analysed to determine kinds of algal species normally found in each habitat. Changes in population levels as well as successional trends were also noted.

C. Ecological

A total of 97 peat samples were obtained from selected phytosociological and morphological peat types. Chemical analysis -- total nitrogen, total calcium and total iron -- and pH were determined for each of the samples. Rate of thaw of peat was also determined for selected peatland types.

1) Peat Analysis

All peat samples were taken from the upper peat layer to a depth of 30 cm, or to the bottom of the deposit, whichever was less. They were then placed in a refrigeration room to prevent drying. Each sample was subsequently separated on a paper tray to facilitate air drying, and placed in air-flow cabinets and dried at 15^{o}C for at least 48 hours. The peats were then ground through a 1 mm sieve in a Wiley Mill (No. 3) grinder, assigned laboratory numbers and stored in pint containers for analysis.

a) pH

Increments of distilled water were added to about 40 gm of peat soil until the "liquid limit" or slightly wetter than the upper plastic limit was reached. After standing for 10 minutes the pH was determined using a Beckman Zeromatic II pH meter.

b) Total Nitrogen

Use was made of the Kjeldahl method using 0.500 gm of sample (Jackson, 1958, pp. 183-192). % Nitrogen was determined using the formula: % N = (ml in sample - ml in blank) x (N) x (1.4)/(wt sample).

c) Total Calcium and Total Iron

Extractions were made by dry ashing samples at 490°C and ash dissolved in 6NHCl with dilution to 100 ml. Determination was made using an atomic absorption flame emission (Jarrel - Ash). All nutrient contents were determined from standard prepared curves and expressed in mg/g or ppm.

2) Rate of Thaw in Selected Peatland Types

Five different thermal probes were inserted at the 0, 5, 10, 20, and 50 cm depths and connected to a switch box. Because of the friction created by driving the probes through the ice, it was necessary to wait at least two minutes for the temperature to stabilize again. Each temperature was then simultaneously recorded using a YSI Model 42SF Tele-Thermometer. To avoid variation due to diurnal temperature fluctuations, the readings were taken at approximately noon hour of each sample day.

Terminology

The following terms - plant community, association, peatland, bog and fen - are used extensively throughout the text and are defined as follows:

Plant Community (Bridgewater, 1970): - a group of individual plant species, the composition of which is determined by the environmental conditions and the mutual relationships of these species, i.e., composition, dominance, sociability.

Association (Westhoff and Den Held, 1969): - an abstraction of a number of plant communities which agree in floristic composition and the demands they make upon the environment.

Peatland (Heinselman, 1963): - a generic term including all types of peat-covered terrain. Many peatlands are a complex of swamps, bogs, and fens, sometimes called a "mire complex".

Bogs (Zoltai, et al, 1975): - peat-covered areas or peat-filled depressions with a high water table and surface carpet of mosses, chiefly Sphagnum. The water table is at, or near, the surface in the spring, and slightly below during the remainder of the year. The mosses often form raised hummocks, separated by low, wet interstices. The bog surface is often raised or, if flat, or if level with the surrounding wetlands, is virtually isolated from mineral soil waters. Hence the surface bog waters and peat are strongly acid and upper peat layers are extremely deficient in mineral nutrients. Peat is usually formed in sites under closed drainage, and oxygen saturation is very low. Although bogs are usually covered with Sphagnum, sedges may grow on them. They may be treed or treeless, and they are frequently characterized by a layer of ericaceous shrubs.

Fens (Zoltai, et al, 1975): - peatlands characterized by surface layers of poorly to moderately decomposed peat often with well decomposed peat near the base. They are covered by a dominant component of sedges, although grasses and reeds may be associated in local ponds. Sphagnum is usually subordinate or absent, with the more exacting mosses being common. Often there is much low to medium height shrub cover and sometimes a sparse layer of trees. The waters and peats are less acid than in bogs of the same area, and sometimes show somewhat alkaline reactions. Fens usually develop in restricted drainage situations where oxygen saturation is relatively low and mineral supply is restricted. Usually very slow internal drainage occurs through seepage down very low gradient slopes, although sheet surface flow may occur during spring melt or periods of heavy precipitation.

Botanical Sources

The botanical sources used for nomenclature were as follows:

Vascular plants	Fernald (1950)
Mosses	Crum, Steere and Anderson (1965) except: Sphagnum L. (Isoviita, 1966); Dicranum bergeri Bland (Dixon, 1954); Polytrichum strictum (Hoppe) Brid (Dixon, 1954)
Liverworts	Schuster (1953), except: Odontoschisma sphagnii (Dicks) Dumont (Watson, 1963)
Lichens	Hale and Culberson (1966)
Algae	Bourrelly (1968a, 1968b); Desikachary (1959)

CHAPTER II. A MORPHOLOGICAL CLASSIFICATION OF PEATLANDS IN EASTERN NEWFOUNDLAND

Introduction

The development of a morphological classification for peatlands has been the goal of numerous researchers in boreal regions since the turn of the century. The system used in this particular study incorporates elements of a variety of approaches. A review of the various approaches is given below.

Review of Literature

Many of the basics used in morphological classifications have been developed in Finland. The first major Finnish classification of peatlands originated with Cajander's (1913) treatise of the "Moorkomplextypen". He proposed that peatland site types form peatland complexes which show a similar vegetation, morphology, and stratigraphy. To illustrate this, he defined the following complexes:

1. Raised bog)
2. Aapa bog) based on climate
3. Palsa bog)
4. Karelian bog - based on topography

The three climatic bog complexes described are widely used in subsequent peatland classifications. Raised bog and palsa bog are well defined units. Aapa bog, however, is often used in reference to a number of patterned fen types such as string fen and net fen.

Ruuhijarvi (1960) in his treatment of the Finnish aapa bog or "aapamoor" subdivided the unit into three distinct geographic types ranging from north to south, based on regional differences in plant cover brought about by microclimatological factors. These three types include the northern aapa fens (the Forest-Lapland type), the main aapa fens (the Perapohjola type) and the southern aapa fens (the Pohjanmaa type). In addition, he described the Lapland raised bogs and concluded that isothermal lines separated the raised, aapa and palsa zones in Finland.

The raised bog region of southern Finland was further divided by Eurola and Ruuhijarvi (1961) into three zones: the southwest coast, the plains bordering the Bothnian Gulf and the Gulf of Finland (containing the "Kermi" raised bogs), and the central raised bog zone.

In a refinement of these divisions, Ruuhijarvi (1972) noted that the three geographic zones corresponded to the distribution of three particular raised bog types - plateau bogs, concentric raised bogs and eccentric raised bogs, respectively. Descriptions of each type were given.

The Finnish approach to peatland classification was also applied in other boreal countries, for example, in Alaska by Drury (1956) and later in the Russian classifications of aapamoor (Boch, 1973; Boch and Yurkovskaja, 1964) and raised bogs (Katz, 1962). Furthermore, Nitsenko (1960, 1967) suggested the widespread use of the Finnish "Moorkomplextypen" for all Russian peatland classifications.

An important work which influenced subsequent peatland classifications in Great Britain and in North America was developed by Tansley (1949). Tansley proposed that four peatland formations be used as a basis of peatland classification for the British Isles:- marsh, fen, swamp, and bog. This classification was considered too general to account for all the climatic variation and associated hydrotopographical differences that exist throughout the British Isles (Pollett, 1972a). In addition, Burnett (1964) cited the many interpretations of swamp, fen, bog and marsh by different authorities as a major problem of classification. Nevertheless as a first level division the system has proved successful. Modifications of Tansley's classification system include the single fen unit of Spence (1964) comprising fen, marsh and much of the valley bog formations, and Ratcliff's (1964) morphological units of bog (raised and valley), mire (soligenous bog), springs and flushes.

Another approach to morphological classification was developed by Jessen (1949) who subdivided the peatlands of Ireland into topogenous and paludification bogs in an attempt to provide a more general classification system. This approach has not been used by other peatland researchers, yet it did focus attention on topogenic and paludification processes in peatland classification. Fraser (1954) proposed an alternate division of the Irish peatlands into climatic or zonal bogs (blanket bogs, hill peat) and intrazonal or topogenic bogs (basin bogs, valley bogs). However, Barry (1954) criticized this classification on the basis of the term 'climate' which he believed was not applicable to many Irish peatlands. Barry further suggested that Irish peatlands be divided into three categories - raised bog, blanket bog, and high level blanket bog. This work was very similar to the earlier proposals of Tansley (1949).

One of the more recent approaches to morphological peatland classification involves the system developed for Canada by Zoltai, et al. (1975). The first two levels of the classification describe the morphological types that occur within the main wetland classes of bog, fen, swamp, marsh and open water. This system incorporates elements of both the Tansley and Cajander approaches.

The approach taken by Zoltai, et al. (1975) was used in the present study for classifying peatland types of eastern Newfoundland. In addition the peatland categories defined were further delineated on the basis of their organic soil characteristics, fibric, mesic, humic (Day, 1968) and the humification scale (H1-H10) described by von Post (1926).

Morphological Peatland Types of Eastern Newfoundland

This study of the peatlands in eastern Newfoundland has resulted in the establishment of the first morphological bog and fen classification for the region. A total of six types were delineated. These are:

1. Raised Bog
2. Blanket Bog
3. Slope Bog
4. Basin Bog
5. Patterned Fen
6. Flat Fen

The growth and development and the areal distribution of these bog and fen types are indicative of environmental site conditions particularly the wet maritime climate, degree of site exposure, and hydrotopographic characteristics. Certain of the peatland types delineated -- raised bog, blanket bog, patterned fen and flat fen -- have been described from other boreal regions of the world. However, two bog types, the slope bog and basin bog, have not been previously recorded elsewhere. Slope bog formation is influenced primarily by a combination of climatic and edaphic site conditions whereas basin bog is an expression of the hydrotopographic situation in which it develops.

For each type of peatland classified in eastern Newfoundland interpretation keys have been prepared (Figures 2-1 to 2-6). These keys include A. ground view; B. aerial view; and C. stratigraphic features (organic soil types, botanical constituents and surface vegetation types).

A. Raised Bogs

The raised bogs of eastern Newfoundland (Figure 2-1) occur mainly within the coniferous forest region of the Avalon and Bonavista peninsulas and, to a lesser extent, the Burin peninsula. They are neither concentric raised bogs, which are characterized by a concentric distribution of strings and hollows, nor eccentric raised bogs which are usually sloping in one direction with the patterned strings and hollows being placed in parallel rows down the slope. Instead the pools or flashets are distributed in a diffuse pattern. Although this peatland type is ombrotrophic (i.e. derives nutrients only from precipitation) tussocks of Scirpus cespitosus are scattered throughout the Sphagnum carpet, surviving in this habitat as a result of the high annual precipitation.

Most of the raised bogs of eastern Newfoundland are scattered over a large moraine plain in the center of the Avalon peninsula. This forested region has a gently rolling terrain characterized by thousands of small ponds with northeast-southwest alignment. The topography is almost entirely the result of glacial deposition with many lakes and ponds located between morainal ridges and in the depressions of kettle and kame terrain (Summers, 1949). Henderson (1959) indicated that there is little large-scale damming of water on the Avalon except in this forested zone where bogs developed in depressions at the termination of esker formations.

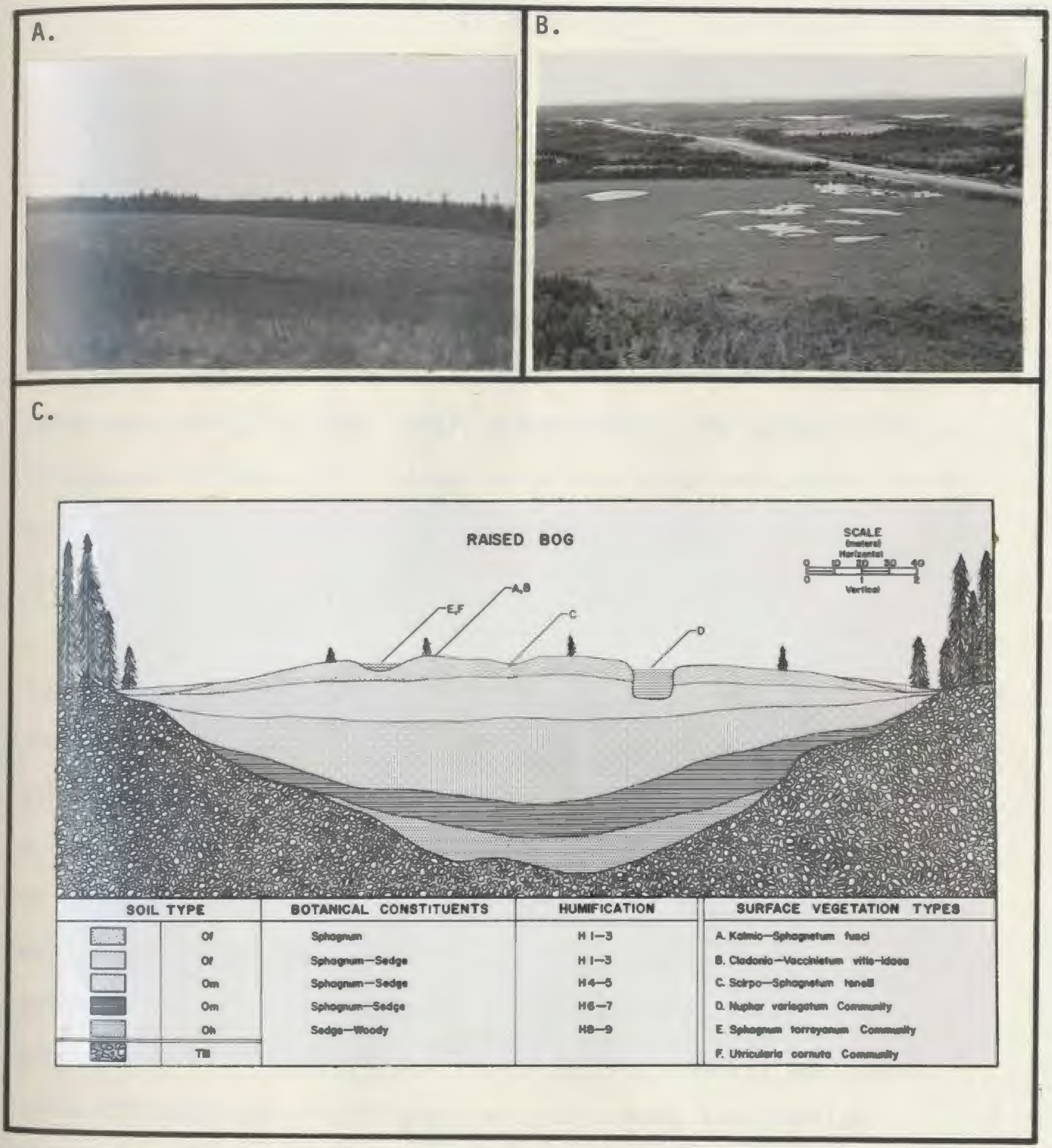

Figure 2-1: Raised bog near Whitbourne, central Avalon; A. ground view showing gentle doming of surface; B. aerial view showing diffuse pool pattern; C. peat stratigraphy showing peat soil types, botanical constituents, humification values, and the major vegetation types of dry sites (Kalmio-Sphagnetum fusci, Cladonio-Vaccinietum vitis-idaea), wetter sites (Scirpo-Sphagnetum tenelli), and pools (Nuphar variegatum Community, Sphagnum torreyanum Community, Utricularia cornuta Community).

The present study of raised bogs in eastern Newfoundland indicated that the peat strata (Figure 2-1C) are similar to those described for raised bogs in central Newfoundland, (Pollett, 1968). The top 50 cm consists mainly of fibric (Day, 1968) Sphagnum peat followed by a fibric layer (100 cm) of Sphagnum-sedge peat. Below this a more mesic Sphagnum-sedge peat (H4+,/von Post, 1926/) predominates. The bottom 30-40 cm is composed of humic (H8-9) sedge-woody peat which indicates a fen to bog succession so common in bog development throughout Britain (Gorham, 1957).

The age and development of raised bogs in eastern Newfoundland have been poorly documented. The only palynological works undertaken in the study area is that of Terasmae (1963) in which a radiocarbon age of 8,420 ± 300 years was determined for a raised bog in the forested area of the Avalon peninsula. Although the sample was taken at the five meter depth, the pollen sequence extended to six meters deep in the sediments beneath the dated level. Terasmae describes this age as a minimum date for deglaciation of the area, and suggests that deglaciation did occur some 10,000 years ago, or perhaps even earlier. Furthermore, the late-glacial vegetation in the forested area was a grass and sedge meadow with alder (Alnus spp.), willow (Salix spp.) and ericaceous and birch shrubs. The occurrence of spruce (Picea spp.) and white birch (Betula papyrifera) was sporadic. Similar studies of raised bogs in Scotland (Ratcliff, 1964) have shown that such peatlands usually originated as minerotrophic fen, which formed the basal peat layers, sometimes over lake sediments.

The development of raised bogs is an expression of climatic conditions, particularly of precipitation. Gorham (1957) suggests that:

> "...if atmospheric humidity is sufficient, the bog moss grows above the level of the groundwater table and begins to form what is known as a 'raised bog' because of the convexity it exhibits when seen in sideview."

Likewise, Nichols (1918) described the distribution of raised bogs as unquestionably correlated with the character of the climate: the abundant precipitation, relatively low atmospheric humidity, cool summers, and the absence of extreme winter temperatures.

Continentality plays an important role in determining the vegetation cover of raised bogs. Most bogs of northern Ontario, Finland and continental U.S.S.R. are forested, usually with a tree cover having less than merchantable volumes. Yet, in most maritime climates, forested bogs are the exception with most raised bogs having an open surface. The boreal forest also influences the distribution of raised bogs. For example, the smaller, but deeper raised bogs occur within forested regions whereas the more extensive, shallower raised bogs occur in more exposed sites.

Raised bogs develop at different altitudes and latitudes, under the influence of various climatic and topographic conditions. Rigg (1940) compared the development, origin, flora and morphology of Atlantic coast raised bogs from Maine, Massachusetts, New Hampshire and New Jersey, with interior raised bogs from Minnesota and Ohio, and Pacific coast raised bogs from Alaska, British Columbia and Washington. Apart from differences in flora, and minor differences in origin, the development and morphology of all the raised bogs are very similar.

The occurrence of raised bogs has been reported for Finland (Ruuhijarvi, 1970, 1972; Puustijarvi, 1968), northern Sweden (Sjors, 1965) southern Sweden (Malmer, 1965), central Russia (Katz, 1926), northwestern Russia (Bradis and Andrienko, 1972; Olenin, 1972), and Alps (Ullman and Stehlik, 1972), Ireland (Barry, 1954), Wales (Godwin and Mitchell, 1938; Taylor and Tucker, 1963) and Scotland, Ireland and England (Osvald, 1949).

In North America this peatland type has been described for the coastal regions of Alaska, British Columbia, Oregon and Washington (Rigg, 1937), central Saskatchewan (Jeglum, 1972), central Alberta (Lewis and Dowding, 1926; Osvald, 1970), Manitoba (Tarnocai, 1970), Hudson Bay Lowlands (Sjors, 1959, 1961a), Minnesota (Heinselman, 1963, 1970) northern Wisconsin, northern Michigan, Indiana, Ohio, New York, Maine, and the Atlantic coastal regions of Virginia and North Carolina (Soper and Osbon, 1922), New England (Dachnowski, 1926), Maine (Bastin and Davis, 1909; Dachnowski, 1929), New Brunswick and Nova Scotia (Ganong, 1897; Osvald, 1970) and Newfoundland (Pollett, 1968a, 1968b, 1972a, 1972b).

B. Blanket Bogs

The blanket bogs of eastern Newfoundland (Figure 2-2) occur within the humid southern regions of the Burin and Avalon peninsulas. These bogs are shallow, rarely exceeding a depth of two meters, and are characterized by diffuse pond patterns. Unlike raised bogs which generally develop in depressions, valleys, or fen basins the blanket peats cover the land continuously quite often covering steep slopes. Tansley (1949) describes blanket bog as a climatic formation independent of localized water supplies; furthermore, it is either ombrogenous or weakly minerotrophic, occurring in regions of cool summers, high rainfall and very high atmospheric humidity.

The present stratigraphical studies of eastern Newfoundland peatlands suggest that the blanket bogs originated as small fens in poorly-drained basins (Figure 2-2C). Such depressions or basins were filled by a sedge peat varying in decomposition from H4-5 to H7-8. The upper layers of peat which formed over this fen consist of fibric (H1-3) to meso-fibric (H3-4) Sphagnum-sedge peat, indicating a climatic change to wetter conditions following the establishment of Sphagnum mosses. There are no carbon dates recorded for the blanket peatlands and that period of succession from fen to bog cannot easily be determined.

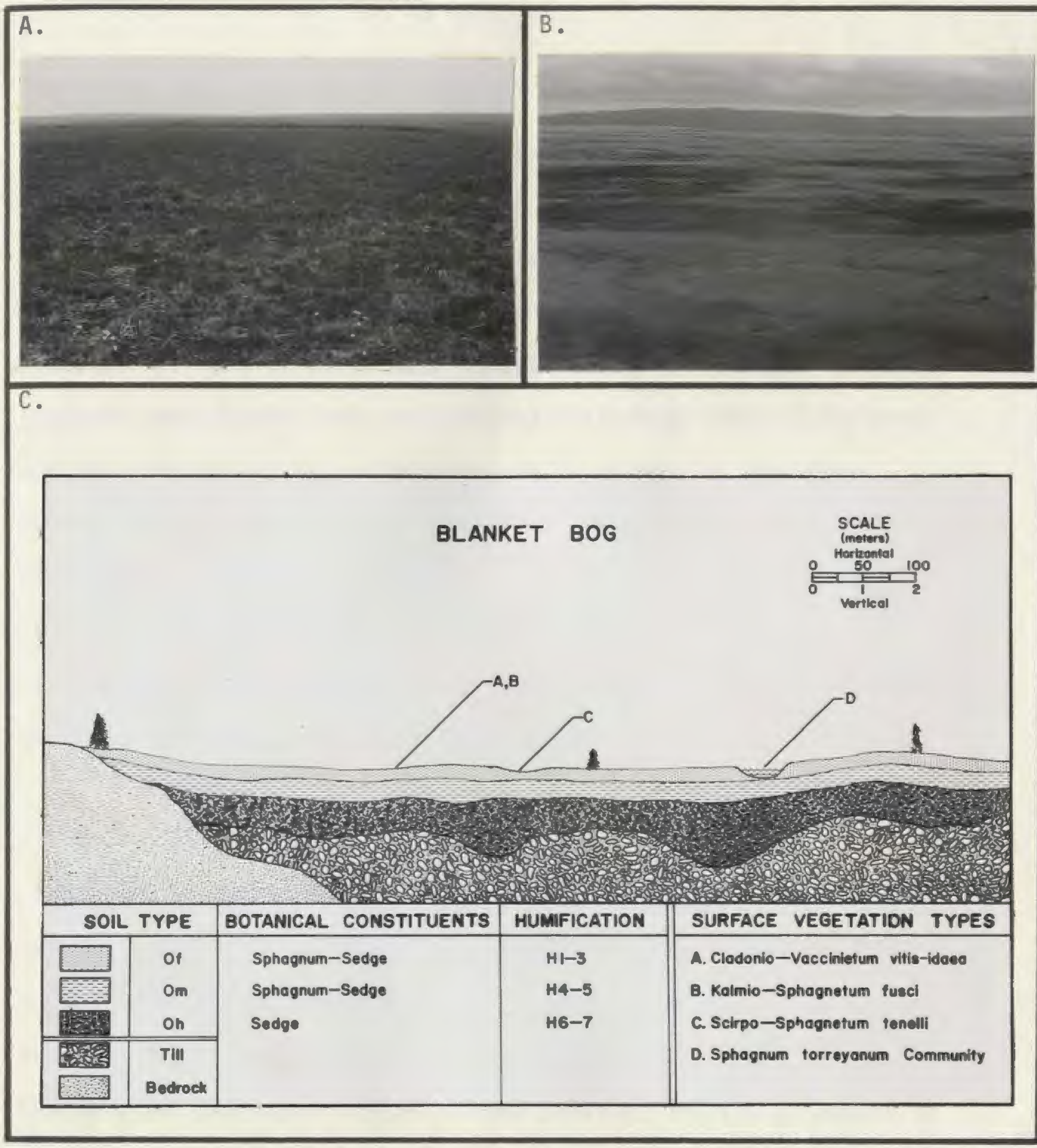

Figure 2-2: Blanket bog near Trepassey, southern Avalon; A. ground view showing flat surface; B. aerial view showing blanket-like expanse of peat deposit; C. peat stratigraphy showing a predominance of mesic and humic peat in subsurface soil horizons and the major surface vegetation types of drier sites (_Kalmio-Sphagnetum fusci_, _Cladonio Vaccinietum vitis-idaea_), wetter sites (_Scirpo-Sphagnetum tenelli_) and shallow pools (_Sphagnum torreyanum_ Community).

Sedges, particularly Scirpus cespitosus are prominent throughout the surface Sphagnum cover. The presence of sedges indicates that these bogs are influenced by minerotrophic seepage. It also suggests that these bogs may still be in a transition stage between fen and bog. Although the ages of local peat deposits are not known, Durno (1961) suggests that blanket bogs in Scotland originated about 7,200 years ago in response to the marked increase in wetness at that time. Instead of overgrowing earlier swamp or vegetation, as did raised bogs, the blanket bogs usually developed on once dry ground occupied by forests. No woody material was encountered in the eastern Newfoundland blanket bog samples and there is no palynological evidence to indicate that these regions were previously forested.

Although blanket peats generally develop in wetter regions, Ratcliff (1964) points out the problem of defining "wetness". For instance, Tansley (1949) found little correlation between rainfall as an index of climatic wetness, and the distribution of blanket bogs in Scotland. However, the highest amount of mean annual rainfall (127 cm) in Newfoundland (Atmospheric Environment Service, 1941-1970) occurs in the blanket bog region of the Avalon and Burin peninsulas.

Ratcliff (1964) suggests that potential evapotranspiration (P.E.) may be the best of all indices of wetness for defining vegetation types.

Because P.E. controls the wetness of the ground and is also a measure of the humidity affecting vegetation, it must have a direct relationship to peat formation. Such an approach describes the combined annual water loss by soil evaporation and transpiration under optimal soil and moisture conditions (Thornthwaite, 1948). According to Hare (1952) the mean annual potential evapotranspiration for southeastern Newfoundland is 45-48 cm, the same as described for the central region of the Island. Unfortunately, these P.E. values are based on data from a limited number of meteorological stations scattered through Newfoundland and, in many instances, are incorrectly interpolated values.

The south and east coasts of Newfoundland border the world's foggiest seas, with the most prevalent fogs occurring south and east of the Avalon peninsula (Hare, 1952). Climatological data (Atmospheric Environment Service, 1941-1970) for eastern Newfoundland indicate a fog frequency (Mean annual hours; visibility 1/2 mile or less) of 1145, 1130, and 901 for Cape Race, Argentia and Torbay Airport, respectively, in contrast to the more continental climatic region of central Newfoundland: Botwood (136), Buchans (360) and Gander (550). This high frequency of fog plus a high annual rainfall would result in a lowering of both transpiration and evaporation and, consequently, a lower potential evapotranspiration for southeastern Newfoundland. Sjors (1950) indicates that such a lessening of evaporation is also similar to an increase in precipitation and favours the development of blanket peat.

Extensive areas of blanket bog characterize the coastal regions of Ireland (Barry, 1954) and areas of high rainfall in England (Osvald, 1949), Scotland (Fraser, 1954; Boatman, 1972) and Mid-Wales (Moore, 1972). In North America, blanket peats have been described for Newfoundland (Pollett, 1968b, 1972a, 1972b) and the coast of Maine (Nichol, 1919).

C. Slope Bogs

Slope bogs (Figure 2-3) occur throughout both the forests and heathlands of eastern Newfoundland. Many of the smaller bog deposits are located within the coniferous forests, whereas the larger more extensive peats are characteristic of severely exposed regions like the Witless Bay line (Avalon peninsula), the Isthmus of the Avalon, and the northern barren areas of the Bonavista and Burin peninsulas. Unlike the blanket bogs which cover valleys and hillsides, the slope bogs are more topographically confined to poorly drained slopes.

This peatland type is characterized by a surface vegetation of *Sphagnum* mosses (e.g. *S. papillosum*, *S. magellanicum*, *S. subnitens*), an abundance of sedges, with *Scirpus cespitosus* dominant, and a water table at, or close to, the surface. However, because of the acid nature of the underlying substrate, the nutrient status of the slope bogs is similar to that of blanket peats and ranges from ombrotrophic to weakly minerotrophic.

No apparent climatic changes have occurred in Newfoundland over the past 3,000 years (Terasmae, 1963). However, stratigraphical investigations carried out in this study (Figure 2-3C) suggests that these sloping peatlands have undergone or are undergoing a fen to bog succession, and are presently more characteristic of bog than fen.

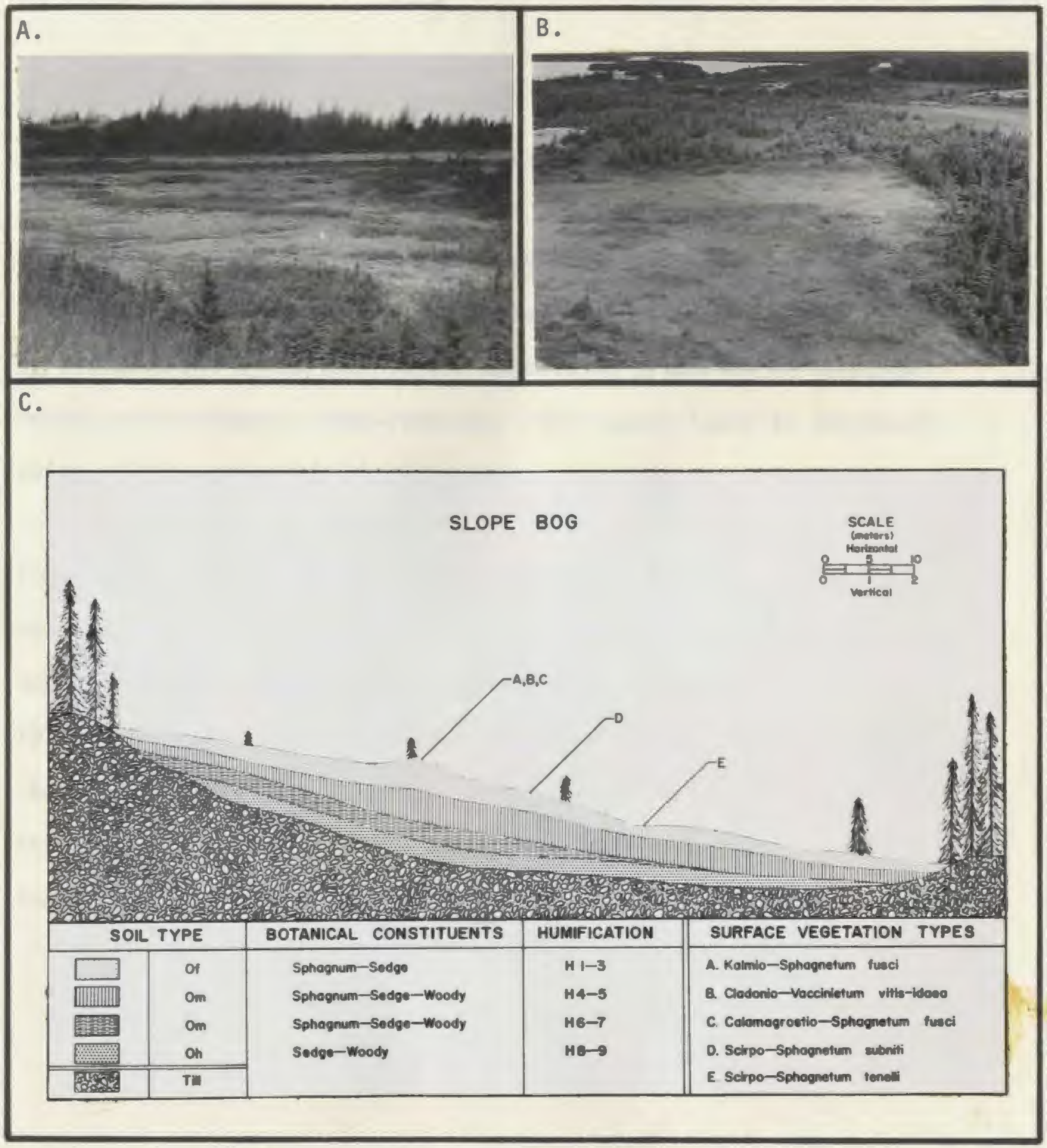

Figure 2-3: Slope bog near Hodgewater line/TCH junction. A. ground view showing slope and abundance of sedges; B. aerial view showing its topographic confinement to poorly drained slopes; C. peat stratigraphy showing a mixture of fibric to humic Sphagnum/ sedge/woody peats and the major vegetation types of dry sites (Kalmio-Sphagnetum fusci, Cladonio Vaccinietum vitis-idaea), nutrient-enriched hummocks (Calamagrostio-Sphagnetum fusci), wetter sites (Scirpo-Sphagnetum tenelli) and the main bog complex (Scirpo-Sphagnum subniti).

The humic bottom layers of sedge-woody peat are indicative of the original sloping fens. A more marked increase in *Sphagnum* growth appears in the two layers of sedge-*Sphagnum*-woody peat (H5-6) and *Sphagnum*-sedge-woody peat (H4-5). These layers are recently covered by a fibric (H1-3) surface layer, consisting primarily of *Sphagnum* mosses and scattered sedge-remnants. This upper layer is representative of the present dry bog conditions.

Slope bogs have not been described for Europe or North America. However, they are morphologically comparable to the slope fens of northern Sweden (Sjors, 1965; Persson, 1965), Manitoba (Tarnocai, 1970), and central Newfoundland (Pollett, 1972b). Such slope fens are characterized by more pool strings. Also, they are more minerotrophic and are differentiated from slope bogs by the presence of true fen indicator species.

D. Basin Bog

The alpine heath ecoregion (Meades, 1973) of the Avalon peninsula is characterized by plant species with subarctic affinities, (e.g. Diapensia lapponica, Juncus trifidus) by patterned fens, rock barrens, arctic-like climate, soil-frost disturbances, high winds and small topographic "basin bogs" (Figure 2-4). Such bogs are exposed, shallow, rarely exceeding two meters in depth, and are characterized by a relatively flat surface.

The development of basin peats is, according to Fraser (1943), influenced by ground water flows. Such soligenous peat deposits vary from eutrophic (calcareous) fen peats to oligotrophic (acidic) bogs supporting only shorter sedges and Sphagnum mosses. Moreover, the rate of growth and rate of decomposition in acid oligotrophic peat deposits are both low and the strata are composed mainly of slightly decomposed light-colored peat.

Current stratigraphical investigations indicate that the basin bogs of eastern Newfoundland (Figure 2-4C) have developed in small basins formed by glacial till. The acidic nature of the underlying soils suggests that they originated as oligotrophic (acidic) to weakly minerotrophic peat deposits. Apart from the humic (H7-8) bottom

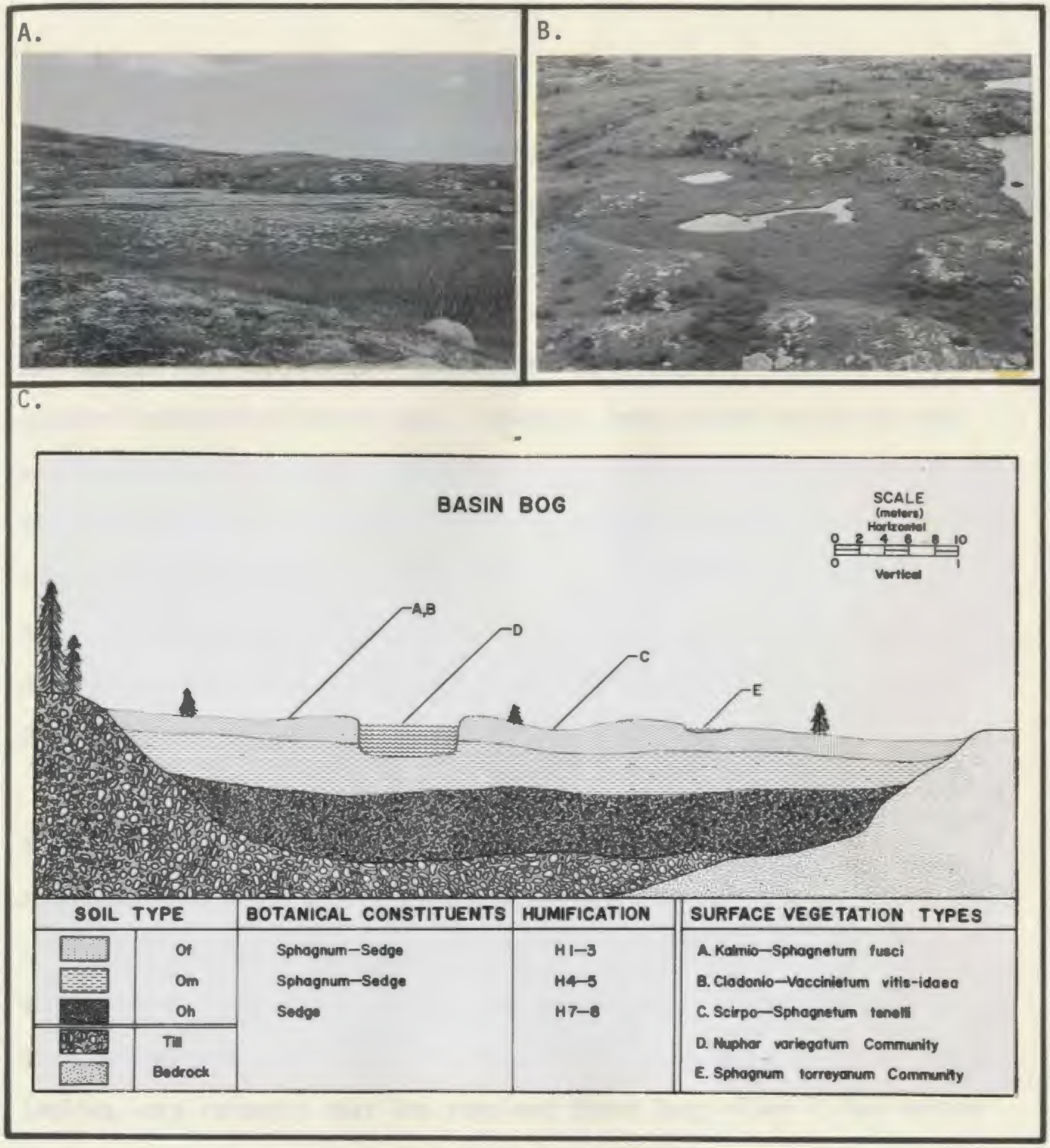

Figure 2-4: Basin bog east of Butterpot Park, central Avalon; A. ground view showing flat surface; B. aerial view showing topographic confinement to poorly drained basin; C. stratigraphy showing an abundance of _Sphagnum_ in upper soil horizons; surface vegetation types are similar to those of raised bog.

sedge layer, the remaining strata consists of a mesic (H4-5) Sphagnum-sedge peat overlain by a fibric (H1-3) layer of light brown Sphagnum-sedge peat.

Surface doming, a prominent feature of raised bogs, is absent in the eastern Newfoundland basin bogs. However, both raised and basin bogs are floristically similar. Fraser (1943) indicates that basin peat deposits remain in a low-moore (or fen) stage as long as the influence of ground water persists. Once peat growth raises the surface of the deposit above the influence of the ground water such that vegetation depends on precipitation for water and nutrients, it has then reached the raised bog stage.

Although the age of these basin peat deposits is unknown, floristic and geomorphic evidence suggest that they may be in an early stage of raised bog development. Rogerson and Tucker (1972) indicate that an abundance of stagnant ice and melt-water features in the northward sloping valleys of the Hawke Hills range of the central Avalon barrens implies very strongly that ice remained there long after it had melted from the adjacent plateaus and lowlands. Consequently, these bogs could not have begun their development until sometime after the ice had melted. However, Rogerson (pers comm) points out that little evidence exists to indicate the duration of this late deglaciation. It could have been an extra hundred years or maybe several thousand years.

Unlike the more sheltered raised bogs within the coniferous forest, the basin bogs are scattered throughout the wind-swept treeless heath barrens. The effect of high winds is to reduce transpiration and, sometimes, possibly cause stomatal closure (Devlin, 1966). As a result, upward peat growth would be retarded and surface doming, generally attributed to growth of Sphagnum mosses, would be minimal.

Basin bogs characterized by similar morphological features have not been recorded elsewhere. Fraser (1954) described basin (topogenic) bogs for Ireland, but only in reference to raised bog development.

E. Patterned Fen

The patterned fens (string fens, aapa fens, aapa mires) of eastern Newfoundland occur in exposed regions of high elevation characterized by a shallow snow cover. These fens are very shallow, rarely exceeding a depth of one meter, and are characterized by scattered erratics, surface patterning and outcroppings of mineral soils (Figure 2-5). Bellamy (1972) describes similar "aapamires" in their typical form as being very extensive mire complexes formed on gentle slopes. Surface patterning is usually very distinct and is orientated at right angles to the main slope of the mire complex.

The patterned fens of eastern Newfoundland are represented by Figure 2-5C. Peat cone samples obtained during this study indicate shallow peat deposits consisting of a thin (15 cm) surface layer of fibric (H3) sedge-*Sphagnum* peat, and a bottom layer (25 cm) of mesic (H4-5) sedge peat. Shallow flarks (25-50 cm deep) are scattered throughout. According to Sjors (1965) their arrangement at right angles to the slope is "...self-evident for any horizontal surfaces inserted into an inclined plane, provided the horizontal structures are supposed to expand".

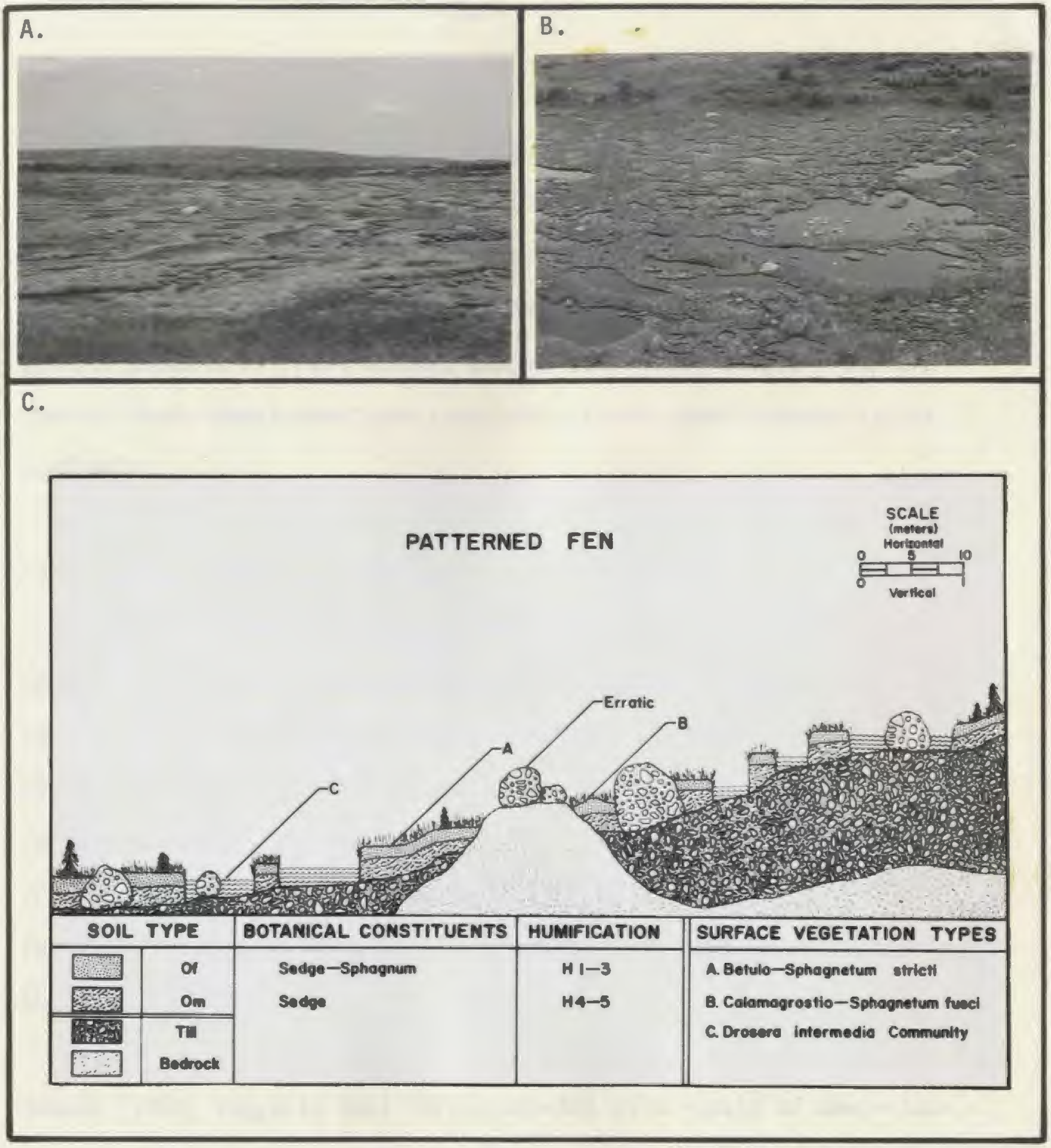

Figure 2-5: Patterned fen on the Witless Bay line, eastern Avalon; ground view (A) and aerial view (B) showing flarks orientated at right angles to direction of slope, and boulders and rock outcrops; C. stratigraphy showing the thin, predominantly sedge peat broken by numerous flarks, and the major vegetation types of the fen matrix (Betulo-Sphagnetum stricti), fen hummocks (Calamagrostio-Sphagnetum fusci) and fen pools (Drosera intermedia Community).

Most peatlands develop either through processes of paludification (e.g. blanket bogs) or by lake infilling (e.g. some raised bogs). However, the origin of patterned peatlands is still unclear. Drury (1956) suggests that the existing patterns are a "phenomena of the general process of frost action, but no completely adequate explanation of their development and especially first establishment is yet available".

According to Auer (1920), the hollows of a patterned fen freeze first in autumn, followed later by the ridges in which a squeezing of the peat occurs. Mid-winter frosts cause the ridges to freeze more solidly producing a further vaulting effect. In spring the ice persists in the ridge much longer than in the hollows resulting in a further uplift of the ridge. Likewise, Allington (1961) suggests frost action at the surface and depth to which the peat is thawed out in spring as several factors contributing to the formation of string bogs in Labrador-Ungava.

Hanson (1950) suggests that flarks develop as a result of down-slope pressure of the peat. The down-hill movement of sub-surface water, plus the weight of the saturated material on a slope, would result in a horizontal cracking and movement downslope." He supports his theory by the lobed appearance of the ridge and the crowding together at the base of the slope. Such a theory suggests that flarks are confined mainly to steep slopes where downhill movement of peat could occur. Sjors (1959), however, points out that the most conspicuous flarks in boreal peatlands are found on slopes that are much too small to allow for any peat-flow at all, and that very few flarks occur on steeper slopes.

Although flarks are influenced by an abundance of minerotrophic waters, they are generally characterized by an absence of peat accumulation. Lundqvist (1951) has shown that no peat has formed for 2,000 - 3,000 years in some of the flarks of the central Swedish uplands. Consequently, Sjors (1965) attributes the distribution of the flarks within the peatland complex to hydrotopographical conditions rather than frost action or slope. The horizontal waterlogged flarks represent a large flow of water that cannot escape freely enough, mainly as a result of the damming action of the ridge. A necessary prerequisite for such a system is that the strings grow in height faster at their lower than at their higher and drier sections, and that flarks form peat slower or at least no faster than the strings (Sjors, 1965). Furthermore, the rate of decay of peat in flarks in the boreal zone is more rapid than in flarks of more southern regions. Sjors (1965) attributes this condition to "...northward increasing competitive ability of micro-algae to outcrowd peat-forming mosses, and an almost corrosive type of oxidation occurring on the wet peat surfaces of the flarks".

No studies have been initiated to determine the origin and establishment of patterned fens in eastern Newfoundland, however, it seems possible that frost action is instrumental in maintaining present day patterns. These fens of the Avalon peninsula occur within the Alpine heath ecoregion described by Meades (1973). Although the altitudes of the ecoregion (150-300 m) is atypical for alpine vegetation, Wilton (1956) points out that this altitude is above the limit of productive forest on the Avalon. Rock barrens, unique to this ecoregion, are characterized by a discontinuous vegetation carpet interrupted by patterned ground, mainly in the form of nonsorted nets. In addition, freeze-thaw cycles, high winds (up to 161 kph), the absence of deep winter snow cover except in depressions, and the widespread occurrence of bare soil are conducive to severe soil-frost disturbance (Meades, 1973).

Patterned fens are described by Drury (1956) as a phenomenon of the region just south of the continuous permafrost in eastern and central Canada. Their distribution coincides with the northern edge of the boreal forest which, within 200 mile limits, corresponds with the limit of continuous permafrost. Heinselman (1963), on the other hand, refutes such a relationship by indicating that the string bogs of Minnesota are barely on the southern fringes of the boreal forest. Furthermore, their occurrence in Minnesota marks the southern limit in North America of that circumboreal peatland type.

Patterned peatlands have been reported from Labrador (Allington, 1961), northern Manitoba (Ritchie, 1957, 1960a, 1960b), the James Bay region (Sjors, 1959, 1961a, 1961b) and in large areas of the Buchan's Plateau in west-central Newfoundland (Pollett, pers comm). Similarly, aapa fens occur in upper Michigan (Heinselman, 1965), Finland (Ruuhijarvi, 1970, 1972; Puustijarvi, 1968), northern Sweden (Sjors, 1965; Nordqvist, 1965) and northwestern Russia (Bellamy, 1972; Eliña, 1972).

F. Flat Fens

Eastern Newfoundland is characterized by a relative absence of nutrient-enriched peatlands. However, flat fens (Figure 2-6) occur within the coniferous forests especially near Terra Nova and in the Salmonier Valley on the Avalon peninsula. These fens are lawn-like in appearance, and are dominated mainly by Sphagnum mosses (e.g. S. papillosum), sedges (e.g. Scirpus cespitosus, Carex oligosperma, Carex exilis), and grasses (e.g. Calamagrostis inexpansa). The water table is usually at, or close to, the surface and is influenced somewhat by the surrounding mineral soil.

Eutrophic sites, which are characterized by true fen indicator species (e.g. Campylium stellatum, Selaginella selaginoides, Potentilla fruticosa) are common occurrences in the forested regions of western Newfoundland. However, such nutrient-rich sites generally occur in eastern Newfoundland in juxtaposition with the more exposed aapa fens on the Burin peninsula. The scarcity of eutrophic flat fens, especially in the forested regions of the Avalon peninsula, is due largely to the acid nature of the underlying substrata.

Morphologically, the flat fens are shallow, rarely exceeding 1.5 m in depth, and have originated in catchment basins (Figure 2-6C). The lower peat strata consists mainly of a humic (H6-7) sedge peat.

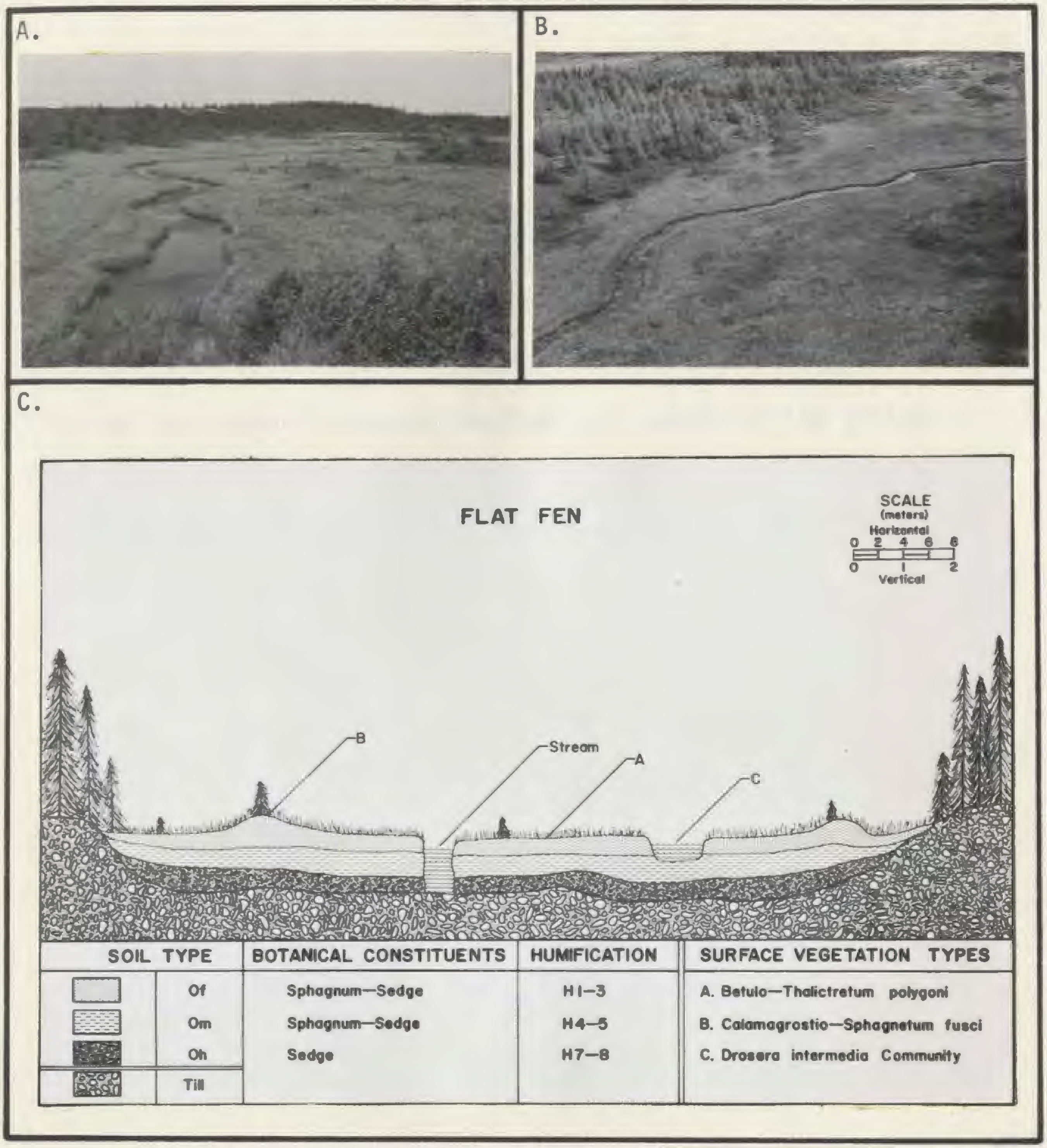

Figure 2-6: Flat fen near the Hodgewater line/TCH junction, central Avalon; ground view (A) and aerial view (B) showing abundance of grasses and sedges, and topographic confinement to minerotrophic forest basin; C. peat stratigraphy showing predominance of mesic to humic sedge peat, and the major vegetation types of the fen matrix (<u>Betulo-Thalictretum polygoni</u>), fen hummocks (<u>Calamagrostio-Sphagnetum fusci</u>) and the fen pools (<u>Drosera intermedia</u> Community).

Sphagnum mosses dominate the upper layers of fibric (H1-3) to mesic (H4-5) Sphagnum-sedge peat. The abundance of Sphagnum mosses at the surface suggest that these fens may be in an early stage of transition to bog.

Flat fens are common in Western Newfoundland because of the influence of the calcareous enriched substrata. Similar peatlands have been described for Manitoba (Tarnocai, 1970) and Sweden (Nordqvist, 1965).

Summary

The peatlands of eastern Newfoundland have been divided into six morphological types:- raised bog, blanket bog, slope bog, basin bog, patterned fen and flat fen. Although geology, geomorphology, topography, climate and pedology are only briefly discussed in this chapter, each of these factors is instrumental in the formation and distribution of the peatland types.

Stratigraphical observations indicate that all bog types originated as fens, and that slope, basin and blanket bogs, may presently be in an early stage of bog succession. Flat fens are characterized by an abundance of Sphagnum mosses, rather than typical fen indicator species. Possibly, these fens indicate a transitional stage in fen to bog succession.

In the following chapter these morphological peatland types are subdivided into phytosociological units to provide a more in-depth insight into the ecological relationships of various bog and fen systems.

CHAPTER III. PHYTOSOCIOLOGICAL CLASSIFICATION OF PEATLANDS IN EASTERN NEWFOUNDLAND

Introduction

Multifarious phytosociological classifications of peatlands have been developed throughout boreal countries. Although these studies are primarily European, many have direct relationships with the phytosociological peatland units determined for Newfoundland by Pollett (1972a) and Pollett and Bridgewater (1973). Also, as expected, certain of the units described for eastern Newfoundland have floristic affinities with vegetation classifications developed for northern Europe and for northern Canada.

Review of Literature

The study of peatland phytosociology originated within the European schools of thought (e.g. Cajander, 1913; Braun-Blanquet, 1932; Nordhagen, 1936, 1943; Tansley, 1949; DuRietz, 1954). The influence of these schools has spread such that their methodologies are now used universally. Since the development of peatland phytosociological classifications involved many researchers in different countries, only the major works are discussed below.

Cajander's (1913) treatise on the "Moorkomplextypen" not only defined morphological peatland types, but suggested four phytosociological subunits called "moortypens".

1. Weismoore: - dominated in the field layer by graminaceous plants, while in the bottom layers, Sphagna and brown mosses predominate;

2. Braunmoore: - similar to Weismoore in physiognomy except it is more calcareous;

3. Reisermoore: - dominated in the field layer by dwarf shrubs with bottom layer dominated by Sphagnum;

4. Bruchmoore: - peatlands having woody (tree) communities.

Cajander's classification was further subdivided into 72 sub-types by Lukkala (1929, 1935), Kivinen (1948) and Lukkala and Kotilainen (1945) who attempted to define phytosociological peatland units for application in land classification for use in agriculture and forestry inventories. However, such a large number of sub-types was too cumbersome for practical use. Subsequent attempts were made toward more simplified classification systems for industrial purposes (Heikurainen and Huikari, 1972; Huikari, 1952).

Heikurainen (1960) followed Cajander's system but proposed the use of the following four terms incorporating the names of significant vegetation to form both types and sub-types of the four major "moortypen" groups:

1. Korpi (Bruchmoore) - Spruce-broadleaved tree-covered peatland;
2. Rame (Reisermoore) - Peatland dominated by ericaceous shrubs and pine;
3. Letto (Braunmoore) - Rich treeless fens;
4. Nevo (Weismoore) - Nutrient-poor treeless fens.

One other approach of the Northern or Scandinavian tradition involved the concept of formations (or associations) proposed by Grisebach (1892). A follower of this concept was Hult (1881) who, while supporting the theory that plant communities could best be described and classified on the basis of physiognomy, grouped stands by their affinities of structural layering. Further development of this approach by Sernander (1898, 1901), and von Post and Sernander (1910) led to the foundation of the Uppsala school of plant sociology.

Classification of peatlands based on this system have been refined by DuRietz (1949, 1954, 1957, 1964). His classification divided the

European peatlands into a bog class, termed the Ombrosphagnetea, and a fen class, the Sphagno-Drepanocladetea. Within each class there are a number of subunits separated largely on the basis of nutrient status and species dominance. Contributions to the study of peatlands by other students of the Uppsala school include the works of Thunmark (1942, 1948), Witting (1947, 1949), Osvald (1949), Sjors (1952, 1956), Malmer (1958, 1962a, 1962b, 1968), Mornsjo (1968) and Sonesson (1970).

The criterion of DuRietz's fen classification is based mainly on the presence of so-called "fen indicator species", often termed "euminerobionten" (Ackenheil, 1955), "fen plant" (Sjors, 1946, 1948), "exclusive fen plants" (DuRietz, 1950). Westhoff and Den Held (1969), however, object to the use of the "fen species" concept since "...precipitation in oceanic areas can be so mineral-rich that ombrotrophic moors occurring in these regions may show a number of species which are considered 'Mineralbodenwasserzeiger' in more continental climates". The occurrence of the fen species on ombrotrophic bogs is quite evident around the Newfoundland coast.

A Scandinavian phytosociological system based on mountain peatland units has been described by Nordhagen (1936, 1943). However, Nordhagen, like Cajander (1913) did not consider the clear-cut difference between ombrotrophic and poor minerotrophic vegetation. Furthermore, according to Sjors (1965) Nordhagen did not utilize the bottom layer of plants (bryophytes and liverworts) as indicator species. Consequently, Nordhagen's system was not widely applied in peatland surveys.

One of the most widely used systems for classifying peatlands today is the Zurich-Montpellier Method (Z-M) developed by Braun-Blanquet (1932). In contrast to Cajander's (1913) approach, this method deals with the plant community as a social unit. Units of lower rank (variants, sub-associations and associations) are recognized from local and regional studies. Groupings of these lower units result in the formation of units of higher rank (alliances, orders and classes) representing extensive surveys of large regions, countries, continents, etc.

As early as 1949, the European peatlands and the wet heath vegetation were united into one phytosociological class, the Sphagno-Caricetea fuscae (Duvigneaud, 1949). However, the present-day peatland classification consists of two widely separated classes (after Westhoff and Den Held, 1971):

A. Bog Class (and wet heath)
   Oxycocco-Sphagnetea (Braun-Blanquet, 1951)

B. Fen Class
   Scheuchzerio-Caricetea nigra (=fusca)
   (Nordhagen, 1936; Tuxen, 1937)

In Canada the Z-M methodology has been used to classify peatlands in Newfoundland (Pollett, 1972a, 1972b; Pollett and Bridgewater, 1973) and Quebec (Gauthier, 1971). Since these studies are regional, the vegetation units are described at the association level.

Janssen (1967), recognized thirteen main types of vegetation (alliances) from his study of a 1,200 square mile area of forest and peatland in northwestern Minnesota. Although this is somewhat contrary to the Braun-Blanquet approach, Janssen suggested that "...their placement on the alliance level makes the system better balanced upwards and downwards. Moreover, many of the units are comparable to units recognized in Europe that are also on the level of the alliance and that are also strongly characterized ecologically". However, Janssen's classification failed to utilize _Sphagna_ and other non-vasculars as indicator species. Furthermore, the erection of hierarchical units above the association level is considered premature in view of the present status of peat classification in North America (Pollett, 1972a).

Vegetation Units within Eastern Newfoundland Peatlands

Based on the analysis and synthesis of 248 relevés the peatlands of eastern Newfoundland have been classified into eleven vegetation units which are presented in Synthesis Tables 3-1 to 3-11 in approximate order of increasing minerotrophy. Although such associations and communities may occur as separate vegetation units, several different vegetation types are frequently found on any one peatland type. Their position on the bog or fen is determined mainly by nutrient gradients.

This phytosociological classification substantiates the morphological units already defined (Chapter 2). Together, they form the basis of a biophysical peatland classification. Both classifications complement one another and may be utilized as the ecological basis for land-use planning of peatlands in integrated resource management involving forestry, agriculture, wildlife, and recreation interests. The phytosociological units delineated for eastern Newfoundland are described as follows:

3-1 *Cladonio-Vaccinietum vitis-idaea* Association

3-2 *Kalmio-Sphagnetum fusci* Association

3-3 *Calamagrostio-Sphagnetum fusci* Association

3-4 *Scirpo-Sphagnetum tenelli* Association

3-5 *Scirpo-Sphagnetum subniti* Association

3-6 *Betulo-Sphagnetum stricti* Association

3-7 *Betulo-Thalictretum polygoni* Association

3-8 *Nuphar variegatum* Community

3-9 *Sphagnum torreyanum* Community

3-10 *Utricularia cornuta* Community

3-11 *Drosera intermedia* Community

3-1. Cladonio-Vaccinietum vitis-idaea Association

Differentiation of the Association:

The differential species group defining the association includes:

Cladonia rangiferina	Vaccinium angustifolium
Cladonia alpestris	Vaccinium vitis-idaea
Cladonia boryi	Rubus chamaemorus
Kalmia angustifolia	Hypogymnia physodes
Cornicularia aculeata	Empetrum nigrum

This association is differentiated from all other associations by the abundance of Vaccinium vitis-idaea, Cladonia boryi, Cornicularia aculeata and Hypogymnia physodes.

Ecological Interpretation

The Cladonio-Vaccinietum vitis-idaea association (Table 3-1) occurs only on the Avalon and Bonavista peninsulas (Figure 3-1C) located in very dry portions of slope, blanket, basin and raised bogs (Figure 3-1A, 3-1B). Its occurrence on these bogs is confined mainly to dry Sphagnum fuscum hummocks. Lichens are abundant throughout the plant cover, usually having overgrown the Sphagnum carpet. The dry, heath-like conditions are characterized by the presence of Vaccinium vitis-idaea.

TABLE 3-1: CLADONIO-VACCINIETUM VITIS-IDAEA ASSOCIATION

Releve Number	152 B	157 A	45 A	150 B	18 C	150 A	55 B	53 C	8 A	9 C	9 A	55 A	
Altitude(ft)	550	150	100	150	250	150	50	150	350	800	800	50	
Cryptogams (% cover)	60	60	50	60	70	70	40	80	70	60	70	50	
Phanerogams (% cover)	60	50	70	70	50	50	70	40	60	60	60	85	
Number of Species	90	20	16	18	24	19	15	14	21	18	19	15	
Differential Species of the Variant													**Presence Value**
Kalmia polifolia	+	+	1.1	+	+	+	.	.	.	.	.	1.1	III
Chamaedaphne calyculata	2.1	+	2.1	1.1	1.1	+	.	.	+	.	.	.	III
Vaccinium oxycoccus	1.1	.	2.1	2.1	1.1	.	1.1	.	.	.	.	.	II
Andromeda glaucophylla	+	+	.	+	+	+	.	.	.	.	.	.	II
Eriophorum angustifolium	+	+	.	2.1	.	1.1	.	.	.	.	.	.	II
Scirpus cespitosus	2.2	+	3.2	.	1.2	.	.	.	.	.	.	.	II
Myrica gale	1.1	.	.	+	.	+	.	.	.	.	.	.	II
Differential Species of the Association													
Cladonia rangiferina	1.2	2.1	2.1	2.3	3.2	2.1	1.1	2.1	2.2	2.3	3.2	2.3	V
Kalmia angustifolia	+	3.1	1.1	+	1.1	2.1	2.1	2.1	2.1	2.3	1.1	2.1	V
Cladonia arbuscula	2.2	2.1	.	1.2	2.2	3.2	1.2	1.1	3.2	2.3	2.2	2.2	V
Vaccinium vitis-idaea	.	.	2.1	+	+	1.1	1.1	1.1	2.1	2.3	2.1	1.1	IV
Empetrum nigrum	2.1	.	2.1	3.3	2.1	2.2	3.2	2.3	2.2	2.3	.	2.2	IV
Cladonia alpestris	+	1.1	1.1	.	1.2	1.2	1.2	1.2	2.2	1.2	+	1.2	V
Cornicularia aculeata	1.2	1.2	+	.	1.2	.	.	1.2	.	2.2	2.2	2.2	IV
Vaccinium angustifolium	.	2.1	.	.	.	1.1	+	2.1	3.1	2.2	1.1	1.1	IV
Rubus chamaemorus	+	1.1	2.1	3.3	1.1	2.2	+	+	.	.	+	.	IV
Hypogymnia physodes	.	.	.	.	+	.	+	+	+	+	1.2	.	III
Cladonia mitis	+	.	2.2	2.2	.	2.1	.	.	1.2	1.2	.	+	III
Cetraria islandica	1.1	1.1	+	.	.	+	.	1.1	1.2	.	.	1.2	III
Cladonia boryi	1.2	.	.	.	2.2	.	1.2	.	.	2.2	2.2	.	II
Companion Species													
Ledum groenlandicum	1.1	2.1	1.1	2.1	1.1	2.1	1.1	1.1	2.1	1.2	+	2.1	V
Cornus canadensis	+	.	.	2.1	1.1	1.1	.	.	+	.	+	.	III
Ochrolechia frigida	+	+	.	.	.	.	.	1.2	.	.	.	+	II
Eriophorum spissum	+	+	.	.	.	.	1.2	.	.	.	.	1.2	II
Ptilidium ciliare	.	.	1.2	.	.	.	.	.	+	.	.	+	II
Dicranum bergeri	.	.	+	.	.	.	.	.	2.2	.	2.2	.	II
Cladonia elongata	.	.	.	1.1	.	.	.	.	1.2	.	1.2	.	II
Cladonia uncialis	+	.	.	.	.	.	1.2	.	.	+	.	.	II
Pyrus floribunda	+	.	.	1.1	+	.	.	.	.	.	.	.	II
Alectoria nigricans	.	.	.	.	.	.	.	.	+	.	1.2	.	I
Polytrichum strictum	.	.	.	.	+	.	.	.	.	+	.	.	I
Cladonia coccifera	.	.	.	.	.	.	.	.	.	+	2.2	.	I
Cladonia alpicola	.	.	.	.	.	.	.	+	.	+	1.2	.	I
Rhacomitrium lanuginosum	2.3	2.2	.	.	.	.	.	.	.	.	.	.	I
Drosera rotundifolia	+	.	.	.	+	.	.	.	.	.	.	.	I
Sphaerophorus globosus	+	.	.	.	.	1.1	.	.	.	.	.	.	I
Pleurozium schreberi	.	1.2	.	.	.	.	2.2	.	.	.	.	.	I
Alectoria ochroleuca	.	+	.	.	.	.	.	.	+	.	.	.	I

Additional Species:

152B: – Solidago uliginosa (+); Trientalis borealis (+);
Cladonia squamosa (+); Sphagnum imbricatum (+)
157A: – Cladonia verticellata (+)
9A: – Smilacina trifolia (+); Dicranum fulvum (+)
9C: – Cladonia pyxidata (+); Maianthemum canadense (+)
18C: – Cladonia crispata (+); Sarracenia purpurea (+);
Icmadophila ericetorum (+); Mylia anomala (1.2)
150A: – Vaccinium uliginosum (+)
150B: – Juniperus communis (+)
8A: – Calamagrostis inexpansa (+); Potentilla tridentata (1.1);
Stereocaulon paschale (+)

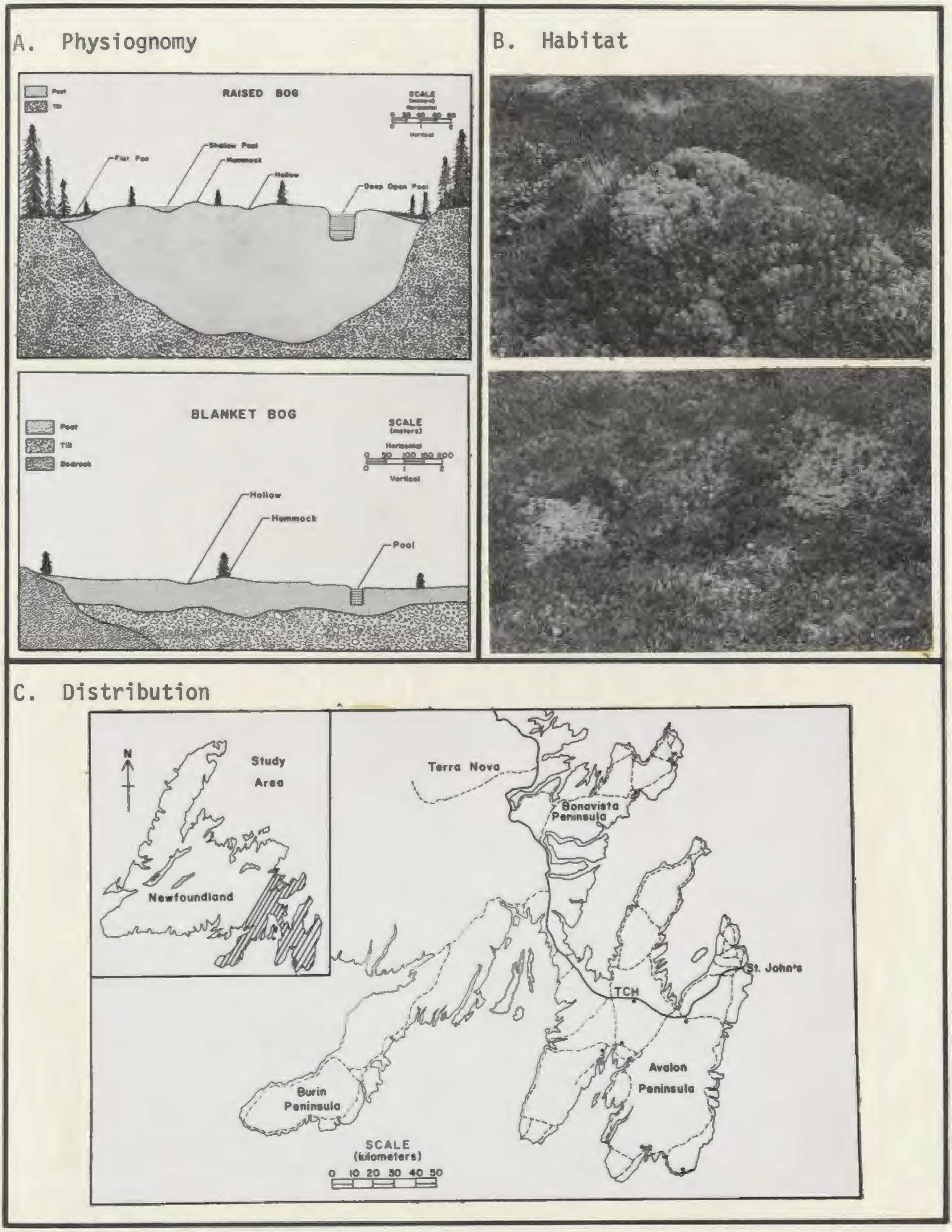

Figure 3-1: Cladonio-Vaccinietum vitis-idaea Association; A. physiognomy showing peatland types most characteristic of this vegetation type; B. habitat of each physiognomic type showing typical site conditions of the vegetation unit; C. distribution of the association within the study area.

The sedge, Scirpus cespitosus, is a principal species used in differentiating bog from heath in eastern Newfoundland (Meades, 1973). Within this association, the Scirpus cespitosus - Kalmia polifolia variant represents the moist areas where the water table is near the surface during spring and early summer.

3-2. Kalmio-Sphagnetum fusci Association (Pollett and Bridgewater, 1973)

Differentiation of the Association

The differential species group of the association includes:

Sphagnum fuscum	Rubus chamaemorus
Polytrichum strictum	Cladonia rangiferina
Mylia anomala	Sphagnum rubellum
Empetrum nigrum	Kalmia angustifolia

This association is differentiated from the Cladonio-Vaccinietum vitis-idaea association by the absence of Vaccinium vitis-idaea and the scarcity of Cladonia boryi, Hypogymnia physodes, and Cornicularia aculeata.

Ecological Interpretation

The Kalmio-Sphagnetum fusci association (Table 3-2) is the most common and widely distributed peatland association throughout eastern Newfoundland. It occurs both on the drier flats and on the hummocks of raised, blanket, slope, and basin bogs (Figure 3-2). This vegetation unit has previously been described by Pollett (1972b) from the raised bogs of central Newfoundland and from the extensive areas of blanket-like peat in western Newfoundland.

TABLE 3-2: KALMIO-SPHAGNETUM FUSCI

Relevé Number	87	16	18	44	58	7	56	25	60	132	64	90	84	67	76	182	130	51	79	65	122	135	136	144	43	4	11
	B	A	A	B	A	B	B	A	D	B	B	A	B	B	C	A	A	C	A	D	A	A	A	B	B		C
Altitude (ft)	400	300	250	100	100	100	400	200	400	350	300	550	200	400	350	200	400	250	350	200	400	400	450	100	350	100	500
Cryptogams (% cover)	100	80	90	60	80	80	90	100	100	90	70	80	90	90	60	90	50	70	60	80	80	90	90	100	70	100	90
Phanerogams (% cover)	70	80	40	40	50	70	60	40	60	60	40	70	70	60	40	60	60	40	40	60	50	50	40	50	50	70	40
Number of Species	23	15	20	14	16	14	17	14	22	15	17	18	20	24	18	17	20	19	17	21	19	19	20	20	16	24	20
Differential Species of the Variant																											
Coptis groenlandica																										+	
Smilacina trifolia																							1.1				
Cornus canadensis			1.1																								
Eriophorum angustifolium																					1.1						
Juniperus communis																										+	+
Differential Species of the Sub-Association														TYPICUM													
Pyrus floribunda																1.1											1.1
Myrica gale																							+				
Calamagrostis inexpansa																										1.1	
Solidago uliginosa																											
Betula michauxii																											
Differential Species of the Association																											
Sphagnum fuscum	2.2	2.2	+	2.2	3.3	3.3	3.3	2.3	4.4	3.2	3.2	3.2	3.3	2.2	+	4.4	+	2.4	2.1	2.2	1.1	2.2	1.1	1.2	3.2	2.2	1.2
Mylia anomala		+		1.2	2.1		1.1	1.1	1.1	2.1	2.2	3.1	2.2	1.1	+	2.1	1.1	1.1	1.1		1.1	1.1	1.1	2.1			1.1
Cladonia rangiferina	1.2	2.2	2.1		1.1	2.2	1.2	2.2	1.2	+	3.1	2.1	2.2	+	2.1	1.1		1.1	2.1	3.1	1.1	2.1	1.1	+	1.1	3.2	2.2
Kalmia angustifolia	+	2.1	2.1		1.1	3.1	1.1	1.1	1.1	1.1	2.1	+	1.1	+	1.1	2.1	1.1			2.1	+	1.1		2.1	1.1		2.1
Cladonia arbuscula	1.2	+	1.2			3.3	1.2		+	+	1.1	2.2	1.2	r	2.2	1.1		+	1.1	1.2	1.2	2.2	+	+		3.2	2.2
Empetrum nigrum	+	3.3	2.1		3.2	3.3	3.1	2.1	1.1	3.1		+	2.3	1.1	1.2	2.1	1.1	2.1	1.1	3.1	2.1	2.2	2.1	1.1	2.1	2.2	2.2
Sphagnum rubellum	+	2.2						2.3	1.2	1.2		2.2		1.2			+		3.3		1.1	2.1	2.1				
Rubus chamaemorus		+	1.1	+	1.1		2.1		1.1	+	+		+	1.1	+		+		1.1	+	1.1	3.1	+	1.1	1.1		+
Cladonia mitis	+		1.1		+	+	1.2	1.1	1.1		1.1	2.1	1.1					+		+	1.1				1.1	1.2	
Polytrichum strictum	+			2.1							2.2		+	+		2.1			+					+	+	1.1	+
Cetraria islandica	2.2				1.1		2.2		+			2.1		+			2.1	2.1	2.1	2.2				+	+		
Vaccinium angustifolium											1.1		+			1.1					+						
Cladonia alpestris	1.2		1.2			3.3					2.2		1.2		+	1.1				3.2				+		1.2	2.2
Companion Species																											
Scirpus caespitosus	3.1	2.2	1.2	2.2	1.2	2.2	+	3.2	2.2	2.2		3.2		2.2	1.2	1.2	2.2	3.2	3.3	+	2.2	2.2	2.2		1.2	3.2	1.2
Vaccinium oxycoccus	2.1	1.1	1.1	2.1	1.1	+	2.1	2.1	1.1	2.1	3.1	1.1	2.1	3.1	1.1	2.1	1.1	1.1	1.1	2.1	2.1	2.1	1.1	1.1	1.1	2.2	2.1
Ledum groenlandicum	1.1	1.1	1.1	3.1	2.1	2.1	1.1	1.1	1.1	1.1	2.1	1.1	1.1	1.1	1.1	2.1	2.1	1.1	+	1.1	1.1	1.1	+	2.1	1.1		2.1
Chamaedaphne calyculata	1.1		1.1			3.1	1.1		2.1	2.1		1.1	1.1	2.1	+	2.1	+	2.1		1.1	1.1	1.1	1.1	2.1	1.1	2.1	1.1
Kalmia polifolia	1.1	+	1.1	+	2.1		1.1	1.1	1.1	1.1	2.1		+	1.1	1.1	1.1	+	1.1	1.1	1.1	1.1	1.1	1.1	+	1.1		1.1
Drosera rotundifolia	+	+	1.1	+	1.1		+	1.1	+	+		1.1		+		+			1.1	+	1.1	1.1	1.1	+	1.1		
Andromeda glaucophylla	1.1	1.1					1.1	1.1	+			1.1		1.1			1.1	1.1	+							2.1	
Sarracenia purpurea	+					+			+					+									+			+	
Dicranum bergeri			1.1	1.2													1.1					1.2				1.2	
Eriophorum spissum				1.1					+			+									+	+	+			+2	
Carex oligosperma	1.1											2.1	1.1				2.1	1.1	2.1								
Rhacomitrium lanuginosum			+			2.2									2.2											1.2	
Sphagnum imbricatum			4.4																					5.5		3.4	
Dicranum scoparium									+			+		+				+						+			1.2
Sphagnum papillosum	1.2			2.2										3.3				3.3									
Cornicularia aculeata					+								1.2		3.2					1.2				+	1.2		
Gaylussacia dumosa	1.1															1.1			1.1		1.1						
Sphagnum flavicomans	4.4																2.2					3.3	3.3				
Larix laricina	k								+					r										k			
Carex exilis				1.1																						3.1	
Lepidozia reptans																						1.1	1.1				
Carex rostrata																					1.1		1.1				
Maianthemum canadense																											
Trientalis borealis																										+	
Cladonia pyxidata		r								+	+				+					+							
Hypogymnia physodes											+	+								+				+			
Sphagnum magellanicum														+													2.
Picea mariana																				+						+	
Carex pauciflora																											
Ochrolechia frigida														+	+										1.1		
Cephalozia connivens														1.1			+			+							
Lycopodium annotinum																		1.1									
Pleurozium schreberi																											2.2
Icmadophila ericetorum					1.2										+										+		
Cladonia verticellata											+		r														
Nemopanthus mucronata			+																								
Aster nemoralis																											
Cladonia boryi			+																								
Cladonia uncialis						1.2																					
Sphagnum subnitens									1.2									1.1									
Cladonia terra-novae																											

Additional Species:

58A: – Riccardia palmata (+)
56B: – Vaccinium uliginosum (+)
140A: – Hylocomium splendens (+)
116A: – Arethusa bulbosa (+)
81A: – Ptilidium ciliare (1.2)
33D: – Betula pumila (2.1); Lycopodium clavatum (1.1)
110E: – Betula papyrifera (r); Abies balsamea (k); Linnaea borealis (+)
105D: – Eriophorum virginicum (1.1)
123D: – Cladonia elongata (+)
19A: – Hypnum crista-castrensis (+)
6C: – Stereocaulon evolutoides (+); Cladonia turgida (+)
4 : – Lycopodium obscurum (2.1); Vaccinium macrocarpon (1.1)
11C: – Dicranum spurium (+)
108D: – Schizaea pusilla (+)
28E: – Cladonia tenuis (2.2); Cladonia alpicola (+)
44B: – Sphagnum tenellum (1.1)
51C: – Odontoschisma sphagni (1.1)

TABLE 2-21 KALMIO-SPHAGNETUM FUSCI ASSOCIATION

130	51	79	65	122	135	136	144	21	4	11	6	146	30	116	57	27	94	74	26	23	81	82	33	158	133	110	105	49	108	145	123	28	19	29	34	154	140	163	Presence value
A	C	A	A	A	A	A	B	B		C	C	B	D	A	D	B	A	A	C	A	A	D	D	B	A	E	D	B	D	D	B	E	A	A	C	B	A	A	
400	250	350	200	400	400	450	100	350	100	500	450	250	800	50	350	650	550	250	750	250	300	300	700	300	550	350	300	150	400	200	350	250	250	300	650	450	450	200	
50	70	60	80	80	90	90	100	70	100	90	100	90	90	80	100	70	70	80	90	100	70	100	100	70	70	90	60	100	70	80	70	100	100	90	100	80	90	80	
60	40	40	60	50	50	40	50	50	70	40	70	60	60	70	50	50	60	50	70	50	60	80	50	50	70	70	70	70	80	70	70	60	60	60	70	50	60	60	
20	19	17	21	19	19	20	20	16	24	20	22	23	21	20	22	27	19	23	22	19	24	22	21	24	25	35	31	21	33	25	27	27	23	24	27	25	26	28	
.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	1.1	+	+	.	+	.	+	.	+	1.1	1.1	+	1.1	+	.	1.1	II
.	.	.	.	.	.	1.1	.	.	.	.	.	.	.	.	.	1.1	.	.	.	.	.	.	+	.	1.1	.	.	1.1	.	+	.	r	1.1	1.1	.	+	1.1	+	I
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.	.	.	.	1.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2.1	+	.	1.1	.	1.1	1.1	.	.	.	.	1.1	.	1.1	I
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	1.1	+	.	+	.	.	.	.	.	2.2	+	.	.	I
																						PYRETOSUM																	
.	.	.	.	.	.	.	.	.	.	1.1	.	1.1	2.1	1.1	+	1.1	1.1	+	+	+	1.1	+	1.1	1.1	1.1	+	+	.	1.1	+	+	+	+	1.1	+	+	.	+	III
.	.	.	.	.	.	+	.	.	.	.	+	.	1.1	.	+	1.1	.	+	+	+	1.1	+	+	.	.	1.1	1.1	+	.	+	1.1	1.1	1.1	1.1	1.1	2.1	1.1	.	II
.	.	.	.	.	.	.	.	.	1.1	.	.	.	1.1	1.1	.	1.1	1.1	.	.	1.1	1.1	+	1.1	+	1.1	+	1.1	1.1	1.1	1.1	1.1	1.1	.	1.1	1.1	1.1	.	+	II
.	.	.	.	.	.	.	.	.	.	.	.	+	1.1	.	+	+	.	.	+	.	+	.	.	+	+	+	+	.	+	.	+	+	.	+	+	+	+	+	II
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.1	.	.	.	.	.	.	+	1.1	.	.	.	1.1	.	+	.	.	.	.	.	2.1	.	1.1	.	I
+	2.1	2.4	1.2	1.1	2.2	1.1	1.2	3.2	2.2	1.2	4.4	3.3	2.2	3.2	4.3	3.3	2.2	2.3	3.2	4.3	2.2	4.4	5.5	2.2	1.1	2.3	2.2	4.3	3.2	1.2	1.2	2.2	3.3	4.3	4.4	1.1	1.1	3.3	V
1.1	1.1	1.1	.	1.1	1.1	1.1	2.1	.	.	1.1	+	1.2	+	1.1	.	2.1	+	1.1	1.1	1.1	1.1	2.1	.	1.1	1.1	2.1	2.1	+	2.1	2.1	1.2	2.1	.	1.1	+	+	.	1.1	IV
.	1.1	1.1	3.1	1.1	2.1	1.1	+	1.3	3.2	2.2	3.3	1.2	.	+	1.1	2.2	.	2.1	1.1	.	2.1	+	+	+	.	+	1.2	+	1.2	+	+	1.2	.	+	1.2	.	.	1.1	V
1.1	.	.	2.1	+	1.1	.	2.1	1.2	.	2.1	.	+	1.1	.	1.1	+	.	2.1	1.1	.	1.1	.	+	1.1	.	2.1	1.1	.	.	2.1	1.1	2.1	1.1	2.1	+	1.1	1.1	1.1	IV
.	+	1.1	1.2	1.2	2.2	+	+	.	3.2	2.2	2.3	+	.	1.2	1.2	2.2	+	2.2	2.2	+	.	+	.	+	+	1.2	1.2	.	1.2	1.2	2.1	2.2	.	.	.	.	1.2	1.2	IV
1.1	2.1	1.1	3.1	2.1	2.2	2.1	1.1	2.1	2.2	2.2	2.3	2.2	.	.	2.1	.	.	.	.	+	.	3.3	1.1	+	1.1	3.3	.	3.2	1.1	3.3	.	.	2.1	2.1	.	1.1	2.1	2.1	IV
+	.	3.3	.	1.1	2.1	1.1	.	.	.	.	2.2	+	+	2.2	.	1.2	2.2	1.1	1.2	1.1	1.1	+	.	1.1	2.1	1.1	1.1	.	1.2	.	1.2	2.2	1.1	1.1	1.2	2.2	1.1	2.1	IV
+	.	1.1	.	1.1	3.1	+	1.1	1.1	.	+	.	.	.	.	1.1	.	.	.	.	.	.	3.1	.	1.1	.	3.1	1.1	+	+	3.1	.	.	.	+	.	.	1.1	1.1	III
.	.	.	+	1.1	.	.	.	1.1	1.2	.	.	2.2	.	.	+	1.2	.	+	+	.	1.1	.	.	.	.	+	+	.	+	.	.	.	.	.	1.2	.	.	1.1	III
.	.	.	.	.	.	.	+	.	1.1	+	.	+	.	.	.	1.1	.	1.1	1.2	+	.	.	.	+	.	+	.	.	+	.	.	2.1	.	.	1.1	1.1	.	1.1	III
1.1	2.1	2.1	.	.	.	.	+	.	.	.	1.2	+	+	1.2	1.2	.	1.1	.	2.2	.	2.2	1.2	.	.	.	+	.	.	1.1	.	.	+	.	.	.	.	.	1.1	III
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.1	.	1.1	.	+	.	2.1	+	.	.	+	1.1	+	.	.	II
.	.	.	.	.	.	.	.	.	1.2	2.2	2.2	1.2	.	.	.	.	.	1.2	.	.	.	.	+	.	.	.	.	.	.	.	.	2.2	.	.	.	.	.	.	II
2.2	3.2	3.3	+	2.2	2.2	2.2	.	1.2	3.2	1.2	4.2	2.2	3.2	3.2	1.2	2.2	2.2	1.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	1.2	1.2	1.2	2.1	.	2.2	1.2	2.2	3.2	1.2	+	+	2.2	V
.	2.1	1.1	2.1	2.1	2.1	1.1	1.1	1.1	2.2	2.1	+	2.1	1.1	2.1	2.1	1.1	1.1	1.1	1.1	1.1	2.1	2.1	1.1	+	1.1	2.1	1.1	2.1	2.1	2.1	2.1	2.1	1.1	2.1	1.1	1.1	2.1	1.1	V
1.1	1.1	.	1.1	1.1	1.1	+	2.1	1.1	.	2.1	2.2	1.1	1.1	.	+	1.1	.	2.1	1.1	+	1.1	1.1	.	1.1	+	+	1.1	1.1	+	1.1	+	1.1	1.1	1.1	1.1	.	+	1.1	V
+	2.1	.	1.1	1.1	1.1	1.1	2.1	1.1	2.1	1.1	2.2	.	1.1	.	+	+	1.1	2.1	1.1	1.1	1.1	2.1	.	1.1	1.2	1.1	1.1	1.1	.	1.1	1.1	1.1	2.1	1.1	1.1	2.1	+	1.1	V
.	1.1	1.1	1.1	1.1	1.1	1.1	+	1.1	.	1.1	.	+	1.1	+	1.1	+	1.1	1.1	1.1	1.1	+	+	.	+	.	1.1	+	1.1	1.1	+	1.1	2.1	1.1	1.1	1.1	+	+	1.1	V
.	.	1.1	.	1.1	1.1	1.1	+	1.1	.	.	.	+	1.1	1.1	+	+	1.1	+	.	1.1	1.1	+	.	+	+	+	+	+	+	+	+	.	.	1.1	+	+	1.1	1.1	IV
1.1	1.1	+	.	.	.	.	.	.	2.1	.	.	+	+	1.1	1.1	+	1.1	.	2.1	1.1	1.1	+	+	.	.	+	.	+	+	.	+	.	1.1	.	.	1.1	.	1.1	III
.	.	.	.	.	+	+	.	.	+	.	+	.	+	.	+	+	.	.	.	+	+	.	+	.	.	.	.	+	+	+	.	.	+	+	+	.	+	.	II
1.1	.	.	.	.	1.1	.	.	.	1.2	.	+	.	.	.	.	+	.	1.2	.	.	.	.	.	.	.	+	+	+	.	.	.	.	+	1.2	.	.	.	.	II
.	.	.	.	.	+	+	.	.	1.2	.	.	.	.	.	1.1	+	.	.	.	.	.	1.2	.	.	+	+	+	2.2	.	+	.	.	1.2	1.1	.	.	.	.	II
1.1	1.1	1.1	.	.	.	.	.	.	.	.	.	2.1	.	1.1	.	.	.	.	.	.	1.1	.	2.1	.	2.1	.	.	.	1.1	.	1.1	.	.	.	.	.	.	1.1	II
.	.	.	.	.	.	.	.	.	1.2	.	+	2.2	.	.	.	.	.	+	.	.	.	.	.	1.2	+	.	.	.	2.2	.	+	.	.	.	.	.	1.2	.	II
.	.	.	.	.	.	.	5.5	.	3.4	.	2.2	.	.	.	.	1.1	.	.	1.1	.	.	.	.	1.2	.	3.3	1.2	.	.	2.2	.	.	.	+	.	.	.	.	I
.	.	.	.	.	.	.	+	.	.	1.2	+	.	.	.	+	.	1.2	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	1.1	II
.	3.3	.	.	.	.	.	.	.	.	.	.	.	3.2	.	.	.	1.1	.	.	.	2.2	1.2	.	.	.	.	.	.	.	.	.	1.1	1.2	.	.	.	.	.	I
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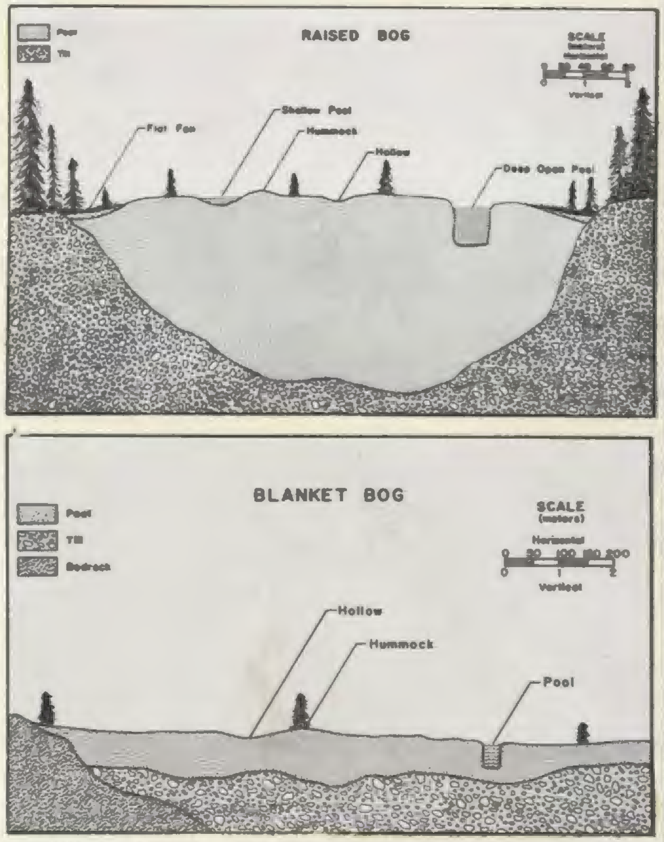
A. Physiognomy



B. Habitat

C. Distribution

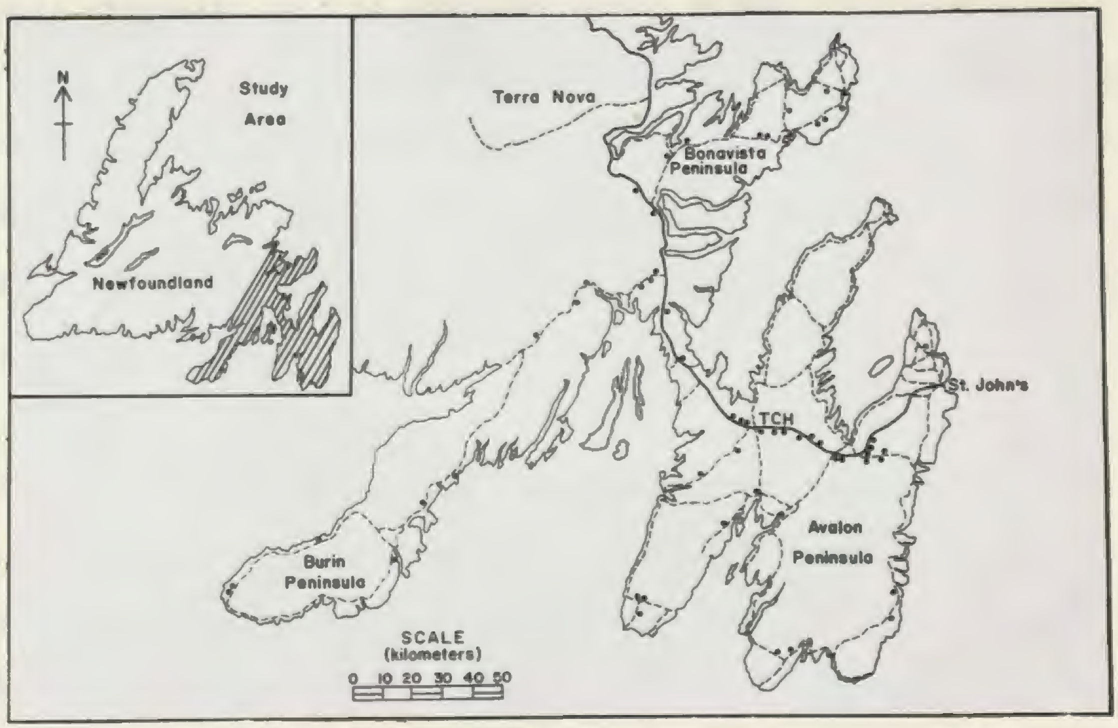


Figure 3-2: Kalmio-Sphagnetum fusci Association.

Sphagnum mosses (e.g. *S. fuscum*, *S. imbricatum*, *S. rubellum*) are dominant in the bog carpet usually with the sedge, *Scirpus cespitosus*, common throughout. These *Sphagna* grow above the level of the ground water table producing ombrotrophic conditions (i.e., water and nutrients are supplied solely by rainfall). Godwin (1946) attributes the convexity of raised bogs to the fact that such *Sphagna* are inhibited from lateral expansion by nutrient-rich waters from the surrounding mineral soil.

Two subassociations (Table 3-2) characterize this vegetation type. The *Pyretosum* subassociation is differentiated by the species, *Pyrus floribunda*, *Myrica gale*, *Calamagrostis inexpansa*, *Solidago uliginosa*, and *Betula michauxii*, and is confined mainly to the slope and blanket bogs. Most of the above species are indicators of weakly minerotrophic conditions in central Newfoundland peatlands (Pollett, 1972b). Their occurrence on eastern Newfoundland bogs is attributed to the influence of added nutrients supplied through the higher precipitation and wind-blown sea-salts in coastal sites.

Many of the slope bogs of eastern Newfoundland are also characterized by small *Sphagnum fuscum* hummocks which, although physiognomically similar to fen hummocks (Table 3-3) lack true fen indicator species. Such nutrient-poor hummocks are represented by the *Coptis groenlandica*-*Cornus canadensis*-*Juniperus communis* variant. The wetness of this variant is evidenced by the presence of Smilacina trifolia and Eriophorum angustifolium.

An anomaly characterizing eastern blanket and slope bogs is the presence of the large sedge, Carex rostrata, which only occurs on nutrient-enriched sites in western and central Newfoundland. This 'beaked' sedge is harvested on blanket bogs on the Burin peninsula and used as a roughage crop for sheep (Lear, 1960). Carex rostrata has been described as occurring primarily on marshes, wet moderately rich fens, and, occasionally, on oceanic bogs of eastern Newfoundland (Robertson, Pollett and Olsen, 1973).

Both Carex rostrata and Eriophorum angustifolium have been described by DuRietz (1954) as mineral-soil-water indicators in Swedish peatlands. Gorham (1957) indicated that in many areas being transformed from sedge-fen into Sphagnum bogs, the sedges remain for a long time pushing through moss cushions -- surviving by virtue of having their roots in the richer peat or, sometimes, the moving ground water beneath.

The Typicum subassociation represents the drier regions of the blanket, slope, raised and basin bogs. The presence of Scirpus cespitosus throughout the association indicates a possible link with the oligotrophic Scirpetosum subassociation (Pollett and Bridgewater, 1973).

3-3. Calamagrostio-Sphagnetum fusci Association (Pollett and Bridgewater, 1973).

Differentiation of the Association

The differential species group defining the association includes:

Sphagnum fuscum	Scirpus cespitosus
Sphagnum rubellum	Sphagnum papillosum
Empetrum nigrum	Calamagrostis inexpansa
Polytrichum strictum	Juniperus communis
Myrica gale	Mylia anomala
Lonicera villosa	Rosa nitida

This association is differentiated from all other bog associations by the presence of fen indicator species (e.g. Calamagrostis inexpansa, Rosa nitida) and is differentiated from all fen associations by the presence of bog indicator species (e.g. Sphagnum fuscum, S. rubellum, Polytrichum strictum, Empetrum nigrum).

Ecological Interpretation

The Calamagrostio-Sphagnetum fusci association (Table 3-3) is widely distributed through Newfoundland representing the ombrotrophic or oligotrophic fen hummocks (Figures 3-3A, 3-3B). These hummocks were

TABLE 3-3: CALAMAGROSTIO-SPHAGNETUM FUSCI ASSOCIATION

Relevé Number	126A	126B	113B	113A	91C	89A	88A	99A	117A	93A	125A	13B	12B	61D	61A	24B	75C	14A	72B	48A	120A	110B	35C	112D	173C	35B	71A	Presence Value
Altitude (ft)	300	300	250	250	650	450	450	300	50	600	50	600	500	300	300	250	350	550	600	150	450	350	100	600	700	600	400	
Cryptogams (% cover)	90	100	100	80	80	90	90	100	100	100	100	60	100	100	90	80	80	80	90	100	90	50	90	85	90	90	90	
Phanerogams (% cover)	60	60	70	70	70	80	80	90	80	90	90	70	90	70	70	60	70	70	70	90	80	70	70	80	70	80	70	
Number of Species	31	30	29	34	28	28	28	33	26	23	35	23	23	23	27	24	30	18	22	20	23	25	22	25	21	22	22	
Differential Species of the Sub-Variant																												
Rhacomitrium lanuginosum	4.4	4.4	1.2	1.2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Potentilla tridentata	1.1	+	1.1	1.1	.	.	.	.	.	.	.	.	.	1.1	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Differential Species of the Variants																												
Sanguisorba canadensis	1.1	+	+	1.1	.	1.1	1.1	2.1	+	1.1	1.1	.	.	.	.	.	.	.	.	.	1.1	+	.	.	.	.	.	III
Trientalis borealis	.	+	+	+	.	+	+	1.1	.	.	+	.	.	.	.	+	.	.	.	.	.	+	.	.	.	.	.	II
Betula michauxii	1.1	1.1	+	+	1.1	1.1	1.1	2.1	1.1	2.1	1.1	.	.	.	.	+	.	.	.	.	.	+	.	1.1	+	.	2.1	III
Gaylussacia dumosa	.	1.1	1.1	1.1	2.1	2.1	3.1	.	.	.	1.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II
Cetraria islandica	+	+	+	+	1.1	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	II
Pleurozium schreberi	+	.	.	+	.	.	.	.	.	.	.	2.3	+	.	.	1.1	1.1	1.2	.	.	.	.	.	.	.	+	.	II
Picea mariana	.	.	.	.	.	.	.	.	.	.	.	2.1	+	+	1.1	.	.	.	.	.	.	.	.	.	.	.	.	I
Larix laricina	.	.	.	.	.	.	.	.	.	.	.	+	+	+	+	+	+	.	.	.	.	1.1	.	.	.	.	.	II
Smilacina trifolia	.	.	.	.	.	.	.	.	.	.	+	.	1.1	1.1	1.1	+	+	.	.	.	.	.	.	.	.	1.1	.	II
Differential Species of the Association																												
Sphagnum fuscum	+	+	1.2	2.2	2.2	2.2	3.2	3.4	4.4	4.4	3.3	2.2	4.4	4.4	2.2	2.2	2.2	3.3	4.4	2.1	2.1	2.2	3.3	3.2	4.4	2.3	4.4	V
Calamagrostis inexpansa	2.1	1.1	1.1	1.1	1.1	2.1	1.1	2.1	1.1	1.1	+	1.1	1.1	.	1.1	.	1.1	1.1	1.1	2.1	.	2.1	2.1	2.1	.	1.1	1.1	V
Solidago uliginosa	+	+	+	+	+	1.1	+	1.1	1.1	+	+	.	.	.	.	+	.	+	.	1.1	1.1	+	+	1.1	+	.	1.1	IV
Polytrichum strictum	1.2	.	+	.	2.1	1.1	2.1	1.1	+	1.1	.	.	1.1	1.1	1.1	1.1	+	1.1	1.1	.	.	1.2	1.1	2.1	.	2.1	1.1	[illegible]
Lonicera villosa	.	+	.	1.1	.	2.1	1.1	1.1	1.1	2.1	.	1.1	2.1	+	+	+	.	2.1	1.1	1.1	1.1	.	1.1	.	+	.	1.1	IV
Sphagnum rubellum	.	1.2	2.2	.	2.2	2.1	2.1	1.1	2.1	2.1	.	1.2	.	.	1.1	1.1	1.2	.	.	+	1.1	.	3.3	2.2	2.1	.	.	III
Sphagnum papillosum	.	1.2	1.2	+	1.1	3.3	.	2.2	.	1.1	.	.	.	+	4.4	.	2.2	2.2	.	3.3	1.1	.	.	+	1.1	1.2	2.2	III
Myrica gale	.	+	.	.	+	2.1	2.1	3.1	3.1	2.1	1.1	1.1	1.1	.	.	2.1	.	.	1.1	1.1	2.1	1.1	.	1.1	.	.	+	III
Empetrum nigrum	+	.	.	.	.	.	.	1.1	1.1	1.1	1.2	3.2	2.1	1.1	1.1	+	1.1	.	.	2.1	1.1	3.3	1.1	.	.	2.1	+	III
Aster nemoralis	1.1	+	+	.	.	.	3.1	.	1.1	.	.	.	+	+	1.1	.	1.1	.	+	+	.	.	+	+	1.1	+	1.1	III
Juniperus communis	+	+	.	+	1.1	.	.	+	.	.	1.2	+	1.2	.	+	.	1.1	.	.	1.2	1.1	.	.	1.2	.	2.1	.	III
Aster novi-belgii	.	+	.	.	.	1.1	1.1	2.1	.	1.1	1.1	.	.	.	1.1	.	1.1	1.1	.	+	.	.	.	1.1	+	.	.	III
Mylia anomala	.	.	.	.	1.1	.	+	1.1	.	.	.	1.1	2.2	2.1	1.2	.	.	1.2	.	2.1	.	.	.	2.1	3.1	3.1	.	III
Cladonia rangiferina	1.1	1.1	+	.	2.1	+	.	.	.	.	1.1	+	.	.	.	.	1.1	.	+	.	.	1.1	.	.	.	1.1	.	II
Rosa nitida	.	.	+	.	.	+	+	+	+	.	.	.	+	.	+	+	.	.	.	.	+	.	.	.	.	.	.	II
Carex livida	1.1	+	.	.	.	1.1	.	.	.	.	.	.	1.1	.	.	.	.	.	1.1	2.1	.	.	2.1	.	.	.	1.1	II
Cladonia arbuscula	1.1	+	.	+	1.2	.	.	.	.	.	+	+	.	.	.	.	.	.	+	.	+	.	.	+	+	.	+	II
Companion Species																												
Ledum groenlandicum	1.1	+	+	1.1	1.1	1.1	1.1	2.1	1.1	1.1	1.1	+	2.1	1.1	1.1	1.1	+	+	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	V
Vaccinium oxycoccus	+	+	1.1	1.1	2.1	1.1	1.1	1.1	2.1	1.1	1.1	2.1	1.1	1.1	1.1	2.1	1.1	1.1	2.1	2.1	2.1	2.1	1.1	2.1	2.1	2.1	1.1	V
Kalmia polifolia	1.1	+	+	1.1	1.1	+	1.1	2.1	1.1	2.1	1.1	1.1	.	+	+	+	+	1.1	1.1	1.1	1.1	1.1	+	1.1	1.1	.	1.1	V
Sarracenia purpurea	+	.	+	+	+	+	+	1.1	+	+	+	+	+	+	+	+	+	+	+	.	+	.	+	+	+	+	+	V
Pyrus floribunda	1.1	+	1.1	+	1.1	+	+	2.1	1.1	1.1	+	.	.	1.1	1.1	1.1	1.1	.	1.1	.	.	+	.	.	+	1.1	1.1	IV
Drosera rotundifolia	.	.	+	1.1	1.1	+	1.1	1.1	1.1	+	1.1	.	+	+	1.1	+	1.1	+	.	1.1	.	.	+	1.1	1.1	+	1.1	IV
Carex exilis	+	.	+	+	2.2	1.1	1.1	1.2	2.2	2.2	1.1	.	.	1.2	3.2	.	+	2.2	2.2	3.1	2.2	.	2.2	+	[illegible]	.	2.2	IV
Chamaedaphne calyculata	.	.	1.1	1.1	1.1	+	2.1	.	.	+	1.1	.	+	.	.	1.1	1.1	+	1.1	.	+	1.1	.	1.1	1.1	1.1	.	III
Andromeda glaucophylla	1.1	.	+	1.1	1.1	+	.	1.1	+	.	1.1	.	.	+	.	.	1.1	.	.	.	1.1	+	+	1.1	1.1	.	1.1	III
Eriophorum angustifolium	.	+	.	.	.	.	.	+	.	.	+	1.1	+	.	.	.	+	+	.	1.1	1.1	+	1.1	.	.	2.1	.	III
Scirpus cespitosus	1.2	1.2	1.2	2.2	.	2.2	.	2.2	.	.	1.2	2.2	.	.	.	.	2.2	3.2	.	.	.	2.2	2.2	3.2	1.2	1.2	2.2	III
Coptis groenlandica	.	.	.	1.1	1.1	.	.	1.1	.	.	.	1.1	.	+	+	.	+	.	.	.	.	+	1.1	.	.	.	.	II
Carex oligosperma	.	.	.	.	2.1	.	1.1	.	.	1.1	.	.	+	+	.	.	2.1	.	+	.	.	.	1.1	.	.	.	.	II
Carex pauciflora	.	.	.	.	.	.	1.1	1.1	.	.	.	.	.	+	1.1	.	.	.	1.2	.	+	.	.	.	.	.	1.1	II
Dicranum scoparium	+	.	.	.	.	.	1.1	2.2	.	1.2	.	1.1	.	.	.	.	1.1	.	.	.	.	.	.	.	.	.	.	II
Maianthemum canadense	.	+	.	.	1.1	.	.	1.1	.	.	.	1.1	.	.	.	.	.	.	.	.	+	+	1.1	.	.	.	.	II
Linnaea borealis	.	.	.	.	.	1.1	.	.	.	.	1.1	.	.	.	1.1	1.1	.	.	.	.	+	.	.	.	+	.	.	II
Dicranum bergeri	.	.	.	.	2.2	.	+	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	+	.	.	I
Cladonia mitis	.	.	+	.	1.1	.	.	+	.	.	1.1	.	.	.	.	.	1.2	.	.	.	.	.	.	.	.	.	.	I
Kalmia angustifolia	+	+	.	+	.	.	.	.	.	.	1.1	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	I
Sphagnum flavicomans	.	.	4.2	2.2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3.3	1.2	.	.	.	.	.	I
Cladonia alpestris	1.2	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	I
Lepidozia reptans	.	.	.	.	[illegible]	.	.	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	I
Vaccinium angustifolium	1.1	.	.	.	.	.	.	.	.	.	1.1	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	I
Betula pumila	.	.	.	+	.	.	.	+	.	.	1.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Agrostis geminata	.	.	.	+	.	.	.	.	1.1	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Viburnum cassinoides	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	I
Arethusa bulbosa	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Cladonia uncialis	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Cornus canadensis	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	I
Aulacomnium palustre	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1.2	.	.	.	.	.	.	.	.	.	1.1	I
Hypogymnia physodes	.	.	.	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Sphagnum magellanicum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	2.1	.	.	.	.	.	.	I
Carex rostrata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.1	.	.	.	.	+	.	.	.	.	.	.	I
Sphagnum imbricatum	.	.	.	.	.	.	2.3	.	.	.	2.2	.	.	.	.	1.1	.	.	.	.	.	.	.	.	.	.	.	I

Additional Species

125A: - Eriophorum spissum (+); Rubus chamaemorus (1.1)
24B: - Carex trisperma (2.3)
72B: - Cornicularia aculeata (+)
120A: - Gaultheria hispidula (1.1)
110B: - Cladonia pyxidata (+)
35C: - Nemopanthus mucronata (+)
172D: - Eriophorum virginicum (+); Schizaea pusilla (2.2)
126B: - Vaccinium macrocarpon (+)
113A: - Cladonia elongata (+); Sphagnum strictum (+); Juniperus horizontalis (+); Cornus canadensis (1.1)
126A: - Drepanocladus revolvens (+); Rhinanthus crista-galli (+)
89A: - Thalictrum polygamum (1.1); Prenanthes trifoliolata (+)
99A: - Riccardia palmata (+)
12B: - Hylocomium splendens (+)

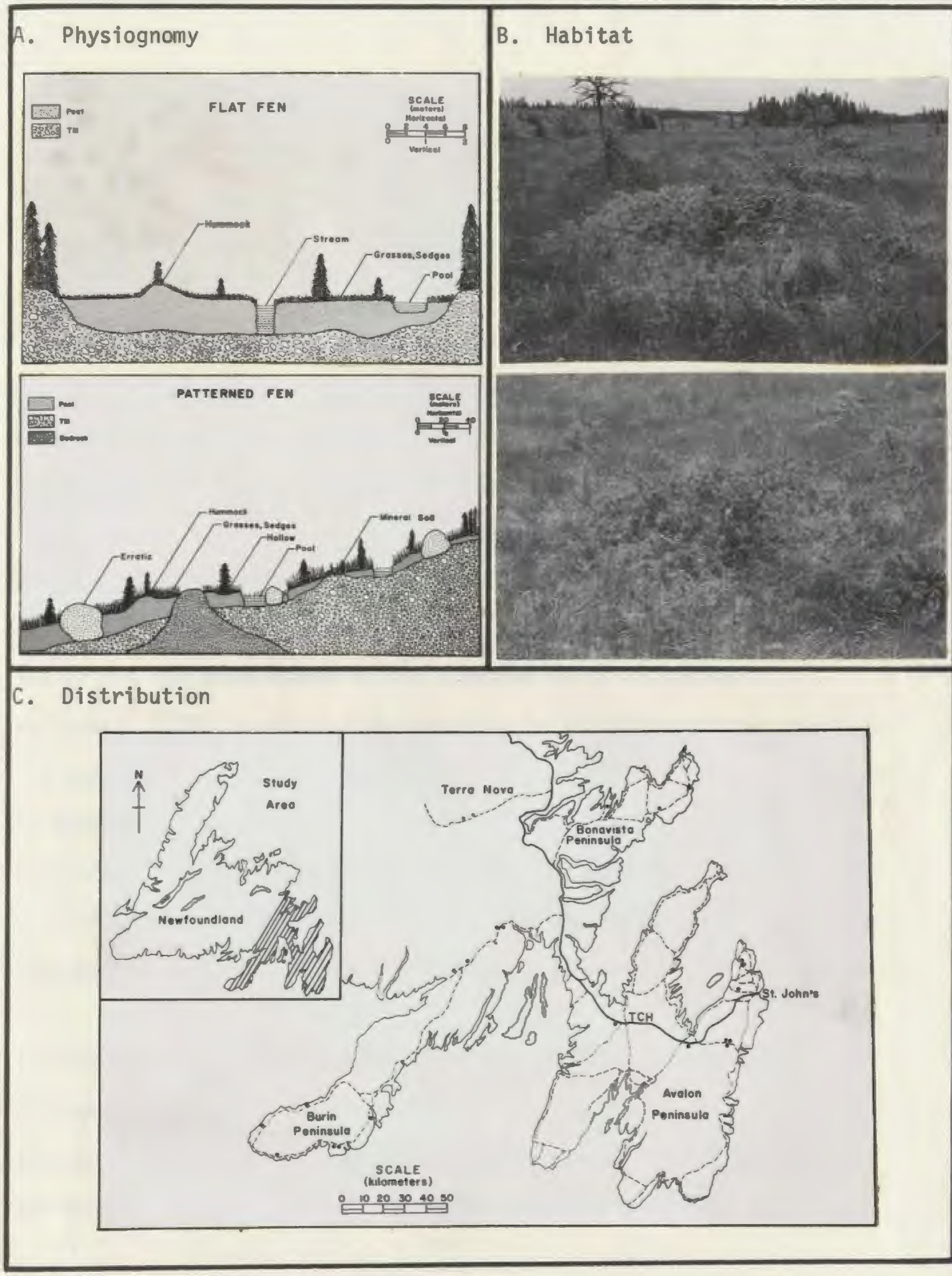


Figure 3-3: Calamagrostio-Sphagnetum fusci Association.

found to occur in eastern Newfoundland both on the exposed patterned fens and on the more sheltered fens within forested regions (Figure 3-3C).

This association has been described for central Newfoundland (Pollett and Bridgewater, 1973) as being the richest in species of all the nutrient-poor peatlands because it occurs as hummocks in the fen mat. These so-called "miniature bogs" (Bellamy and Rieley, 1967) are characterized by both bog and fen species, although many of the fen species are rooted in the fen matrix at the edge of the fen hummock.

The origin and development of fen hummocks is still unclear. Kulczynski (1949) suggests that nutrient-deficient substrates occur in the upper fen peat resulting in conditions favourable for the invasion of Sphagnum mosses. When the growth of such Sphagna (e.g. S. papillosum, S. magellanicum, S. tenellum) is above the water table, conditions are ideal for the establishment of the hummock-forming moss, Sphagnum fuscum and the ultimate development of a hummock.

The convex, dome-shape of the fen hummock suggests that the hummocks are ombrotrophic, i.e. their nutrients are supplied solely through precipitation. Although Bellamy and Rieley (1967) conclude that the hummock has shut off all effects of the mobile base-rich ground water from the area it occupies, they suggest a possibility of upward movement of water and ions through the hummock by capillary action. Pollett (1972a) has shown that the peats comprising this association in central Newfoundland have high iron contents in the upper layers, suggesting possible vertical movement of ions from the fen peats below. Both Pollett (1972a) and Puustjarvi (1952) consider iron concentrations as a reliable and useful indicator for the separation of poor and rich peats.

Both nutrition and climate are instrumental in the development of fen hummocks. According to Sjörs (1965) such ombrotrophic hummocks need a:

> "...moderate minerotrophic flow, very slight slopes and a sub-continental type of climate".

Furthermore,

> "...they are more or less concentrated to the districts with a low winter temperature".

Such is the case in central Newfoundland where fen hummocks are well developed.

Pollett (1972a) reports that the growth form of hummocks in the central Newfoundland peatlands is often much flatter in the more minerotrophic fen areas than in the more ombrotrophic sites. This phenomenon may be attributed to the fact that the growth of most raised bog _Sphagna_ (e.g. S. fuscum, the principal hummock-forming moss in fens) is retarded by nutrient-rich waters (Godwin, 1946). Although the fens of eastern Newfoundland are more nutrient-poor than those of central Newfoundland, the fen hummocks are correspondingly smaller (Figure 3-4). The more humid, suboceanic climate of eastern Newfoundland retards the upward growth of the Sphagnum fuscum hummock and results in a more even growth of other Sphagnum mosses (e.g. S. papillosum, S. magellanicum, S. subnitens) throughout the fen complex.

The Sanguisorba canadensis - Betula michauxii variant (Table 3-3) represents the hummocks of patterned fens on the Burin peninsula. Similar hummocks of patterned fens on the Avalon peninsula are characterized by the absence of the species, Sanguisorba canadensis. This anomaly is difficult to explain particularly because Sanguisorba usually occurs around the edge of such fens and, occasionally, occurs on the fens of the southern Avalon. It is also a differential species of the eutrophic fens and fen hummocks in central Newfoundland (Pollett and Bridgewater, 1973) and its distribution may be determined by edaphic factors. Huxter (1964), however, explained its occurrence in eastern Newfoundland by the constant high humidity and frequency of coastal fog in the area which satisfies its moisture requirement. Extreme exposure and foggy conditions are evidenced by the Rhacomitrium lanuginosum - Potentilla tridentata subvariant which occurs on the coastal patterned fens of the southern Burin peninsula.

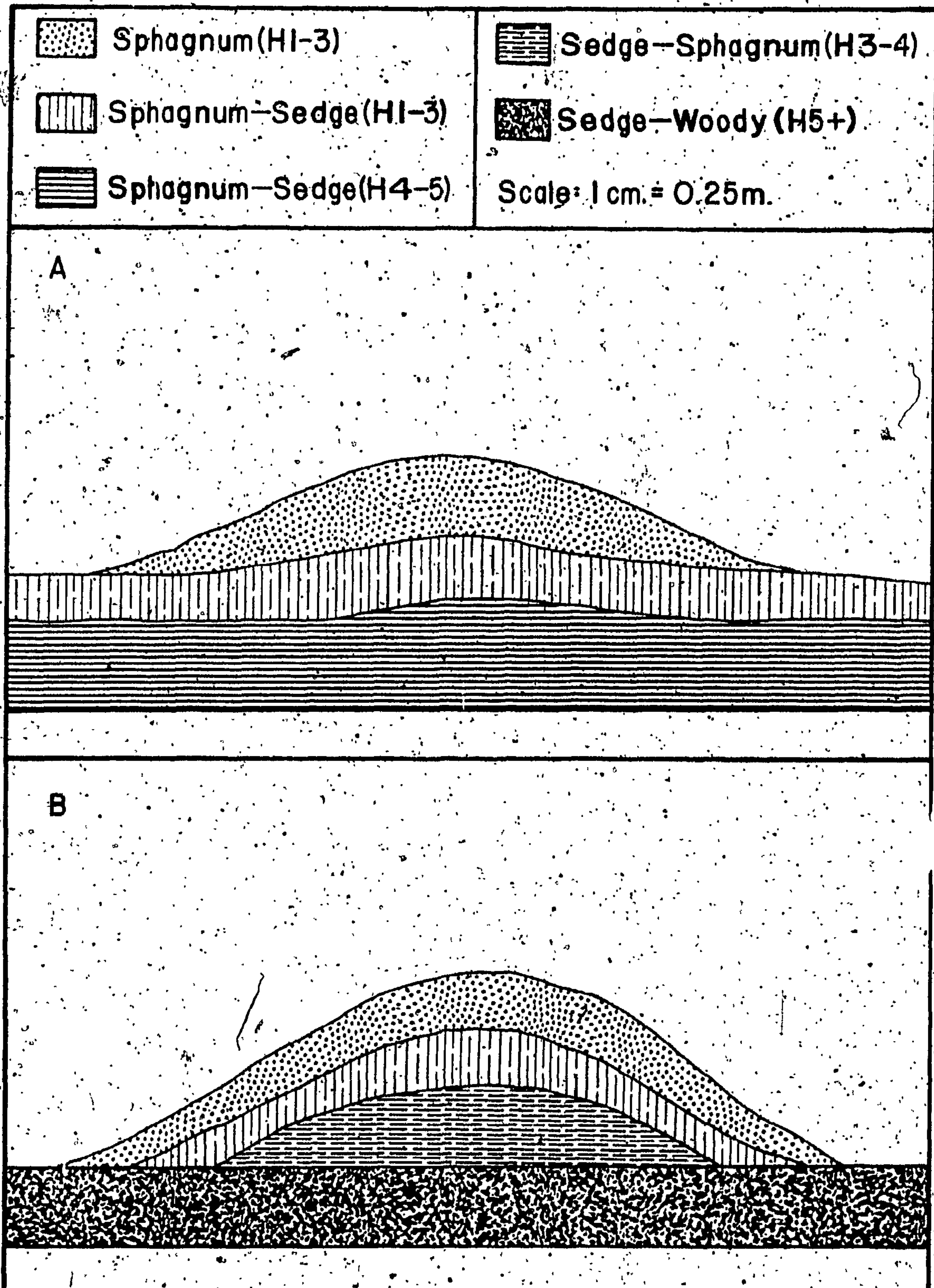


Figure 3-4: Profiles of low hummock(A) characteristic of the eastern Newfoundland fens, and hummock(B) (after Pollett, Bridgewater and Meades, 1970) of central Newfoundland fens.

A second variant, defined by the woodland species, Picea mariana, Larix laricina and Pleurozium schreberi is confined to the small sheltered flat fens within the coniferous forest. The remaining sites (e.g. 14, 72, 48, etc.) represent the higher hummocks of patterned fens and weakly-minerotrophic slope bogs. These hummocks are differentiated from the Kalmio-Sphagnetum fusci association only by the fen indicators Lonicera villosa, Carex livida, Solidago uliginosa and Juniperus communis.

3-4. *Scirpo-Sphagnetum tenelli* Association

Differentiation of the Association

The differential species group of the association includes:

Sphagnum tenellum

Odontoschisma sphagnii

Sphagnum subnitens

This association is differentiated from all other associations by the occurrence of *Sphagnum tenellum* and *Odontoschisma sphagnii*. It is differentiated from the drier associations (e.g. *Kalmio-Sphagnetum fusci* and *Calamagrostio-Sphagnetum fusci*) by the abundance of *Sphagnum subnitens*.

Ecological Interpretation

The *Scirpo-Sphagnetum tenelli* association (Table 3-4) is widely distributed throughout eastern Newfoundland (Figure 3-5C) representing the wet hollows of the ombrotrophic raised and basin bogs, and the flatter, sometimes extensive, wet areas of the blanket and slope bogs (Figures 3-5A, 3-5B).

TABLE 3-4: SCIRPO-SPHAGNETUM TENELLI ASSOCIATION

Releve Number	152	157	18	11	7	78	76	59	5	6	26	43	78	27	189	191	176	30	31	28	62	175	82	145	188	192	Presence Value
	A	B	E	B	E	D	B	G	B	B	E	A	C	A		A	C	E	A	C	A	G	A	A	A	B	
Altitude (ft)	550	150	250	500	100	400	350	400	300	450	750	350	400	550	500	400	350	800	800	350	350	300	300	200	500	500	
Cryptogams (% cover)	80	60	80	90	90	80	80	100	100	100	70	100	80	90	90	80	100	90	90	100	90	100	99	90	80	90	
Phanerogams (% cover)	70	60	70	50	60	60	60	60	40	40	60	50	50	60	50	50	50	40	50	50	60	50	50	40	50	50	
Number of Species	22	26	19	16	18	16	17	12	12	16	16	14	11	12	13	11	12	12	15	17	15	16	22	18	13	17	
Differential Species of the Variants																											
Mylia anomala	.	1.2	.	.	+	2.1	3.1	.	.	.	.	.	.	.	1.1	.	.	.	.	.	.	.	.	.	.	.	I
Empetrum nigrum	.	.	1.1	.	.	3.1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Rubus chamaemorus	.	.	.	.	.	2.1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Sphagnum fuscum	.	.	.	.	.	2.1	1.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Calamagrostis inexpansa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.1	+	+	1.1	1.1	1.1	1.1	.	+	1.1	II
Myrica gale	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1.1	.	1.1	+	+	1.1	.	1.1	1.1	1.1	II
Carex exilis	1.2	3.1	1.2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.2	+	+	2.2	1.2	1.1	1.2	+	.	III
Aster nemoralis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.1	.	.	+	1.1	1.1	1.1	1.1	.	+	II
Differential Species of the Sub-Associations			CLADONIETOSUM.													SPHAGNETOSUM											
Cladonia arbuscula	2.2	2.2	2.2	+	2.2	+	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	II
Cladonia mitis	1.1	1.2	2.2	+	1.1	.	+	.	.	+	1.2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II
Cladonia alpestris	.	+	2.2	.	2.2	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Kalmia angustifolia	.	+	+	.	1.1	+	+	.	.	.	.	.	.	.	.	.	.	.	1.1	.	.	.	.	.	.	.	II
Cladonia rangiferina	1.1	1.2	1.2	.	1.2	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	II
Ledum groenlandicum	.	1.1	+	+	1.1	+	+	.	.	1.1	.	.	.	.	1.1	.	.	.	.	.	.	.	.	+	.	.	II
Sphagnum pulchrum	.	.	.	.	.	.	.	2.2	3.3	2.2	2.2	4.4	2.1	2.1	1.1	2.2	.	2.2	2.2	2.2	1.1	+	2.1	.	+	+	IV
Cephalozia connivens	.	.	.	.	+	.	.	.	+	.	.	2.1	.	2.1	2.1	2.1	3.1	1.2	.	1.1	.	4.1	.	1.1	3.1	2.1	III
Carex oligosperma	1.1	.	.	.	.	.	.	4.1	.	2.1	1.1	.	.	+	1.1	2.1	1.1	.	1.1	2.1	3.1	.	1.1	2.1	1.1	2.1	III
Vaccinium macrocarpon	.	.	.	.	+	.	.	1.1	.	.	.	2.1	1.1	.	.	.	1.1	1.1	.	1.1	1.1	+	.	.	2.1	+	III
Differential Species of the Association																											
Sphagnum tenellum	3.2	1.2	3.3	4.4	4.4	4.4	3.3	1.1	2.2	3.3	3.3	1.2	2.3	2.2	2.3	3.2	4.4	4.4	4.3	4.4	2.2	4.4	3.2	4.4	3.3	3.3	V
Sphagnum subnitens	1.1	1.1	2.2	2.2	.	.	.	.	3.3	2.2	2.2	1.1	2.1	1.1	.	.	.	1.2	.	.	.	.	.	.	.	1.1	III
Odontoschisma sphagni	1.1	.	1.2	.	+	.	.	2.2	2.2	+	1.2	.	.	+	.	.	.	2.2	3.1	.	.	.	2.1	1.1	.	.	III
Companion Species																											
Vaccinium oxycoccus	1.1	2.1	1.1	1.1	.	3.1	1.1	1.1	1.1	2.1	1.1	1.1	1.1	2.1	2.1	2.1	2.1	.	2.1	1.1	1.1	1.1	2.1	1.1	[illegible]	2.1	V
Andromeda glaucophylla	2.1	+	.	.	2.2	.	+	.	+	+	+	+	1.1	1.1	1.1	1.1	1.1	+	+	1.1	1.1	+	1.1	+	[illegible]	1.1	V
Chamaedaphne calyculata	+	2.1	1.1	1.1	+	.	1.1	3.1	2.1	+	+	.	.	1.1	1.1	1.1	+	+	1.1	+	+	.	1.1	1.1	.	1.1	IV
Scirpus cespitosus	2.2	2.2	2.2	1.2	2.3	3.1	1.2	2.2	3.2	2.2	2.2	3.2	1.1	3.2	2.2	2.2	2.2	2.2	3.2	3.2	2.2	1.1	3.2	.	2.2	2.2	V
Cetraria islandica	1.1	+	1.2	.	1.1	2.2	+	.	.	1.2	1.2	1.2	+	.	.	+	.	.	+	.	.	.	2.1	1.1	1.1	+	III
Drosera rotundifolia	1.1	1.1	+	.	.	+	+	1.1	.	.	+	1.1	1.1	.	.	.	.	.	.	1.2	+	+	1.1	1.1	.	+	III
Kalmia polifolia	1.1	1.1	1.1	1.1	.	.	+	1.1	.	+	+	+	.	1.1	1.1	+	.	.	1.1	.	.	.	1.1	.	+	.	III
Sarracenia purpurea	1.2	+	.	+	.	.	.	.	+	.	.	1.1	.	.	.	.	.	.	.	.	.	+	.	.	.	.	II
Pyrus floribunda	.	+	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	I
Eriophorum spissum	.	.	.	1.2	.	+	.	.	.	.	.	+	2.2	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Cladonia uncialis	+	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Sphagnum papillosum	.	.	.	.	.	.	.	5.5	.	.	.	.	.	1.1	.	.	.	.	.	.	4.3	.	1.2	.	.	.	I
Sphagnum magellanicum	.	.	.	.	.	.	.	.	.	.	.	1.1	.	.	1.1	.	.	.	.	.	.	1.1	.	.	1.1	.	I
Solidago uliginosa	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	I
Rhacomitrium lanuginosum	.	+	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Smilacina trifolia	.	.	.	1.1	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	I
Rhynchospora alba	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.1	.	.	.	2.1	.	2.1	.	.	I
Sphagnum flavicomans	1.2	.	.	.	.	.	.	.	.	1.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Betula michauxii	.	.	.	.	.	.	.	.	.	.	1.1	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	I
Gaylussacia dumosa	1.1	1.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	I
Trientalis borealis	1.1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	I
Carex rostrata	+	.	.	.	.	.	.	.	.	.	.	.	1.1	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Vaccinium angustifolium	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Dicranum scoparium	.	.	.	2.2	.	.	.	.	.	.	1.2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Ptilidium ciliare	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2.2	.	.	.	I
Arethusa bulbosa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	+	.	.	I

Additional Species:

157B: – Cladonia squamosa (+); Cladonia verticillata (+)
18E: – Hypogymnia physodes (+)
11B: – Eriophorum angustifolium (1.1)
7E: – Dicranum bergeri (+); Stereocaulon evolutoides (+)
5B: – Sphagnum cuspidatum (2.2)
6B: – Cladonia terra-novae (1.2)
26E: – Carex pauciflora (2.1)
82A: – Ochrolechia frigida (1.2); Cladonia crispata (+)
145A: – Lepidozia reptans (+)
192B: – Lycopodium annotinum (+)

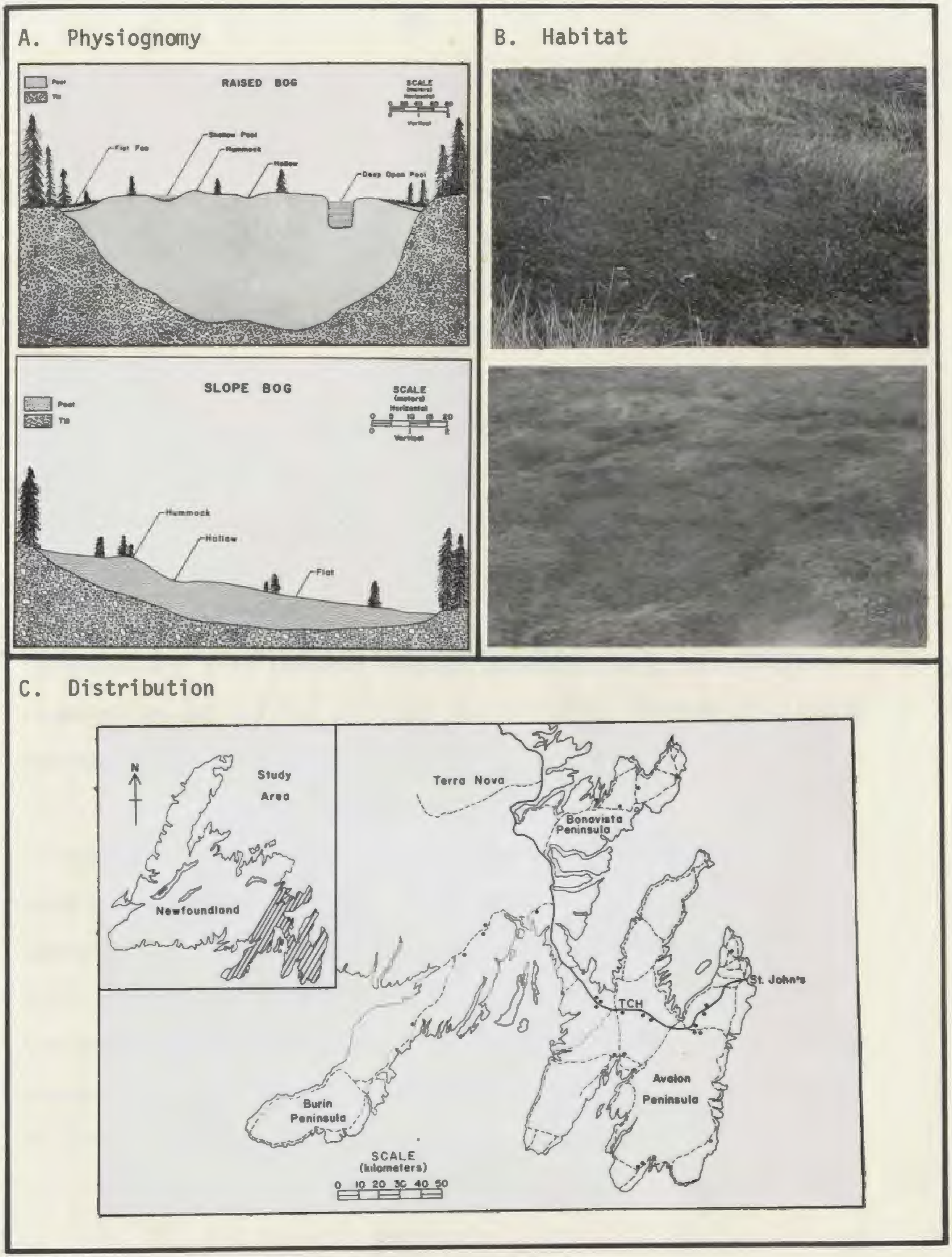


Figure 3-5: Scirpo-Sphagnetum tenelli Association.

The hollows illustrate an early stage of Osvald's (1923) hummock-hollow cycle of peat development. According to this theory the peat within each hollow is built up by the vegetation until it finally forms a new hummock. The old hummocks now occupy a lower level than the new hummocks and consequently become the sites of new hollows. Although all phases of this 'regeneration complex' (Tansley, 1949) are represented at any given time on the surface of an actively growing bog, Gorham (1957) attributed the process of cyclic development to the different ecological requirement of the various species of Sphagnum. This process of peat formation has been described for raised bogs of northwestern Germany (Ernst, 1934) and the Swedish "Blangsmossen" mire (DuRietz, 1950). According to Osvald (1950) regeneration and erosion complexes are essential elements of a living raised bog surface.

Objections to hummock formation via cyclic succession have been published. Both Weber (1926) and Granlund (1932) stress the climate-dependent character of the type of peat formed as being dominant. Their hypothesis suggests that the bog surface forms peat with a uniform degree of humification. Such an approach implies a much more homogeneous vegetation which alters clearly only under the influence of climatic changes (Casparie, 1972).

On-site bog hydrology is described by Casparie (1972) and Schluter (1969) as possibly being the most important factor in peat formation. According to Walker and Walker (1961) even small variations in precipitation have an obvious influence on bog hydrology and consequently on the type of peat which develops there.

A generalized succession cycle of hummock development is presented in Figure 3-6 for the bogs of eastern Newfoundland. Shallow bog pools are usually characterized by the species, Sphagnum torreyanum, S. cuspidatum and S. pulchrum. According to Gorham (1957):

> "Sphagnum cuspidatum favours water-filled depressions on the bog and grows so successfully as to obliterate them, thus providing conditions suitable for other species such as Sphagnum papillosum, S. magellanicum, and S. tenellum. When these have built up a low cushion of peat still other species invade, Sphagnum rubellum, S. fuscum, and perhaps, S. imbricatum".

As the hummock becomes higher, the top dries out enough to permit growth of lichens and liverworts until finally rate of decay is greater than upward growth.

Two subassociations (Table 3-4) represent various stages of the hummock-hollow cycle of bog development in eastern Newfoundland. Sphagnum pulchrum, Cephalozia connivens, Carex oligosperma and Vaccinium macrocarpon compose the Sphagnetosum subassociation characterized by very wet sites with the water table at, or above, the surface. The presence of Calamagrostis inexpansa, Myrica gale, Carex

Hollow with open water

↓

Sphagnum torreyanum

↓

Sphagnum pulchrum (S. cuspidatum)

↓

Sphagnum tenellum

↓

Sphagnum magellanicum

↓

Sphagnum papillosum

↓

Kalmia ———— Scirpus ———— Sphagnum rubellum

↓

Kalmia ———— Sphagnum fuscum ———— Cladonia rangiferina

↓

Cladonia rangiferina

Figure 3-6: A simplified diagram of bog hummock development in eastern Newfoundland. Note the positions of Sphagnum tenellum and Sphagnum pulchrum.

exilis and Aster nemoralis suggests weakly minerotrophic conditions within this subassociation.

The subassociation, Cladonietosum, differentiated by Ledum groenlandicum, Kalmia angustifolia and the Cladonia lichens, is indicative of wet sites with the water table at, or near, the surface. The Mylia anomala - Sphagnum fuscum variant, is found on drier sites and suggests a possible transitional stage from hollow to hummock.

3-5. *Scirpo-Sphagnetum subniti* Association

Differentiation of the Association

The differential species group of the association includes:

Sphagnum subnitens

Sphagnum papillosum

Sphagnum magellanicum

Scirpus cespitosus

Carex oligosperma

This association is differentiated from all other associations by the dominance of *Sphagnum subnitens*, *S. papillosum* and *S. magellanicum*, and the absence of true fen indicator species (e.g. *Thalictrum polygamum*, *Carex livida*, *Rosa nitida*) and true bog indicator species (e.g. *Sphagnum fuscum*, *Kalmia angustifolia*, *Cladonia rangiferina*).

Ecological Interpretation

The *Scirpo-Sphagnetum subniti* association (Table 3-5) occurs throughout eastern Newfoundland (Figure 3-7C) often in juxtaposition with heathland and scrub forest. Physiognomically, the sites are flat, wet areas of slope bogs (Figures 3-6A, 3-6B), topographically confined to poorly-drained slopes and depressions.

TABLE 5-5: SCIRPO-SPHAGNETUM SUBNITIS ASSOCIATION

Relevé Number	175	175	175	176	176	75	48	11	49	13	134	139	24	14	120	192	188	59	85	180	19	127	52	13	66	144	7	73	69	62	17	186	193	190	187	179	179	10	50	[illegible]	56	90	69	190	
	A	B	D	A	D	A	B	A	D	C	A	A	A	B	B	A	B	A	B	C	G	B	A	A	B	A	A	A	A	B	C		B	B		E	F	B	B	B	A	B	B	A	
Altitude (ft)	350	350	350	350	350	300	150	600	150	600	350	500	350	550	250	500	500	400	150	250	350	250	300	500	150	100	100	200	300	350	250	500	400	500	500	350	350	600	250	100	400	550	500	500	
Cryptogams (% cover)	70	80	80	70	60	90	70	70	90	90	80	70	70	60	60	60	70	80	70	70	80	70	70	80	100	60	100	70	100	80	80	80	80	80	90	70	70	70	90	100	100	80	90	90	
Phanerogams (% cover)	30	30	40	30	20	80	60	60	50	60	60	60	60	70	50	50	50	30	40	30	40	60	60	40	30	40	20	50	60	40	40	40	30	30	50	30	20	30	50	40	75	30	60	80	
Number of Species	21	16	18	18	16	26	19	15	14	16	17	18	18	19	24	17	15	18	21	22	20	22	23	23	11	12	15	14	16	17	16	16	12	15	20	13	12	12	18	11	13	15	16	14	
Differential Species of the Variants																																													Presence Value
Cladonia rangiferina	.	.	.	1.1	.	.	.	.	.	.	.	.	.	.	.	.	.	1.1	1.1	1.1	3.2	1.2	1.1	3.2	.	.	.	.	.	.	.	.	.	1.1	.	.	.	.	.	.	.	.	.	.	I
Mylia anomala	.	.	.	.	.	.	.	.	.	.	.	.	.	1.1	.	.	.	.	.	1.1	+	2.2	1.1	.	.	.	.	.	.	.	.	.	.	.	1.1	.	.	.	.	.	.	.	.	.	I
Pyrus floribunda	.	.	.	.	.	.	.	.	.	.	1.?	.	.	.	.	.	.	.	.	1.1	+	1.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.1	.	.	.	.	.	II
Cladonia mitis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.2	.	2.2	.	.	.	1.2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Sphagnum pulchrum	.	.	.	.	.	.	.	.	.	.	.	.	.	1.1	.	.	2.3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2.1	1.1	2.2	3.3	4.4	2.2	4.4	2.2	1.1	II
Vaccinium macrocarpon	.	.	.	.	.	.	.	.	.	.	.	1.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.1	1.1	1.1	.	2.1	1.1	.	+	.	I
Differential Species of the Sub-Associations												CALAMAGROSTETOSUM																					TYPICUM												
Calamagrostis inexpansa	+	1.1	1.1	1.1	1.1	2.1	2.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	2.1	1.1	1.1	1.1	1.1	1.1	1.1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	III
Myrica gale	+	+	1.1	1.1	1.1	+	2.1	+	2.1	1.2	1.1	1.1	2.1	1.1	+	1.1	1.1	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3.1	III
Solidago uliginosa	1.1	1.1	1.1	1.1	1.1	1.1	1.1	+	.	+	.	1.1	.	.	.	.	.	1.1	1.1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	III
Aster nemoralis	+	1.1	1.1	1.1	1.1	.	.	.	.	.	.	2.1	.	.	.	.	.	.	.	1.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II
Smilacina trifolia	1.1	+	1.1	+	.	.	.	1.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.1	.	.	1.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Differential Species of the Association																																													
Sphagnum subnitens	3.2	3.3	3.3	2.1	1.1	2.1	2.2	1.1	1.1	2.2	.	2.1	+	2.2	1.2	1.1	.	1.1	1.1	2.1	3.3	1.2	1.1	1.2	1.2	2.1	3.2	1.1	1.1	2.2	2.2	3.3	+	2.1	3.2	3.3	.	2.2	1.1	2.2	+	1.1	1.2	2.1	V
Sphagnum papillosum	2.2	.	1.1	+	2.2	3.3	3.2	3.3	3.3	4.4	1.1	2.3	3.3	3.2	.	2.1	1.1	3.3	+	2.1	.	1.2	3.2	3.2	4.4	2.2	2.2	3.3	2.1	3.3	3.3	1.2	1.1	1.1	1.1	.	2.1	1.2	2.2	.	3.3	1.2	3.3	2.1	V
Sphagnum magellanicum	1.1	2.2	3.1	2.2	2.2	2.2	1.1	.	2.2	.	3.2	2.2	+	1.1	2.2	3.3	2.2	.	3.3	2.2	.	+	.	1.2	1.2	2.2	2.2	.	2.2	.	1.2	1.1	3.3	3.3	2.2	.	3.3	1.2	.	.	+	2.2	1.2	3.2	IV
Companion Species																																													
Vaccinium oxycoccos	2.1	2.1	2.1	2.1	2.1	1.1	1.1	+	1.1	1.1	1.1	1.1	+	1.1	2.1	.	1.1	1.1	2.1	2.1	.	2.1	1.1	3.1	1.1	+	1.1	1.1	1.1	2.1	1.1	1.1	1.1	1.1	2.1	1.1	1.1	1.1	1.1	+	1.1	1.1	1.1	2.1	V
Scirpus cespitosus	2.2	2.2	2.2	3.2	3.2	2.2	2.1	3.3	2.2	3.2	2.2	2.2	1.2	2.2	2.2	.	2.2	2.2	3.1	3.2	2.2	2.2	3.2	2.2	2.2	3.2	3.2	2.2	3.2	1.2	2.2	2.2	2.2	2.2	2.2	2.2	2.1	3.3	2.1	2.2	3.2	3.1	1.2	2.2	V
Andromeda glaucophylla	1.1	.	.	+	1.1	1.1	1.1	+	1.1	+	.	+	1.1	.	+	1.1	1.1	+	1.1	+	1.1	+	+	+	2.1	1.1	1.1	1.1	+	1.1	1.1	1.1	+	1.1	+	1.1	1.1	1.1	.	.	1.1	+	+	1.1	V
Chamaedaphne calyculata	1.1	+	1.1	1.1	.	1.1	1.1	.	.	+	+	1.1	.	+	.	.	1.1	1.1	+	+	.	1.1	1.1	1.1	.	1.1	1.1	.	1.1	.	2.1	1.1	2.1	1.1	1.1	1.1	1.1	.	+	.	+	.	+	1.1	IV
Kalmia polifolia	+	.	.	1.1	1.1	+	1.1	.	.	+	.	.	+	1.1	+	1.1	1.1	1.1	1.1	1.1	.	1.1	1.1	.	1.1	1.1	1.1	+	1.1	+	.	1.1	.	+	2.1	1.1	+	.	+	.	+	.	+	+	IV
Ledum groenlandicum	1.1	+	+	+	.	1.1	3.1	.	.	.	.	.	.	.	.	.	1.1	.	1.1	1.1	1.1	1.1	1.1	1.1	1.1	.	+	.	1.1	1.1	1.1	+	.	.	1.1	1.1	.	.	.	.	.	.	.	.	III
Carex exilis	2.1	1.2	.	.	1.1	2.2	.	2.1	1.1	2.2	1.2	1.2	2.2	3.2	1.1	.	.	.	1.1	.	1.1	.	.	1.2	.	1.1	.	.	3.2	1.2	.	.	.	.	+	1.1	3.1	.	.	.	.	2.2	1.1	3.1	III
Drosera rotundifolia	.	.	.	.	.	.	.	.	.	.	.	.	1.1	.	.	.	.	.	.	.	.	.	1.1	.	.	.	.	1.1	1.1	+	.	.	.	.	.	.	.	.	.	.	.	2.1	.	.	III
Sarracenia purpurea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.1	.	.	.	.	.	.	.	.	.	.	.	.	II
Carex oligosperma	.	.	.	1.1	1.1	2.1	.	.	.	.	.	1.1	.	.	.	.	1.1	3.1	+	.	1.1	1.1	2.1	.	.	1.1	.	2.1	1.1	.	.	1.1	2.1	2.1	2.1	.	.	.	1.1	.	1.1	2.1	1.1	2.1	III
Cetraria islandica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2.2	.	.	.	1.2	+	.	.	.	2.2	.	.	.	1.1	+	1.1	.	.	.	.	.	.	+	1.2	2.2	1.1	II
Sphagnum flavicomans	.	.	.	.	.	1.1	.	.	.	.	2.1	.	.	.	.	1.1	.	2.3	2.2	.	.	.	.	1.3	1.1	.	.	.	.	2.2	1.2	2.1	.	1.1	.	.	.	.	.	.	.	.	.	1.2	II
Larix laricina	+	r	1.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	r	.	.	.	.	r	r	r	.	.	.	.	.	.	.	.	.	.	.	.	1.2	II
Cephalozia connivens	.	.	3.1	.	.	.	.	.	.	.	.	.	.	1.1	.	.	.	.	.	1.1	.	.	1.1	.	.	.	.	.	2.1	.	.	.	.	.	.	.	.	.	.	3.1	2.2	3.1	2.1	1.1	II
Carex rostrata	.	.	.	.	.	2.1	1.1	.	.	.	2.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2.2	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Lonicera villosa	.	.	.	.	.	.	1.1	.	.	1.1	.	.	1.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Kalmia angustifolia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.1	.	1.1	.	1.1	.	.	.	.	.	.	.	.	.	.	1.1	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Cladonia arbuscula	.	.	.	.	.	.	.	.	.	.	[illegible]	.	.	.	.	.	.	.	.	.	1.2	1.2	.	.	.	.	.	1.2	.	.	.	.	.	.	.	[illegible]	.	.	.	.	.	.	.	.	I
Eriophorum angustifolium	.	.	.	.	.	.	1.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Odontoschisma sphagni	.	.	.	.	1.1	.	.	.	.	.	.	.	1.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Gymnocolea inflata	.	.	.	.	2.1	.	.	.	.	.	.	1.1	.	.	.	.	.	.	.	.	.	1.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.1	1.1	.	.	.	.	.	.	I
Trientalis borealis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Empetrum nigrum	.	.	.	.	.	1.1	.	.	.	.	2.1	.	.	.	.	.	.	.	.	1.1	.	.	2.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Dicranum scoparium	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.1	.	.	.	.	.	.	.	1.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Lepidozia reptans	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3.1	.	.	.	.	.	I
Picea mariana	+	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Aster novi-belgii	.	.	.	.	.	.	.	.	.	.	.	.	1.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Lycopodium annotinum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.1	.	1.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Pleurozium schreberi	.	.	.	.	.	.	.	.	.	.	.	.	.	2.2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Rhynchospora alba	.	.	1.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.1	2.1	.	.	.	.	.	.	I
Sphagnum rubellum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.2	.	.	.	.	.	.	.	.	1.1	2.2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Sanguisorba canadensis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Pellia fabbroniana	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Dicranum spurium	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Sphagnum tenellum	.	.	.	.	.	.	.	.	.	1.2	.	.	.	.	.	.	.	.	.	1.2	+	2.2	.	.	.	.	.	2.3	.	.	.	1.2	.	.	.	.	.	.	.	.	.	.	2.2	.	I
Polytrichum strictum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Eriophorum spissum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Betula michauxii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.1	.	.	.	.	.	.	.	.	.	.	.	1.1	.	.	I
Arethusa bulbosa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Rubus chamaemorus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Sphagnum recurvum	.	.	.	.	.	.	2.2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2.2	.	.	.	.	I
Carex pauciflora	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Coptis groenlandica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I

Additional Species:

138: – Dicranum bergeri (+)
176A: – Cladonia alpestris (+)
13C: – Alnus crispa (+)
[illegible]: – Sphagnum [illegible] (1.1)
7D: – Cladonia uncialis (+)
69B: – Carex limosa (1.1)
73A: – Linnaea borealis (2.1); Selaginella selaginoides (1.1)
17C: – Sphagnum cuspidatum (2.2)

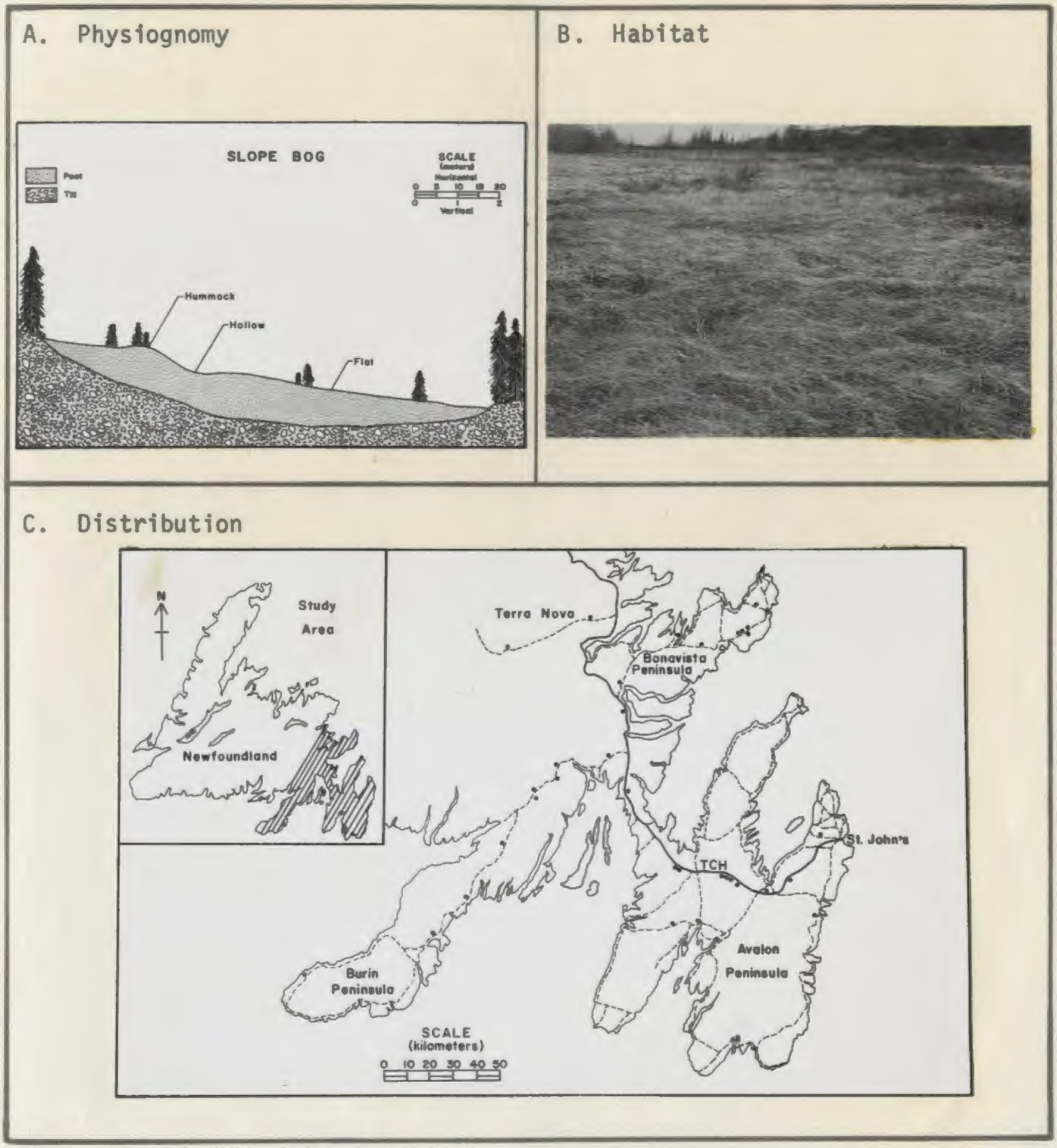


Figure 3-7: Scirpo-Sphagnetum subniti Association.

This peatland type has been defined as bog because of its high water table and its surface carpet of Sphagnum mosses. However, grasses (e.g. Calamagrostis inexpansa), sedges (e.g. Scirpus cespitosus, Carex exilis, Carex oligosperma), and some weakly minerotrophic fen indicators (e.g. Aster nemoralis, Myrica gale) occur on many sites. Pollett (1972b) describes these peatlands as "wet minerotrophic bog", the term 'bog' denoting the absence of true fen indicator species. Such peatlands are possibly transitional between bog and fen and might well be classified as "bogfens" (Zoltai, et al, 1975).

Two subassociations (Table 3-5) illustrate the importance of hydrology in this bog type as a dominant ecological gradient. The Calamagrostetosum subassociation, differentiated by Calamagrostis inexpansa, Myrica gale, Solidago uliginosa, Aster nemoralis and Smilacina trifolia, represents the weakly minerotrophic sites that are generally adjacent to forests. These more nutrient-demanding species are possibly rooted in the underlying humic fen peat, e.g. Carex rostrata. Drier and more nutrient-poor sites are differentiated by the Cladonia rangiferina variant.

The Typicum subassociation is a wetter, though more nutrient-poor vegetation unit differentiated from the Calamagrostetosum by the absence of weakly minerotrophic indicators. These poorly-drained sites are usually surrounded by heathland and are not influenced by seepage. Extremely wet conditions, with the water table at the surface, are characterized by the Sphagnum pulchrum - Vaccinium macrocarpon variant.

3-6. *Betulo-Sphagnetum stricti* Association

Differentiation of the Association

The differential species group of the association includes:

Betula michauxii	*Aster nemoralis*
Calamagrostis inexpansa	*Aster novi-belgii*
Sphagnum strictum	*Myrica gale*
Scirpus cespitosus	*Solidago uliginosa*

This association is differentiated from all other associations by the presence of *Sphagnum strictum* and *Schizaea pusilla*.

Ecological Interpretation

The *Betulo-Sphagnetum stricti* association (Table 3-6) represents the aapa, or patterned fens which are confined to two areas in eastern Newfoundland (Figure 3-8C). Physiognomically, the association occurs as elevated ridges, mounds, or hummocks scattered throughout the fens alternating with wet hollows or flarks in patterns believed to be determined by the direction of ground water flow (Figures 3-8A, 3-8B).

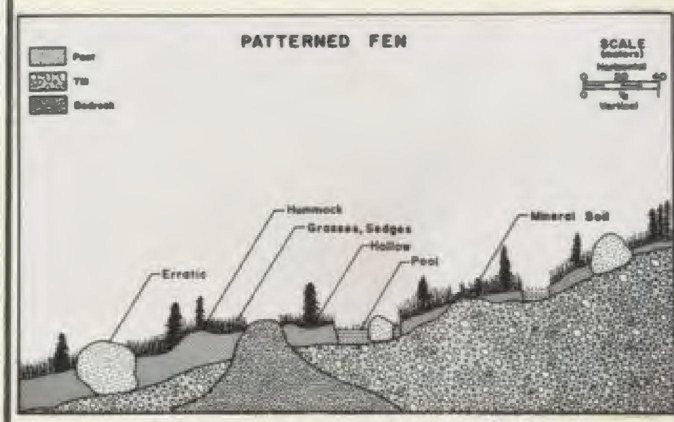
TABLE 3-6: BETULO-SPHAGNETUM STRICTI ASSOCIATION

Relevé Number	33 B	171 B	173 A	173 E	91 A	33 A	89 B	171 G	173 G	173 B	172 F	172 G	
Altitude(ft)	700	700	700	700	650	700	450	700	700	700	600	600	
Cryptogams (% cover)	90	90	70	60	50	70	50	100	100	50	40	70	
Phanerogams (% cover)	50	70	50	60	85	80	70	70	70	40	50	60	
Number of Species	18	18	15	18	32	24	22	19	16	19	15	20	
Differential Species of the Variants													**Presence Value**
Lonicera villosa	.	.	.	+	1.1	1.1	1.1	1.1	.	.	.	.	II
Thalictrum polygamum	.	.	.	.	1.1	+	2.1	1.1	.	.	.	.	II
Sanguisorba canadensis	.	.	.	.	2.1	.	2.1	+	.	.	.	.	II
Gaylussacia dumosa	.	.	.	.	1.1	+	1.1	.	.	.	.	.	I
Vaccinium macrocarpon	.	1.1	.	.	+	.	.	.	1.1	2.1	1.1	1.1	III
Rhynchospora alba	.	.	.	.	.	.	.	.	2.1	3.1	2.2	2.2	II
Differential Species of the Association													
Betula michauxii	+	1.1	1.1	1.1	1.1	1.1	+	1.1	1.1	1.1	1.1	1.1	V
Calamagrostis inexpansa	1.1	1.1	2.1	2.1	2.1	2.1	2.1	1.1	1.1	2.1	1.1	1.1	V
Aster nemoralis	1.1	1.1	+	1.1	1.1	.	1.1	2.1	1.1	1.1	1.1	1.1	V
Aster novi-belgii	.	1.1	1.1	1.1	2.1	1.1	1.1	2.1	1.1	1.1	.	1.1	IV
Sphagnum strictum	2.3	2.3	2.3	2.2	2.2	2.2	1.2	4.4	1.2	.	.	3.3	IV
Myrica gale	1.1	1.1	2.1	2.1	2.1	1.1	2.1	1.1	1.1	.	.	1.1	IV
Sphagnum papillosum	1.2	1.3	.	2.1	1.2	1.2	+	.	.	1.2	.	+	IV
Solidago uliginosa	+	.	1.1	1.1	1.1	1.1	+	+	.	+	.	.	IV
Sphagnum tenellum	1.2	.	.	2.2	.	3.2	.	.	2.2	1.2	.	1.2	III
Schizaea pusilla	.	.	.	.	1.2	.	.	.	.	1.2	2.2	.	II
Companion Species													
Scirpus cespitosus	1.1	2.2	2.1	3.2	3.2	3.2	2.2	2.3	3.2	2.2	3.2	3.2	V
Sarracenia purpurea	+	+	+	+	+	+	.	+	+	+	+	.	IV
Drosera rotundifolia	+	1.1	.	1.1	1.1	1.1	+	.	1.1	1.1	1.1	1.1	IV
Andromeda glaucophylla	+	+	.	.	2.1	+	+	+	1.1	1.1	1.1	+	IV
Kalmia polifolia	.	+	2.1	1.1	2.1	.	+	+	.	.	.	.	III
Carex exilis	1.1	.	.	1.1	1.2	.	2.1	.	1.1	1.1	.	.	III
Rhacomitrium lanuginosum	2.2	1.3	.	.	+2	1.1	.	.	.	2.2	.	1.2	III
Chamaedaphne calyculata	.	.	2.1	1.1	1.1	1.1	1.1	.	+	.	.	+	III
Pyrus floribunda	+	.	.	1.1	1.1	+	.	.	.	.	.	.	II
Maianthemum canadense	.	+	.	.	.	.	.	.	.	1.1	1.1	.	II
Cladonia rangiferina	+	.	.	.	1.1	.	.	.	.	.	.	1.2	II
Ledum groenlandicum	.	.	1.1	.	1.1	+	.	.	.	.	.	.	II
Carex oligosperma	.	.	3.1	1.1	.	.	.	.	.	.	+	.	II
Kalmia angustifolia	.	.	+	.	.	+	.	.	.	.	.	.	I
Betula pumila	.	.	1.1	.	+	.	.	.	.	.	.	.	I
Cephalozia connivens	.	.	.	.	.	1.1	.	.	.	.	2.2	.	I
Prenanthes trifoliolata	.	.	.	.	.	.	+	1.1	.	.	.	.	I
Habenaria dilatata	.	.	.	.	.	+	+	.	.	.	.	.	I
Habenaria clavellata	.	+	.	.	.	.	.	+	.	.	.	.	I
Carex michauxiana	.	.	.	.	.	.	.	.	.	+	.	+	I
Sphagnum compactum	.	.	.	.	.	.	.	.	2.2	2.3	.	.	I
Selaginella selaginoides	.	.	.	.	.	.	.	.	.	.	1.2	2.1	I
Vaccinium oxycoccus	.	.	.	.	1.1	.	.	1.1	.	.	.	.	I

Additional Species:

33B: – Carex folliculata (1.2); Sphagnum magellanicum (+)
171B: – Rhinanthes crista-galli (1.1); Rhynchospora fusca (1.1)
91A: – Coptis groenlandica (1.1); Cetraria islandica (1.1); Eriophorum angustifolium (1.1); Juniperus communis (+2); Vaccinium angustifolium (1.1)
33A: – Rosa nitida (+); Linnaea borealis (+)
89B: – Viola pallens (+); Polytrichum strictum (+)
171G: – Gaylussacia baccata (1.1); Larix laricina (+)
172G: – Cladonia arbuscula (+); Thuidium recognitum (1.1)
172F: – Sphagnum pylaesii (1.1)

A. Physiognomy



B. Habitat

C. Distribution

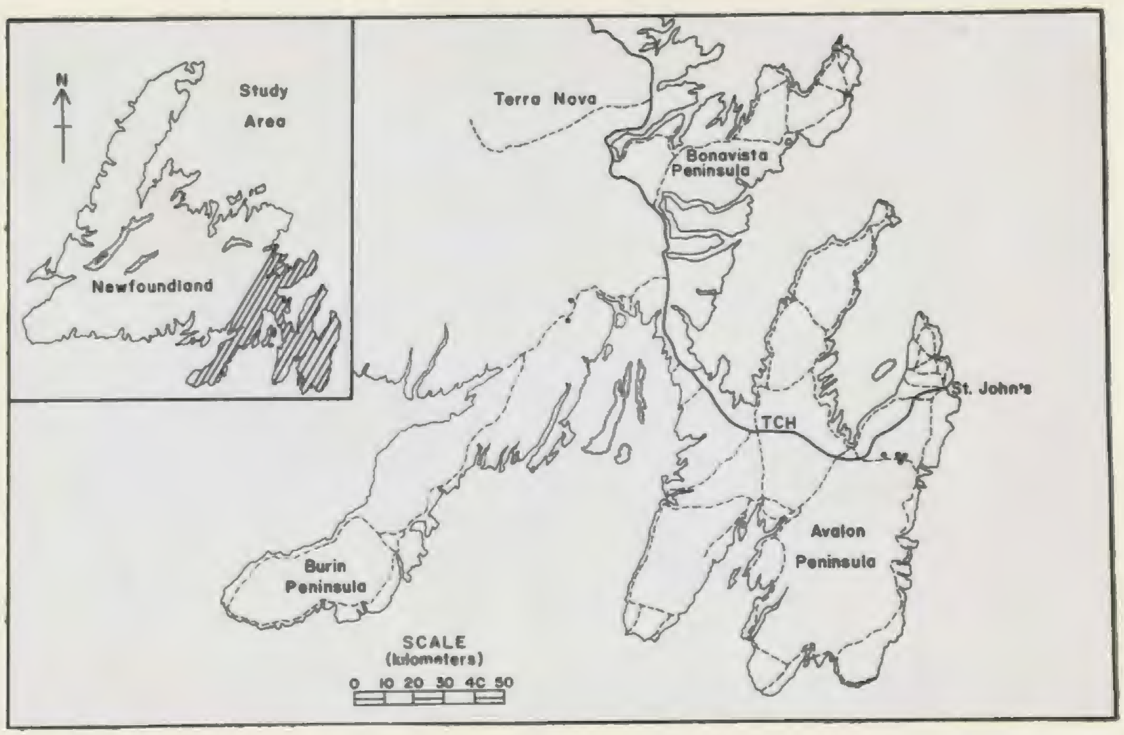


Figure 3-8: Betulo-Sphagnetum stricti Association.

This peatland vegetation is common in Alaska (Drury, 1956), Hudson Bay Lowlands (Sjors, 1959, 1961a), northern Scandinavia (Ruuhijarvi, 1972), and Russia (Bellamy, 1972; Elina, 1972). However, it is restricted to higher plateaus in Newfoundland, and is widespread on the Buchans Plateau in west-central Newfoundland. Extreme exposure and a shallow, highly humified peat layer typifies the habitat for the association which is the poorest of the two fen associations described from eastern Newfoundland. Sphagnum strictum, common in the aapa fens of the Buchan's Plateau, is also prominent throughout the association. Robertson, Pollett, and Olsen (1973) describe this species as occurring on open peat soils, usually on exposed fens.

There are two variants which describe degrees of wetness of the association (Table 3-6). The first, the Lonicera villosa - Thalictrum polygamum variant, occurs on the more minerotrophic peats (0.25 m to 0.75 m deep) adjacent to small streams. Such sites are characterized by a lush vegetation of grasses and sedges. Open wet hollows, where the water table is at the surface and exposed patches of mineral soil occur, are differentiated by the Vaccinium macrocarpon-Rhynchospora alba variant.

3-7. Betulo-Thalictretum polygoni Association

Differentiation of the Association

The differential species group of the association includes:

Betula michauxii	Myrica gale
Thalictrum polygamum	Aster novi-belgii
Lonicera villosa	Rosa nitida
Aster nemoralis	Solidago uliginosa
Carex livida	Calamagrostis inexpansa
Aulaucomnium palustre	Juncus canadensis
Carex buxbaumii	Sphagnum papillosum

This fen vegetation is distinguished from the previous bog and fen units by the presence of such minerotrophic indicators as Rosa nitida, Carex livida, Juncus canadensis, Aulaucomnium palustre and Carex buxbaumii.

Ecological Interpretation

The Betulo-Thalictretum polygoni association (Table 3-7) is distributed throughout the Avalon and Burin peninsulas (Figure 3-9C) representing the more nutrient-rich, flat to gently sloping fens usually found within forested areas (Figures 3-9A, 3-9B).

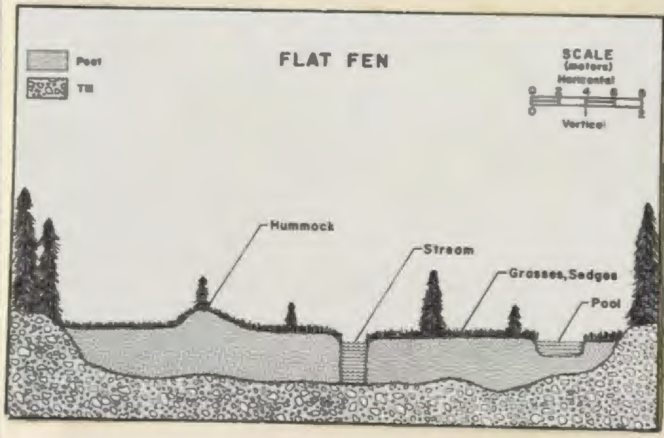
TABLE 3-?: BETULO-THALICTRETUM POLYGONI ASSOCIATION

Relevé Number	68 B	70 A	27 C	177 B	174 A	70 B	114 B	120 D	123 A	114 C	83 C	148 B	91 B	89 E	98 A	125 B	89 D	171 E	171 A	92 B	71 C	12 A	Presence Value
Altitude (ft)	400	700	650	350	350	700	150	250	350	150	300	400	450	450	600	50	250	700	700	600	400	500	
Cryptogams (% cover)	80	70	100	80	70	80	30	40	40	30	70	70	40	30	40	20	40	40	50	50	40	60	
Phanerogams (% cover)	60	70	50	50	60	80	90	80	80	90	60	70	90	90	90	90	100	60	60	80	80	70	
Number of Species	15	19	17	22	16	26	22	20	22	28	23	25	35	35	25	30	40	19	20	24	21	18	
Differential Species of the Variants																							
Potentilla fruticosa	.	.	.	.	.	.	.	.	.	.	.	.	.	1.1	2.1	1.1	+	1.1	1.1	+	.	1.1	II
Campylium stellatum	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	2.2	2.2	+	1.1	2.2	II
Selaginella selaginoides	.	.	.	.	.	.	.	.	.	.	.	.	.	1.1	2.1	+	+	1.1	+	1.1	1.1	.	II
Sphagnum strictum	.	.	.	.	.	.	.	.	.	.	.	.	+	2.2	1.2	1.2	1.2	.	.	.	.	.	II
Eriophorum viridi-carinatum	.	.	.	.	.	.	.	.	.	.	.	.	.	1.1	.	+	+	.	.	.	.	.	I
Sanguisorba canadensis	.	.	.	1.1	.	.	1.1	1.1	2.1	1.1	1.1	2.1	2.1	1.1	2.1	1.1	1.1	.	.	.	.	.	III
Viola pallens	.	.	.	.	.	.	+	.	1.1	3.1	.	.	.	.	1.1	+	1.1	.	.	.	.	.	II
Habenaria dilatata	.	.	.	.	.	.	+	.	1.1	+	+	.	+	+	.	.	+	.	.	.	+	.	II
Carex folliculata	.	.	.	.	.	.	1.1	1.1	1.1	1.1	.	1.1	.	.	1.1	.	.	.	.	.	.	.	II
Betula pumila	.	.	.	.	.	.	.	.	+	+	.	.	+	+	1.1	+	+	.	.	.	.	.	II
Linnaea borealis	.	.	.	.	.	.	.	+	.	2.1	1.1	.	1.1	+	.	.	+	.	.	.	.	.	II
Sphagnum subnitens	1.1	1.1	2.2	2.1	2.2	2.2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II
Sphagnum magellanicum	1.2	3.2	4.4	1.1	2.2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	II
Larix laricina	.	k	.	1.1	+	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Differential Species of the Association																							
Myrica gale	+	.	1.1	+	+	+	+	2.1	2.1	3.1	2.1	2.1	1.1	2.1	4.1	1.1	1.1	2.1	1.1	1.1	1.1	1.1	V
Betula michauxii	1.1	1.1	+	1.1	.	+	+	.	1.1	.	1.1	.	1.1	1.1	1.1	.	+	1.1	1.1	+	+	.	IV
Calamagrostis inexpansa	1.1	2.1	1.1	2.1	.	1.1	3.1	1.1	2.1	2.1	1.1	3.1	2.1	2.1	+	1.1	3.1	2.1	2.1	.	.	.	IV
Solidago uliginosa	+	1.1	+	1.1	1.1	+	+	1.1	.	1.1	.	+	1.1	1.1	1.1	.	1.1	+	.	1.1	+	+	IV
Aster nemoralis	+	1.1	+	1.1	+	+	1.1	1.1	2.1	2.1	.	1.1	1.1	1.1	1.1	+	1.1	1.1	+	+	1.1	+	V
Lonicera villosa	+	+	1.1	1.1	.	1.1	+	+	+	.	1.1	1.1	1.1	1.1	.	+	+	+	.	+	1.1	.	IV
Aster novi-belgii	.	1.1	.	1.1	1.1	+	+	.	.	+	1.1	1.1	+	1.1	.	+	1.1	1.1	1.1	+	1.1	+	IV
Sphagnum papillosum	3.3	2.2	.	3.3	2.1	3.3	1.2	.	.	+	4.4	4.4	1.2	1.2	2.2	1.2	1.2	1.1	.	+	1.1	1.1	IV
Thalictrum polygamum	+	.	.	.	1.1	.	.	+	.	+	.	+	+	1.1	2.1	+	2.1	1.1	.	+	1.1	1.1	III
Carex livida	.	.	+	.	.	.	.	.	2.1	+	.	.	1.1	.	2.1	2.1	+	1.1	.	.	.	1.1	II
Rosa nitida	r	.	.	+	+	+	.	.	.	.	.	.	1.1	+	+	.	.	.	.	.	.	.	II
Juncus canadensis	.	.	.	.	.	+	+	.	.	.	.	.	.	+	+	.	+	.	.	+	.	.	II
Aulacomnium palustre	.	.	.	1.1	.	+	.	+	.	.	.	.	.	.	1.1	+	.	.	.	.	.	.	II
Carex buxbaumii	.	3.1	.	.	.	2.1	.	2.1	2.1	+	.	.	.	.	.	.	.	.	.	.	.	.	II
Companion Species																							
Scirpus cespitosus	.	.	2.2	2.2	3.2	.	2.1	2.2	1.2	2.2	3.2	2.2	2.2	2.2	2.2	2.2	2.2	3.2	2.3	2.2	3.2	2.2	V
Chamaedaphne calyculata	.	+	+	1.1	1.1	.	+	.	+	.	.	1.1	+	1.1	+	+	1.1	+	1.1	+	+	+	IV
Carex exilis	2.1	2.2	2.2	.	.	3.1	2.1	1.1	1.2	+	1.1	+	2.1	1.2	1.2	1.1	1.1	.	.	.	3.2	3.2	IV
Vaccinium oxycoccus	1.1	1.1	.	2.1	2.1	2.1	1.1	1.1	.	+	1.1	1.1	1.1	.	.	1.1	.	1.1	.	1.1	1.1	1.1	IV
Sarracenia purpurea	.	.	+	+	+	+	.	+	+	.	.	1.1	+	.	.	+	+	+	+	+	+	+	IV
Andromeda glaucophylla	.	.	+	1.1	.	.	+	.	.	.	.	+	+	+	.	+	+	.	+	+	1.1	+	III
Drosera rotundifolia	.	.	.	.	.	+	.	.	+	1.1	.	+	+	1.1	+	+	1.1	.	+	.	1.1	.	III
Kalmia polifolia	.	1.1	+	.	.	+	+	+	.	.	.	+	+	+	.	.	+	.	.	.	.	.	II
Ledum groenlandicum	.	.	.	+	+	.	+	+	.	.	.	+	.	+	.	.	1.1	.	.	+	.	.	II
Eriophorum angustifolium	2.1	.	1.1	.	.	.	.	.	+	.	.	+	2.1	.	1.1	.	+	.	.	.	.	.	II
Carex oligosperma	2.1	1.1	.	.	.	1.1	.	.	1.1	1.1	2.1	.	.	.	.	.	1.1	.	.	.	.	.	II
Pyrus floribunda	.	2.1	.	.	.	+	.	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.	II
Trientalis borealis	.	.	.	.	.	+	.	.	.	+	.	.	+	+	.	.	.	.	.	.	.	.	I
Gaylussacia dumosa	.	.	.	.	.	.	1.1	.	.	.	.	.	1.1	1.1	.	.	2.1	.	.	.	.	.	I
Coptis groenlandica	.	.	.	.	.	.	.	.	.	.	+	.	+	+	.	.	+	.	.	.	.	.	I
Juniperus communis	.	.	.	.	.	.	.	.	.	1.1	.	.	+	+	.	.	1.1	.	.	.	.	.	I
Prenanthes trifoliolata	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	1.1	+	+	.	.	.	I
Kalmia angustifolia	.	.	.	.	.	.	.	.	.	.	+	1.1	+	.	.	.	.	.	.	.	.	.	I
Alnus crispa	+	.	.	.	.	+	.	.	.	.	.	.	k	.	.	.	.	.	.	.	.	.	I
Nemopanthus mucronata	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	+	.	.	.	.	.	I
Brachyelytrum erectum	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	.	1.1	.	.	I
Rhinanthus crista-galli	.	.	.	.	.	.	.	.	.	.	2.1	.	.	+	+	.	.	.	+	.	.	.	I
Polytrichum strictum	.	.	.	.	.	+	.	.	.	.	.	.	.	.	1.1	.	+	.	.	.	.	.	I
Sphagnum subfulvum	.	1.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.2	.	3.3	I
Carex rostrata	.	.	1.1	.	.	2.1	.	.	.	1.1	.	.	.	.	.	.	.	.	.	.	.	.	I
Smilacina trifolia	.	.	.	1.1	.	.	.	.	.	+	.	1.1	.	.	.	.	.	.	.	.	.	.	I
Riccardia palmata	.	.	.	.	.	.	.	.	.	.	.	.	.	1.1	.	.	.	.	.	.	+	.	I
Carex michauxiana	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	3.1	.	I
Scirpus hudsonianus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.2	.	.	.	+	.	.	I
Carex demissa	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	1.2	.	.	.	.	.	.	I
Viburnum cassinoides	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.	.	.	.	I
Rhacomitrium lanuginosum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.2	2.2	.	.	.	I
Juniperus horizontalis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.	I
Pleurozium schreberi	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.	.	I
Carex pauciflora	.	1.1	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Alnus rugosa	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	I
Carex lasiocarpa	.	.	.	.	3.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.1	I
Sphagnum recurvum	.	.	.	.	.	.	.	.	2.2	3.3	.	.	.	.	.	.	.	.	.	.	.	.	I
Spiraea latifolia	.	.	.	.	.	.	.	.	.	.	1.1	.	+	.	.	.	.	.	.	.	.	.	I
Rhynchospora fusca	.	.	.	.	.	.	.	.	.	2.1	+	.	.	.	.	.	.	.	.	.	.	.	I
Euphrasia randii	.	.	.	.	.	.	.	.	.	1.1	+	.	.	.	.	+	.	.	.	.	.	.	I

Additional Species

17/B: – Picea mariana (+)
174A: – Betula papyrifera (+)
70B: – Sphagnum pulchrum (+)
120D: – Cornus canadensis (+); Arethusa bulbosa (+); Agrostis geminata (+)
123A: – Sphagnum rubellum (1.2)
114C: – Epilobium palustre (1.1)
83C: – Thuidium recognitum (+)
148B: – Sphagnum tenellum (+); Maianthemum canadense (1.1); Empetrum nigrum (+)
91B: – Vaccinium angustifolium (+)
98A: – Sphagnum warnstorfii (+)
125B: – Triglochin palustris (+); Iris versicolor (+); Conioselinum pumilum (+)
89D: – Cladonia coccifera (+); Sphagnum imbricatum (1.2); Cladonia arbuscula (r)
171A: – Cladonia uncialis (+); Lycopodium annotinum (+); Rhynchospora alba (1.1); Vaccinium macrocarpon (+)
92B: – Rubus acaulis (+); Senecio pauperculus (1.1)
71C: – Pyrola rotundifolia (1.1)
12A: – Equisetum fluviatile (1.1); Drosera intermedia (+)

A. Physiognomy



B. Habitat

C. Distribution

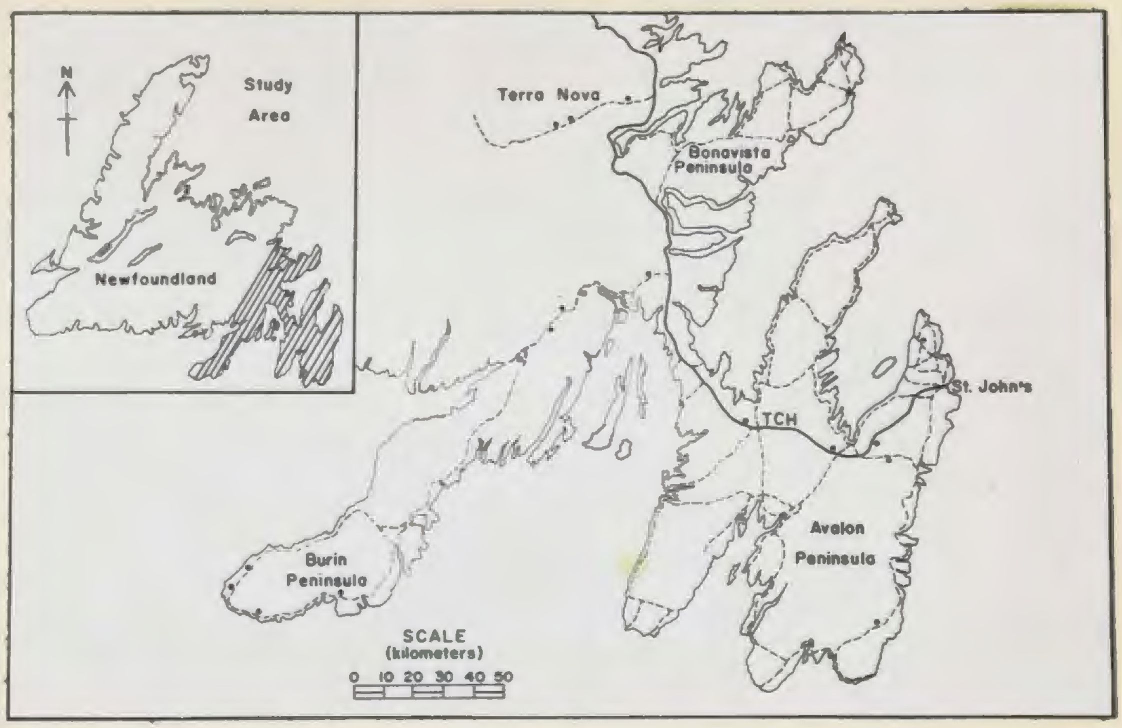


Figure 3-9: Betulo-Thalictretum polygoni Association.

However, unlike the calcareous-enriched fens of western and central Newfoundland, the fens of eastern Newfoundland occupy poorly-drained seepage slopes and depressions of more acid substrates.

Several variants depict nutrient and moisture gradients within the association (Table 3-7). The Sphagnum-Larix variant is relatively species poor, corresponding closely to the mesotrophic bog of Damman (1964) and the Scirpo-Sphagnetum papillosi association (Pollett and Bridgewater, 1973) of central Newfoundland. Sphagnum mosses are abundant where the water table is at, or near, the surface.

The Sanguisorba canadensis - Carex folliculata variant occurs along well-drained stream banks characterized by a lush growth of grasses and sedges. This variant is differentiated by the anomalous species, Sanguisorba canadensis and, with one exception (site 148), was only located on the Burin peninsula.

The more nutrient-rich sites are differentiated by Campylium stellatum, Potentilla fruticosa, and Selaginella selaginoides. These sites generally occur on the Burin peninsula in juxtaposition with aapa fens and the coniferous forest. Such sites are characterized by a compact, shallow layer of sedge-wood peat, in which fast-flowing streams are common. This variant is the richest of all peatland types with a great diversity of fen species, and has close affinities with the Potentillo-Campylietum stellati (Pollett and Bridgewater, 1973) association which occupies the richest sites in the fen category of central Newfoundland peatlands. However, the rich fens of central Newfoundland occur within catchment basins in the coniferous forest.

Pool Communities

The following four vegetation types represent the pools and mudflats of the peatlands of eastern Newfoundland. Because of difficulty in determining where to sample (e.g. open water, mudflat, peat bank, peat bank/pool bottom interface, etc.) these units have only been described at the community level.

3-8. *Nuphar variegatum* Community

Differentiation of the Community

The differential species group of the community includes:

Nuphar variegatum
Sphagnum torreyanum
Eriocaulon septangulare

Ecological Interpretation

The *Nuphar variegatum* community (Table 3-8) represents the deep, open pools of the basin and raised bogs (Figure 3-10). It is characterized by a paucity of species, most of which are rooted in the bank. A variant differentiated by *Sphagnum magellanicum*, *Sphagnum pulchrum* and

TABLE 3-8: NUPHAR VARIEGATUM COMMUNITY

Releve Number	163 A	164 A	7 C	162 B	162 D	
Altitude (ft)	300	300	100	300	300	
Cryptogams (% cover)	90	5	70	80	90	
Phanerogams (% cover)	20	60	60	30	60	
Number of Species	5	4	3	8	9	
Differential Species of the Variant						**Presence Value**
Juncus Sp.	.	.	.	2.1	+	II
Sphagnum pulchrum	.	.	.	2.2	2.2	II
Sphagnum magellanicum	.	.	.	1.2	1.1	II
Differential Species of the Community						
Nuphar variegatum	2.1	3.1	1.1	1.1	2.1	V
Sphagnum torreyanum	4.4	+	3.3	3.3	4.4	V
Eriocaulon septangulare	.	4.1	3.1	.	+	III
Myrica gale	+	.	.	+	.	II

Additional Species:

163A: - Sphagnum pylaesii (2.2); Chamaedaphne calyculata (+)
164A: - Andromeda glaucophylla (1.1)
162B: - Utricularia intermedia (1.1)
162D: - Carex limosa (3.1); Drosera intermedia (+);
Vaccinium macrocarpon (+); Carex exilis (1.1)

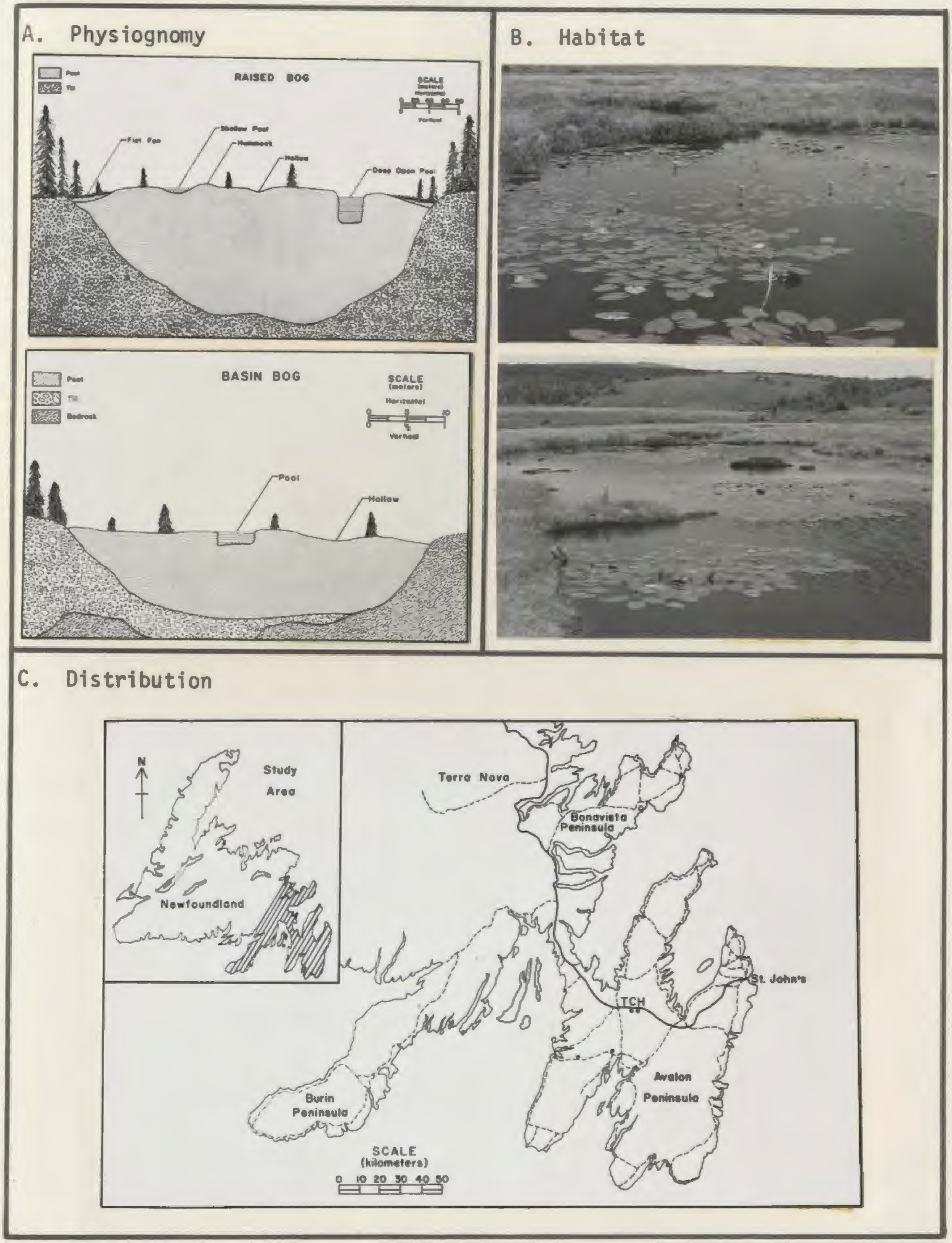


Figure 3-10: Nuphar variegatum Community.

Juncus sp. occurs at the periphery of the pool indicating possible infilling.

3-9. *Sphagnum torreyanum* Community

Differentiation of the Community

The differential species group of the community includes:

Sphagnum torreyanum — *Kalmia polifolia*

Andromeda glaucophylla — *Vaccinium oxycoccus*

Ecological Interpretation

The *Sphagnum torreyanum* community (Table 3-9) is characteristic of the shallow pools on raised, blanket and basin bogs (Figure 3-11). Open shallow pools are differentiated by the *Sphagnum pylaesii* - *Rhynchospora alba* - *Drosera intermedia* variant. The second variant differentiated by *Sphagnum pulchrum* and *Sphagnum papillosum*, is indicative of early stages of infilling by *Sphagnum* mosses.

TABLE 3-9: SPHAGNUM TORREYANUM COMMUNITY

Relevé Number	62 C	16 D	50 A	54 A	163 B	165 A	60 C	78 E	65 E	
Altitude (ft)	350	300	250	50	300	300	400	400	200	
Cryptogams (% cover)	90	90	80	100	50	100	100	80	100	
Phanerogams (% cover)	20	20	10	60	60	20	20	30	40	
Number of Species	9	8	8	11	10	10	7	5	7	
Differential Species of the Variants										**Presence Value**
Sphagnum pulchrum	1.2	3.2	2.2	.	.	.	+	.	.	II
Sphagnum papillosum	2.1	.	3.3	.	.	.	.	.	.	I
Sphagnum pylaesii	.	.	.	4.4	2.2	.	1.2	2.2	+	III
Rhynchospora alba	.	.	.	.	2.1	2.2	+	2.2	3.2	III
Drosera intermedia	.	.	.	2.1	1.2	+	.	2.2	1.2	III
Differential Species of the Community										
Sphagnum torreyanum	5.5	5.5	3.3	2.3	2.2	5.5	5.5	3.2	5.5	V
Andromeda glaucophylla	1.1	+	+	+	+	1.1	1.1	+	1.1	V
Vaccinium oxycoccus	.	+	+	1.1	.	+	.	.	1.1	III
Kalmia polifolia	.	1.1	+	1.1	.	1.1	.	.	.	II
Carex exilis	+	2.2	.	.	.	1.1	.	.	.	II
Carex limosa	.	.	1.1	2.1	+	.	.	.	.	II
Companion Species										
Carex oligosperma	2.1	.	.	3.1	.	.	.	.	.	I
Myrica gale	.	.	.	2.1	1.1	.	.	.	.	I
Chamaedaphne calyculata	+	.	.	.	.	+	.	.	.	I
Sarracenia purpurea	.	+	.	.	.	+	.	.	.	I
Scirpus cespitosus	.	1.2	.	+2	.	.	.	.	.	I
Vaccinium macrocarpon	.	.	.	.	+	.	1.1	.	.	I

Additional Species:

62C: – Nuphar variegatum (+); Scheuchzeria palustris (1.1)
65E: – Utricularia intermedia (1.1)
165A: – Sphagnum magellanicum (2.1)
50A: – Eriophorum spissum (1.2)
60C: – Drosera rotundifolia (1.1)
163B: – Sphagnum cuspidatum (1.2); Nymphae odorata (3.1)
54A: – Menyanthes trifoliata (3.1)

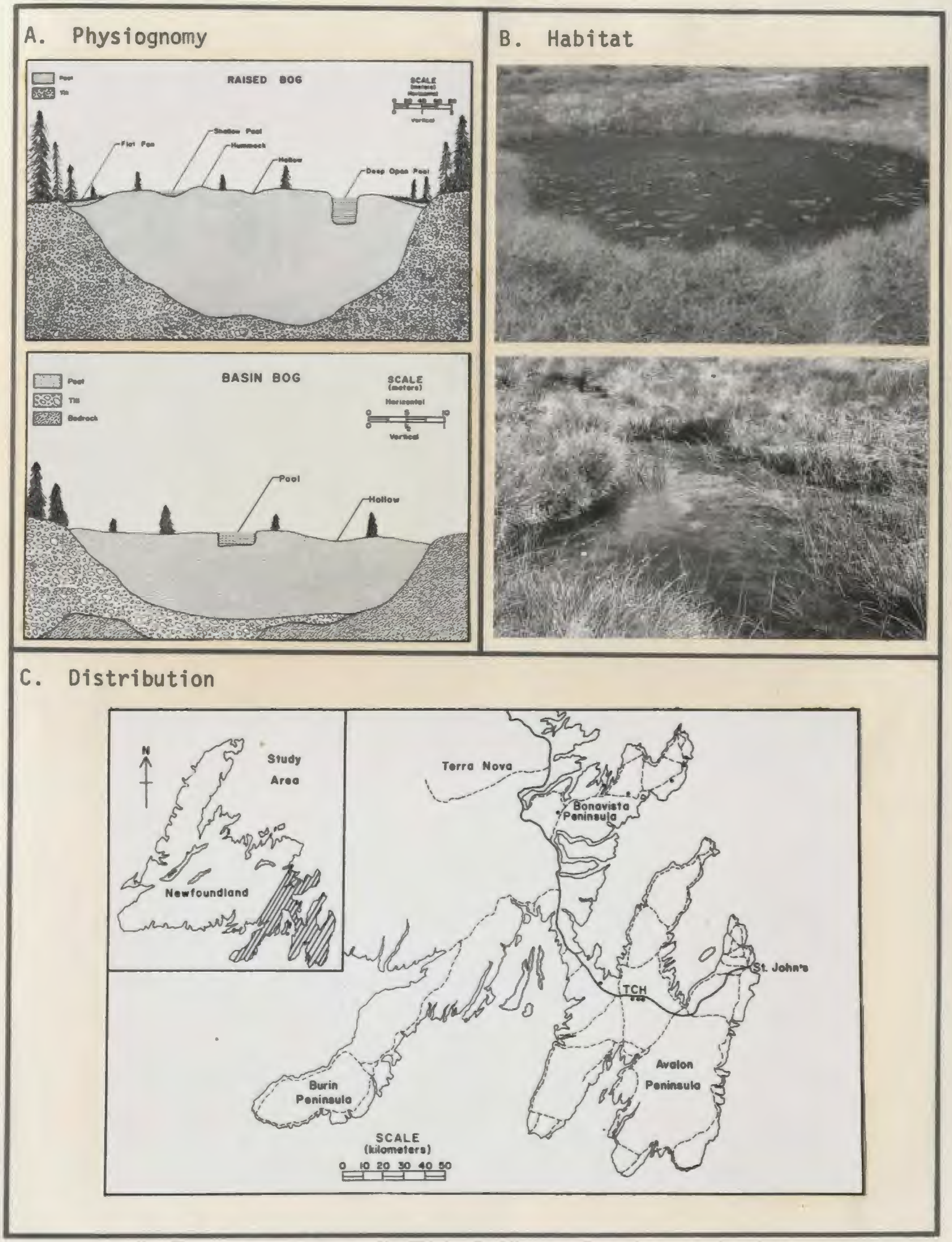


Figure 3-11: Sphagnum torreyanum Community.

3-10. Utricularia cornuta Community

Differentiation of the Community

The differential species group of the community includes:

Utricularia cornuta

Rhynchospora alba

Drosera intermedia

Ecological Interpretation

The Utricularia cornuta community (Table 3-10) occurs as shallow mud pools of the ombrotrophic raised and basin bogs (Figure-3-12). The water level is normally several inches above the surface. However, summer drying often produces a hard-baked mud flat.

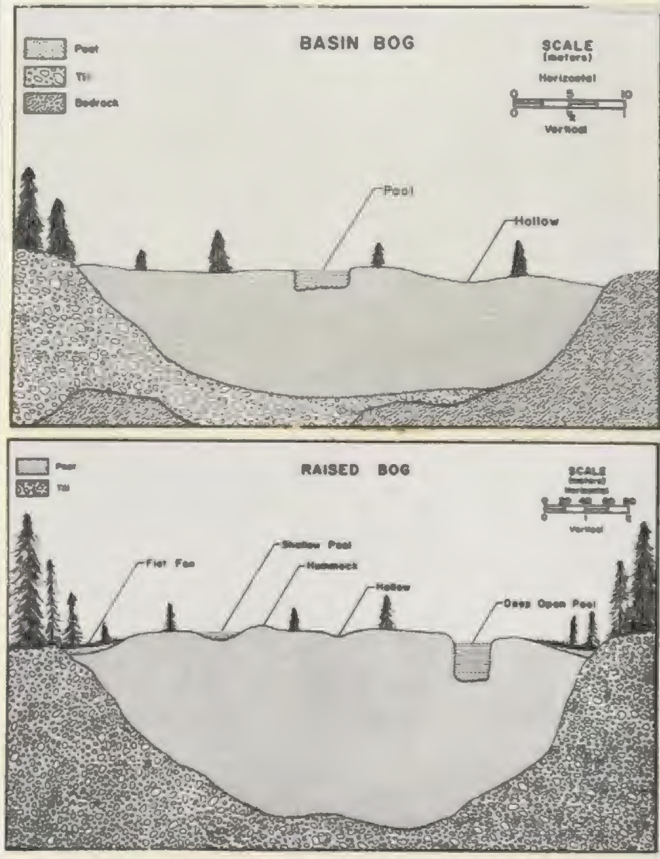
TABLE 3-10: UTRICULARIA CORNUTA COMMUNITY

Releve Number	163 D	163 E	163 C	161 B	
Altitude (ft)	300	300	300	300	
Cryptogams (% cover)	0	10	0	10	
Phanerogams (% cover)	60	60	70	80	
Number of Species	8	5	5	6	
Differential Species of the Community					**Presence Value**
Utricularia cornuta	2.2	4.4	5.5	4.4	4
Rhynchospora alba	1.1	2.2	1.2	1.1	4
Drosera intermedia	3.2	2.1	1.2	3.2	4
Andromeda glaucophylla	+	+	•	•	2
Kalmia polifolia	•	•	+	+	2

Additional Species:

163D: - Chamaedaphne calyculata (+); Utricularia intermedia (1.1); Utricularia geminiscapa (3.2); Vaccinium macrocarpon (+)
163E: - Sphagnum papillosum (1.1)
163C: - Vaccinium oxycoccus (+)
161B: - Sphagnum magellanicum (1.1); Kalmia angustifolia (+)

A. Physiognomy



B. Habitat

C. Distribution

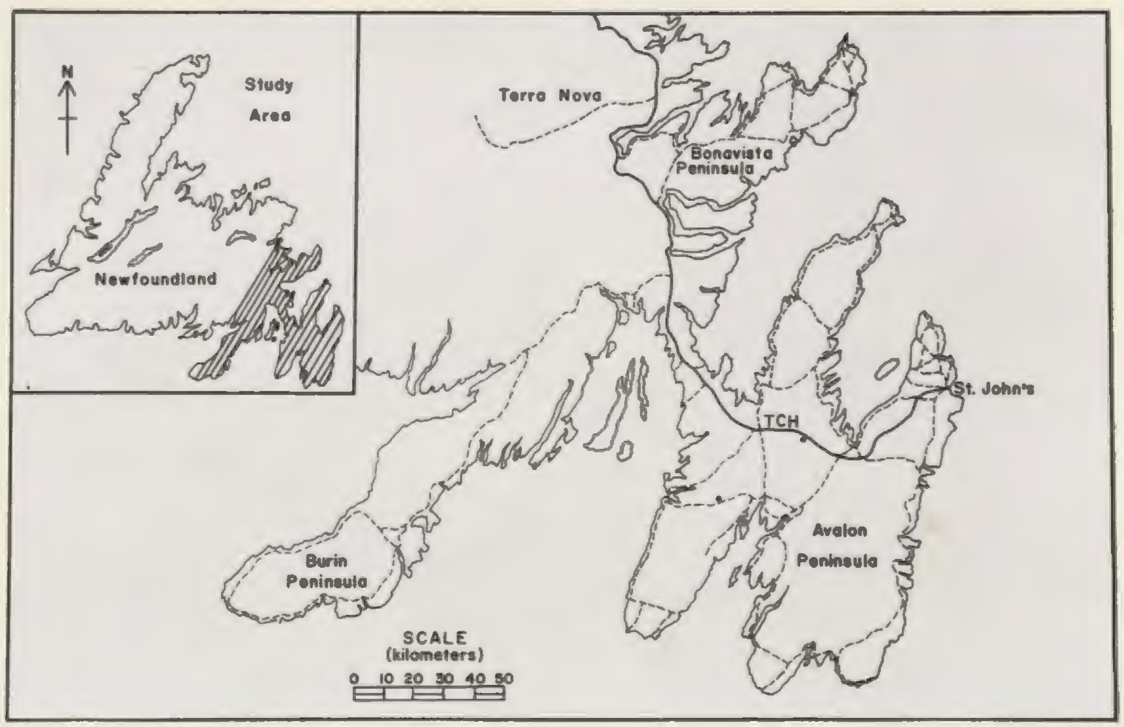


Figure 3-12: Utricularia cornuta Community.

3-11. *Drosera intermedia* Community

Differentiation of the Community

The differential species group of the community includes:

Betula michauxii	*Sphagnum pylaesii*
Drosera intermedia	*Andromeda glaucophylla*
Myrica gale	*Vaccinium macrocarpon*
Carex oligosperma	*Utricularia geminiscapa*
Rhynchospora alba	*Menyanthes trifoliata*
Carex exilis	*Carex livida*

Ecological Interpretation

The *Drosera intermedia* community (Table 3-11) represents the shallow pools of eastern Newfoundland fens (Figure 3-13). It is the most species-rich of all the pool types. The *Eriocaulon septangulare* - *Utricularia cornuta* variant is characteristic of the very shallow pools of exposed patterned fens.

TABLE 3-11: DROSERA INTERMEDIA COMMUNITY

Relevé Number	167 A	80 C	127 A	168 C	170 C	169 A	82 C	89 C	167 B	168 A	85 A	44 A	166 A	70 C	35 A	13 D	72 A	Presence Value
Altitude (ft)	700	650	250	600	550	600	300	450	700	600	150	150	800	700	600	600	600	
Cryptogams (% cover)	40	20	60	0	0	5	80	0	40	0	60	70	5	40	90	80	70	
Phanerogams (% cover)	5	5	5	10	5	5	10	15	10	15	20	15	5	5	5	15	10	
Number of Species	12	14	11	15	9	12	8	11	12	11	17	6	11	7	8	12	7	
Differential Species of the Variant																		
Eriocaulon septangulare	1.1	1.2	2.2	2.1	.	2.1	3.2	2.1	1.1	1.1	2.3	.	.	.	.	.	.	III
Juncus articulatus	+	1.2	.	+	1.1	1.1	.	1.1	+	2.1	.	.	.	.	.	.	.	III
Aster nemoralis	.	.	+	+	+	.	+	1.1	1.1	1.1	+	.	.	.	.	.	.	III
Utricularia cornuta	+	.	.	1.2	.	2.1	.	.	+	1.1	.	.	.	.	.	.	.	II
Calamagrostis inexpansa	.	.	.	+	+	.	.	+	+	.	+	.	.	.	.	.	.	II
Differential Species of the Community																		
Betula michauxii	1.1	1.1	.	1.1	1.1	1.1	1.1	2.1	1.1	1.1	+	+	1.1	1.1	1.1	.	.	IV
Drosera intermedia	+	2.2	2.2	2.1	1.1	1.2	2.2	.	1.1	1.1	2.2	.	1.1	.	3.1	+	1.2	IV
Myrica gale	1.1	+	+	1.1	1.1	1.1	.	.	1.1	1.1	.	1.1	1.1	+	.	1.1	1.1	IV
Carex oligosperma	1.1	.	1.1	.	.	.	3.1	3.1	1.1	2.1	3.1	1.1	2.1	1.1	1.1	4.1	.	IV
Sphagnum pylaesii	2.2	1.2	3.2	.	.	+	4.4	.	2.2	.	3.2	3.3	+	1.2	4.3	3.3	3.3	IV
Andromeda glaucophylla	.	+	+	+	.	+	.	+	.	+	1.1	.	+	.	+	+	+	IV
Vaccinium macrocarpon	1.1	+	1.1	.	+	1.1	.	.	.	.	2.1	.	1.1	.	.	1.2	.	III
Utricularia geminiscapa	.	2.2	.	1.1	.	.	.	.	.	2.2	.	.	+	.	.	2.1	.	II
Rhynchospora alba	.	2.1	3.2	.	.	.	2.2	1.1	1.1	.	1.1	.	1.1	.	2.1	.	.	III
Carex exilis	.	1.2	.	.	.	.	.	1.1	.	.	1.2	1.1	.	.	+	1.2	.	II
Menyanthes trifoliata	.	.	1.1	.	.	.	2.1	.	.	.	1.1	3.1	.	3.1	.	2.1	2.1	II
Carex livida	+	.	.	+	.	+	.	1.1	.	.	.	.	.	.	3.1	.	.	II
Companion Species																		
Nuphar variegatum	.	.	.	2.1	.	.	.	.	1.1	.	.	.	.	.	.	.	.	I
Scirpus cespitosus	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	+	.	I
Sphagnum pulchrum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2.2	+	I
Chamaedaphne calyculata	.	.	.	.	.	+	.	.	.	.	+	.	.	.	.	.	.	I
Sarracenia purpurea	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	I
Juncus militaris	.	.	.	2.1	.	.	.	.	.	2.1	.	.	.	.	.	.	.	I
Scheuchzeria palustris	.	.	.	.	.	.	.	.	.	.	.	.	.	2.1	.	.	2.1	I
Kalmia polifolia	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	I

Additional Species:

167A: – Sparganium angustifolium (1.2); Eriophorum tenellum (1.1)
80C: – Drosera rotundifolia (+)
127A: – Vaccinium oxycoccus (+)
168C: – Lobelia dortmanna (3.1); Potamogeton sp. (2.1)
170C: – Utricularia intermedia (3.2); Juncus stygius var. americanus (2.1)
169A: – Carex michauxiana (2.1)
85A: – Lycopodium inundatum (1.2); Sphagnum torreyanum (2.2)
Smilacina trifolia (+)
70C: – Carex lasiocarpa (3.1)
13D: – Nymphaea odorata (2.1)

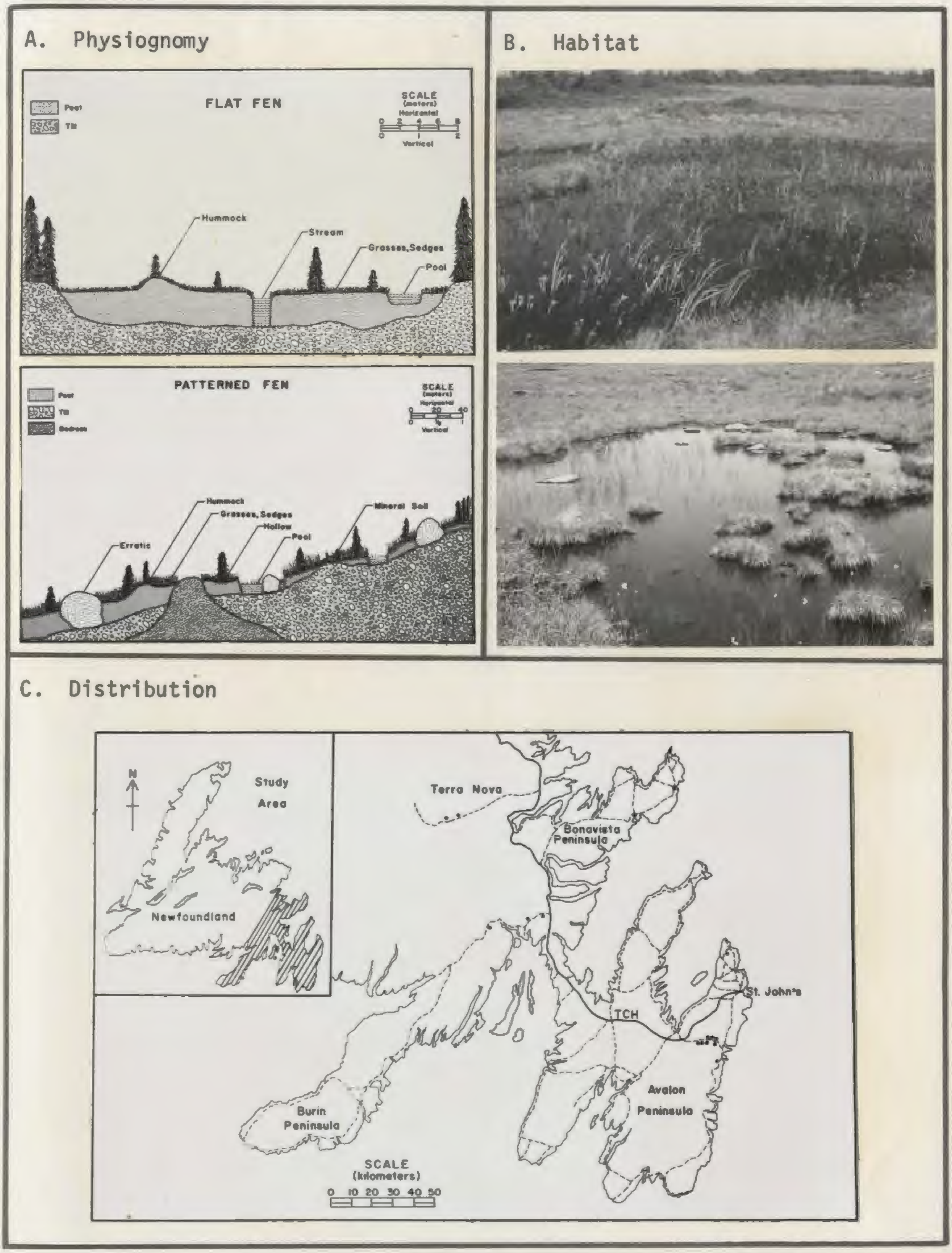


Figure 3-13: Drosera intermedia Community.

Algae: Fen Pool vs. Bog Pool

The study of any peatland ecosystem involves the recognition, delimitation and classification of various habitats which are generally defined on biological, physical and chemical factors and their relationships with the flora. Although the ecological characteristics and requirements of larger plants usually suffice to differentiate bog from fen, the microscopic algae, which comprise a large complement of plant species, are often neglected.

Samples were collected from a deep bog pool, characterized by the Nuphar variegatum community, on an ombrotrophic raised bog and from a shallow pool in the more nutrient-rich patterned fen, characterized by the Drosera intermedia community. The following data presented in Table 3-12 is not intended as a phytosociological approach to the classification of peatland communities, but merely to illustrate the nutrient conditions of selected peat types as determined by the distribution of algal species.

Although the green algal genera, Microspora, Chlorella and Mougeotia, and the filamentous blue-green algae, Oscillatoria and Stigonema, occur frequently throughout the bog pool, (Figure 3-14) the paucity of algal species within that habitat is indicative of the acid, nutrient-poor conditions of raised bogs. The scarcity of diatom

TABLE 3-12: Algal species recorded for two different peatland pools. The study was carried out in the fall of 1973 as part of the graduate course, Biology 6100.

Species	Fen Pool Drosera intermedia Community					Bog Pool Nuphar variegatum Community				
	Sample number					Sample Number				
	1	2	3	4	5	1	2	3	4	5
Netrium digitus				+	+				+	+
Oscillatoria sp.					+				+	+
Stigonema sp.							+	+		
Microspora sp.								+		+
Mougeotia sp.			+				+	+		
Chlorella sp.						+	+	+	+	+
Stephanodiscus sp.					+		+	+	+	+
Navicula sp.	+	+	+			+	+			+
Pinnularia sp.	+	+	+	+	+	+	+	+	+	+
Penium sp.			+		+				+	+
Oedogonium sp.		+	+		+		+	+	+	
Bambusina brebissonii		+	+	+			+	+		+
Tetmemorus brebissonii		+	+	+	+		+		+	
Staurastrum curvatum	+	+	+	+	+				+	+
Eunotia sp.		+	+	+	+		+		+	
Cosmarium reniforme		+	+	+	+					+
Desmidium grevillii	+	+	+	+	+					
Micrasterias cf. denticulata	+	+	+	+	+					
Xanthidium cf. armatum		+	+	+	+					
Euastrum sp.		+	+	+	+					
Tabellaria flocculosa	+	+	+	+	+					
Frustulia rhomboides		+	+	+	+				+	
Closterium sp.	+	+	+	+	+					
Tabellaria fenestrata		+	+	+	+					
Fragellaria sp.	+	+	+	+	+					
Cymbella sp.		+	+	+	+					
Nitzschia obtusata		+	+	+	+					
Staurastrum paradoxum	+	+		+	+					
Pleurotaenium trabecula		+		+	+					
Triploceras verticellatum		+	+	+						
Surirella robusta			+	+	+					
Cosmarium sp.		+	+							
Synedra capitata			+		+					
Micrasterias foliaceae	+		+							
Micrasterias truncata				+	+					
Euglena sp.			+		+					
Xanthidium cristatum var. uncinatum		+			+					
Sphaerozosma granulatum		+								
Staurastrum arachne			+							
Eunotia tridos								+		
Nitzschia cf. acicularis var. closteroides			+							
Desmidium swartzii		+								
Micrasterias crux-melitensis			+							+
Merismopedia sp.					+					+
Chroococcus turgidus							+			
Scytonema sp.								+		
Synedra rumpens			+	+						
Xanthidium cf. antilopeum			+							
No. of Species per Sample	10	26	32	24	29	3	11	10	11	13
No. of Species per Community			41					22		

A. Osillatoria sp.

B. Microspora sp.

C. Mougeotia sp.

D. Stigonema sp.

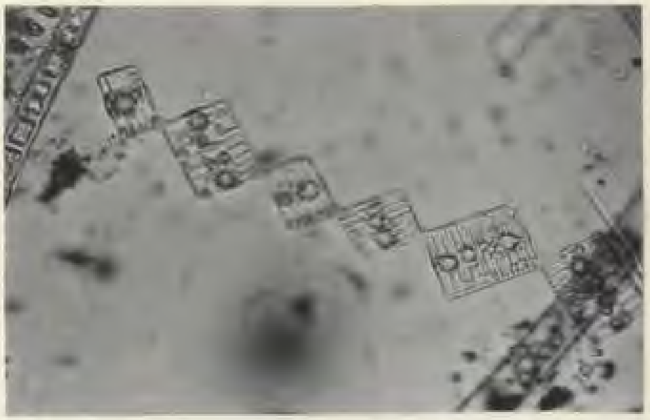
E. Chlorella sp.

Figure 3-14: Algal species common to bog pool.

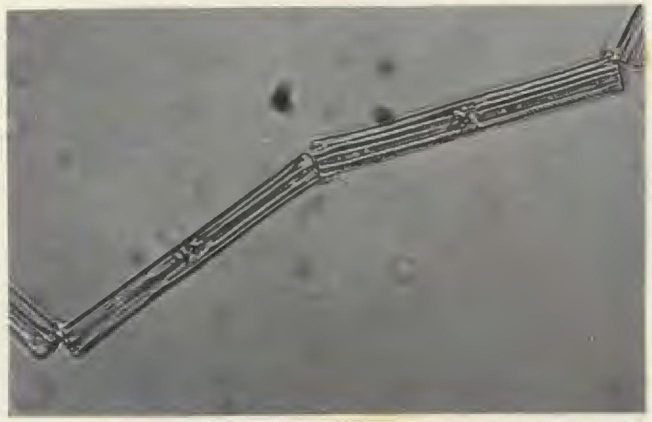
species, which usually possess thick silicious shells or frustules, may be due to the very low content of dissolved silica in ombrogenous bog waters (Gorham, 1956b).

Gorham (1957) states that silica is often much more abundant in peat soils fed by mineral soil water. This may account for the abundance of the diatom species, Tabellaria flocculosa, T. fenestrata, Frustulia rhomboides, Nitzschia obtusata, Surirella robusta, Fragellaria species and Cymbella sp, in the fen pool (Figure 3-15). Certain diatom species, such as Tabellaria fenestrata and T. flocculosa, are described by Round (1966) as indicators of neutral acid, and calcium-poor conditions.

The more minerotrophic fen pool is also characterized by an abundance of desmids (Figure 3-16), e.g. Desmidum grevillii, Cosmarium reniform, Pleurotaenium trabecula, Micrasterias c.f. denticulata, Xanthidium c.f. armatum, Triploceras verticellatum, Staurastrum paradoxum, Closterium sp., and Euastrum sp. According to Smith (1950) "...desmids are found sparingly intermingled with free-floating algae everywhere, but collections rich in species and in number of individuals are usually made only where the waters have a pH of 5 to 6". Although peat samples of the surrounding area were lower in pH value (4.38; see Table 4-1), Sjors (1963) notes that the acidity of bog pools is



A. Tabellaria flocculosa



B. Tabellaria fenestrata

C. Fragellaria sp.

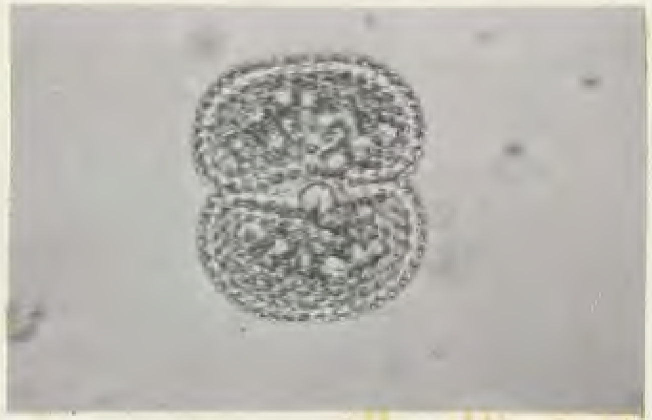
D. Nitzschia obtusta

E. Surirella robusta

F. Frustulia rhomboides

Figure 3-15: Diatoms common to fen pool.

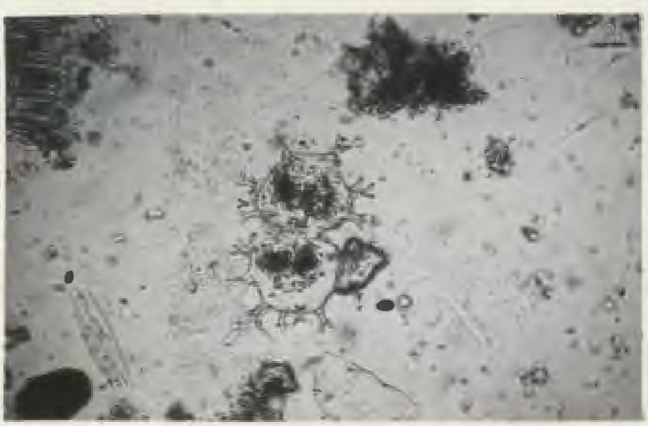
A. Desmidium grevillii



B. Cosmarium reniform

C. Pleurotaenium trabecula

D. Micrasterias cf. denticulata



E. Xanthidium cf. armatum

F. Staurastrum paradoxum

Figure 3-16: Desmids common to fen pool.

slightly less than that of the surrounding peat, if the quantity of peat and *Sphagnum* is small in relation to the amount of water. Similarly, Jeglum (1971) has shown that trials relating plant species behaviour to water pH showed that many species obtained optimum performance at considerably higher pH ranges than shown for moist peat. In addition, the moist-peat pH values averaged approximately 0.5 pH unit lower than the pH values for pools.

DuRietz (1954) describes species belonging to the genera, *Pinnularia*, *Eunotia*, *Closterium*, *Cosmarium*, *Euastrum*, *Tetmemorus*, *Xanthidium*, and *Tabellaria*, as definite mineral soil water indicators in peatland pools in southwestern Sweden. Although these genera occur throughout the fen pool (*Drosera intermedia* community) some of the species of these genera, namely *Pinnularia* sp., *Eunotia* sp., and *Tetmemorus brebissonii*, occur in the bog pool. Gorham (1957) reports the occurrence of such fen species on ombrotrophic bogs which are influenced by sea spray or industrial pollution in Sweden and England. Their occurrence in bog pools of the eastern Newfoundland peatlands may also result from higher precipitation and greater sea-salt concentrations within this region.

Summary

The peatlands of eastern Newfoundland have been classified into seven associations and four pool communities using the Zurich-Montpellier method of phytosociology. Floristic relationships of the associations are represented in the bog and fen summary table (Table 3-13).

The Cladonio-Vaccinietum vitis-idaea Association is representative of dry heath-like conditions throughout the poorer bogs. It is characterized by an absence of many typical peatland species, such as Carex exilis, Scirpus cespitosus, Sphagnum papillosum and Carex oligosperma. In general, these species differentiate peatlands from heathlands in eastern Newfoundland. Cladonia lichens are abundant, and the characteristic heath species, Vaccinium vitis-idaea, is constant throughout. Also, the presence of Rubus chamaemorus is indicative of the nutrient-poor substrate.

The Kalmia-Sphagnetum fusci Association is characterized by the same differential species group as that defined by Pollett (1972b) for ombrotrophic peatlands in Newfoundland:

Kalmia angustifolia	Mylia anomala
Rubus chamaemorus	Cladonia rangiferina

TABLE 3-13: A summary of floristic variation within the eastern Newfoundland peatland vegetation demonstrated by the differential species groups of the Associations 3-1 to 3-7.

Association Number	3-1	3-2	3-3	3-4	3-5	3-6	3-7
Vaccinium vitis-idaea	IV						
Cladonia boryi	II	I					
Hypogymnia physodes	III	I	I	+			
Cornicularia aculeata	IV	I	+				
Cladonia alpestris	V	II	I	+	I		
Rubus chamaemorus	IV	III	+	I	I		
Kalmia angustifolia	V	IV	I	II	I	I	I
Vaccinium angustifolium	IV	II	I	I		+	I
Cladonia mitis	III	III	I	II	I		
Cetraria islandica	III	III	II	III	II	+	
Cladonia rangiferina	V	V	II	II	I	II	
Empetrum nigrum	IV	IV	III	I	I		+
Cladonia arbuscula	V	IV	II	II	I	+	+
Mylia anomala	I	IV	III	I	I		
Sphagnum rubellum		IV	III		I		+
Sphagnum fuscum		V	V	I			
Polytrichum strictum	I	III	IV		I	+	I
Juniperus communis	I	I	III			I	I
Sphagnum tenellum				V	I	III	+
Odontoschisma sphagnii				III	I		
Sphagnum subnitens				III	V		II
Sphagnum magellanicum		I	I	I	IV	I	II
Schizaea pusilla			+			II	
Sphagnum strictum			+			IV	II
Betula michauxii		I	III	I	I	V	IV
Sphagnum papillosum		I	III	I	V	IV	IV
Myrica gale	II	II	III	II	III	IV	V
Calamagrostis inexpansa	I	II	V	II	III	V	IV
Solidago uliginosa	I	II	IV	I	III	IV	IV
Aster novi-belgii			III		I	IV	IV
Aster nemoralis		I	III	II	II	V	V
Rosa nitida			II			+	II
Carex livida			II				II
Lonicera villosa			IV		I	II	IV
Carex buxbaumii							II
Thalictrum polygamum			+			II	III
Aulaucomnium palustre							II
Juncus canadensis							II

Vaccinium angustifolium	Cladonia mitis
Sphagnum fuscum	Cladonia arbuscula
Sphagnum rubellum	Cladonia alpestris

Although the Association represents the drier areas of raised, basin, slope and blanket bogs, the weakly minerotrophic indicators, Myrica gale, Calamagrostis inexpansa, and Solidago uliginosa are common throughout. In most instances, these species are believed to occur on the ombrotrophic bogs as a result of higher precipitation and greater sea-salt concentrations (Pollett, 1972b). The wet flats and hollows of these nutrient-poor bogs comprise the Scirpo-Sphagnetum tenelli Association.

The Scirpo-Sphagnetum subniti Association is representative of slope bogs in eastern Newfoundland. Although Sphagnum subnitens, S. papillosum, and S. magellanicum dominate the surface vegetation, weakly minerotrophic fen indicators are frequently present. Floristically, this vegetation unit is transitional between bog and fen in eastern Newfoundland and comparable to the more minerotrophic sloping fen of central Newfoundland (Pollett and Bridgewater, 1973).

The more minerotropic peatlands of eastern Newfoundland are represented by the Betulo-Thalictretum polygoni Association. This vegetation unit is characterized by a relative absence of differential species of poorer peatlands and the presence of more minerotrophic indicators like Rosa nitida, Thalictrum polygamum, Carex livida, Lonicera villosa, Aster novi-belgii, Betula michauxii, and Solidago uliginosa. Floristically, the Betulo-Sphagnetum stricti Association is very similar. However, this vegetation unit is differentiated by the species Sphagnum strictum which is generally confined to the more exposed aapa fens.

The Calamagrostio-Sphagnetum fusci Association represents the Sphagnum fuscum hummocks scattered throughout the more minerotrophic fens of eastern Newfoundland. Floristically this vegetation unit is characterized by bog species and peripheral fen species whose roots extend into the richer fen peat.

The number of species comprising pool communities is usually indicative of the nutrient status of peatlands. For example, the three bog pool communities are characterized by a paucity of species by comparison with the more nutrient-rich Drosera intermedia (fen pool) community.

The phytosociological classification of peatlands in eastern Newfoundland has clearly demonstrated the ease with which definite plant communities can be recognized and described. For example, the Calamogrostio-Sphagnetum fusci Association (fen hummocks) is differentiated from the Kalmio-Sphagnetum fusci Association by minerotrophic indicator species

(Table 3-13) such as Lonicera villosa, Rosa nitida, Solidago uliginosa, and Aster novi-belgii. Likewise, the Cladonio-Vaccinietum vitis-idaea Association is differentiated from the fen association, Betulo-Thalictretum polygoni, by the presence of such nutrient-poor indicators as Vaccinium vitis-idaea, Cladonia boryi, and Cladonia arbuscula, and the absence of all fen species.

Different peatland types sometimes contain similar levels of nutrients. Vegetation types within such peatlands are differentiated from one another only with difficulty, and although the physiognomy, morphology and depth of such peatlands may vary greatly, the phytosociological units are very similar. An example is the Betulo-Sphagnetum stricti Association which is floristically similar to the Betulo-Thalictretum polygoni Association.

A morphological classification is often necessary to determine if factors, such as hydrology, topography, underlying soils, and depth, texture, and origin of the peat deposit, are responsible for such phytosociologically similar units. Although both phytosociological and morphological classifications can be carried out and described independently, it should be noted that the information from one will quite often substantiate or enhance the findings of the other.

The highest vegetation unit described for the peatlands of eastern Newfoundland is that of the Associations. Since the peatlands of the remaining regions of the Island have already been described (Pollett, 1972b; Pollett and Bridgewater, 1973) serious consideration must now be given to the possible formation of bog and fen alliances for the province of Newfoundland. Both bog and fen communities throughout North America have been poorly described, phytosociologically. For example, the Kalmio-Sphagnetum fusci Association described in this chapter is floristically and morphologically similar to the "Sphagnum peat bog" Association of Gauthier (1971), and the Kalmio-Chamaedaphnetea Class described by Janssen (1967). Further phytosociological investigations of North America peatlands are obviously required to determine the possible existence of bog and fen "classes" which may link up with those already described for Europe.

CHAPTER IV. ECOLOGICAL GRADIENTS WITHIN EASTERN NEWFOUNDLAND PEATLANDS

Introduction

The peatlands of eastern Newfoundland have been qualitatively described and classified using both morphological and phytosociological characteristics. Such approaches provide valid and useful classification systems which generally complement each other. However, an ecological approach to peatland classification provides a better understanding of the environmental relationships between the delineated units. In this study, nutrient analysis, soil temperature and pH were recorded for selected phytosociological types to further test their validity.

Development of the Ecological Classification of Peatlands

The basis of most ecological approaches to peatland classification originated with Weber's (1908) "Verlandungshypothese" of Niedermoore, Urbergangsmoore, and Hochmoore. Since that time, countries world-over, have produced similar classifications. Dachnowski-Stokes (1933) proposed a classification system in the United States based on climate as well as nutrient content of bog waters. He classified peatlands into three groups, oligotrophic, mesotrophic and eutrophic.

Although the ecological approaches to peatland classification vary somewhat from country to country, three basic peatland types have been recognized (After Pollett, 1972a):

A	B	C	
Niedermoore	Ubergangsmoore	Hochmoore	(Weber, 1908)
Lowmoor	Transition moor	Highmoor	(Tansley, 1949)
Flachmoor	Zwischenmoor	Hochmoore	(Potonie, 1908)
Rikkarr	Karr	Mosse	(Melin, 1917)
Eutrophic	Mesotrophic	Oligotrophic	(Dachnowski-Stokes, 1933)
Rich Fen	Poor Fen	Moss	(Sjors, 1948)
Rheophilous mire	Transition mire	Ombrophilous mire	(Kulczynski, 1949)
Euminerotrophic	Weakly minerotrophic	Ombrotrophic	(Pollett, 1972b)

Such categories of peatlands are ideal for defining the typical bog or fen types. For example, DuRietz (1949) defined criteria for the delimitation of each of the three groups. The mineral soil water limit (Thunmark, 1942) represents the dividing line between groups B and C, and the calcareous water limit (Witting, 1947) separates A and B. Sjors (1950), on the other hand, points out difficulties of applying such criteria as strict boundaries, and suggests a gradual variation between groups. This approach is perhaps more valid especially when peatlands from different regions are considered.

The slope bogs of eastern Newfoundland which occur extensively throughout the study area are intermediate between the ombrotrophic bogs and weakly minerotrophic fens and represent such a variation between groups. As a result the following quantitative results of pH, nutrient analysis and rate of thaw, are presented only as a means of defining the different peatland categories within one region.

Results

A. pH

The pH of peat soils complements certain nutrient analyses and is correlated with other habitat factors such as nutrient availability (Lucas and David, 1961), rate of water movement (Sparling, 1966), total nutrient concentrations (Valmari, 1971), rate of decomposition (Ratcliff, 1964), and species distribution (Jeglum, 1971). According to Valmari (1971) pH is a narrow measure which has been given too much significance. However, he shows that acidity is in positive correlation with both total calcium and total nitrogen, even though total calcium and total nitrogen may not be clearly in correlation with each other.

Respiration of plants will generate H+ ions into solution in exchange for cations. Since the base status (K, Ca, Mg) of a raised or blanket bog is low, the cation exchange capacity is very low thereby resulting in an increase in the H+ ion concentration of the soil and a resulting decrease in pH. Clymo (1964) has shown that at some times of the year in areas of England subject to industrial pollution, the supply of H+ ions in rain may form a significant part of the total H+ ions accumulating in a bog system; however, in areas with no great pollution the supply of H+ ions in rain seems unlikely to exceed 30% of the total accumulating in a given time. In addition to precipitation, Clymo (1964) describes three other possible sources of H+ ions in bogs: activity of sulfur-metabolizing bacteria; secretion by live <u>Sphagnum</u> plants of whole organic acid molecules; and cation exchanges in the walls of <u>Sphagnum</u> plants.

Ombrotrophic raised bogs derive their water and nutrients solely from precipitation and atmospheric dust, whereas minerotrophic fens are characterized by seepage from the surrounding mineral soil. Sparling (1966) has shown that pH increases with faster rates of water movement within the peat substrate. In situations with low rates of water movement (e.g. raised bog) the acidity would tend to be high since hydrogen ions are not readily removed from exchange sites. An increase in the rate of water flow (e.g. fens) would result in a larger number of hydrogen ions and other cations adsorbed on the peat being exchanged for cations in the water. Consequently, the acidity would be reduced.

Ratcliff (1964) suggests that the pH of "mire peats" or soils depends largely on content of exchangeable calcium present in the seepage water. For example, two peat deposits of similar drainage conditions will be characterized by different nutrient and pH conditions if the mineral substrate of one is calcareous, and that of the other, non-calcareous. In fact, Ratcliff subdivides "mires" into the three broad classes, oligotrophic, mesotrophic and eutrophic. Such a classification is defined according to exchangeable calcium content which is closely correlated with pH.

The pH values for eastern Newfoundland peatlands (Table 4-1) correspond very closely with the arrangement of associations which were described in Chapter III in approximate order of increasing nutrient status. The Kalmio-Sphagnetum fusci association representing the drier areas of raised, blanket, basin and slope bogs, is characterized by acid peats (pH = 3.81). This value is comparable with results published by Pollett (1972c) for ombrotrophic bogs under the influence of a maritime climate. The acid nature of ombrotrophic peatlands is further exemplified by the pH value (3.72) for the wet hollows of the Scirpo-Sphagnetum tenelli association. There is a gradual increase in pH

TABLE 4-1: Range of selected total nutrients and pH (all expressed as means) determined from peat soils underlying the major bog and fen vegetation types of eastern Newfoundland. All samples were taken from the upper layer to a depth of 30 cm or to the bottom of the deposit whichever was less.

Associations	No. of Samples	pH	N (mg/g)	Ca (ppm)	Fe (ppm)
Kalmio-Sphagnetum fusci					
(a) K-S.f. (Raised Bog)	10	3.89	4.77	22.30	12.00
(b) K-S.f. (Blanket Bog)	7	3.59	11.28	22.67	12.03
(c) K-S.f. (Basin Bog)	10	3.96	4.98	25.97	11.61
(d) K-S.f. (Total)	27	3.81	7.74	23.39	11.88
Scirpo-Sphagnetum tenelli	8	3.72	12.84	15.89	13.99
Scirpo-Sphagnetum subniti	6	4.03	12.32	22.07	31.13
Calamagrostio-Sphagnetum fusci	8	4.25	8.44	23.60	67.80
Betulo-Sphagnetum stricti	13	4.38	26.71	15.75	226.36
Betulo-Thalictretum polygoni	8	4.81	19.76	77.91	241.12

values for the remaining associations as the degree of minerotrophy increases. Although the *Scirpo-Sphagnetum subniti* association represents the wet areas of slope bogs, the increase in pH (4.03) is indicative of weakly minerotrophic conditions. The remaining three associations occur within the fen category which Pollett (1972c) describes as generally having a pH greater than 4.2.

An anomaly within the *Kalmio-Sphagnetum fusci* association is the low pH (3.59) for blanket bogs. These peatlands are generally confined to areas of higher precipitation and greater sea-salt concentrations. Such conditions generally result in a higher concentration of sodium and magnesium ions, thereby increasing the base status and pH of the peat. Unlike raised bogs, the blanket bogs of southeastern Newfoundland are shallow (1-1.5 m) and quite often influenced by seepage. However, peat samples were collected from these areas during mid-summer of 1973, when the peat had dried out considerably. The remaining samples of raised and basin bogs were mostly collected during the early summer of 1974 when water levels were much higher. This may account for the anomaly.

Seasonal fluctuations of soil pH have been reported (Smith and Robertson, 1931; Huberty and Haas, 1940; Bowser and Leat, 1958; Vezina, 1965). Malmer (1962b) reports seasonal variations in pH for water samples taken from bog hollows. However, Pollett (1972a) indicates that seasonal change in pH is not pronounced for peats in central Newfoundland. Stanek (1973), on the other hand, states that for acidic peat, the greater the ratio of water to soil, the higher is its apparent pH. Similarly, Buckman and Brady (1960), report a decline in the pH of mineral soils during the summer due to acids produced by micro-organisms. In winter and spring an increase in pH is often noted possibly because biotic activities during this time are considerably slower.

B. Nutrient Analysis

Total nitrogen (Table 4-1) is comparatively low for the associations Kalmio-Sphagnetum fusci (7.74 mg/g), and the Calamagrostio-Sphagnetum fusci (8.44 mg/g) increasing to a high of 26.71 mg/g in the more highly decomposed sedge fens of the Betulo-Sphagnetum stricti association. Values for total calcium tend to correspond closely to pH, with the highest value recorded for the minerotrophic Betulo-Thalictretum polygoni association. Similarly, total iron ranges from 11.57 to 241 mg/g with an obvious increase indicated from bog through rich fen peats.

(i) Total Nitrogen

Peat soils are usually characterized by high nitrogen contents in relation to mineral soils. However, very little of this nitrogen exists in a form available to plants. Pollett (1972c) has shown that, for peat soils in Newfoundland, total nitrogen ranges from 3.3 mg/g for bogs to 36.6 mg/g for rich fen peats. Available nitrogen, on the other hand, ranges from 0.036 mg/g for nutrient-poor bogs to 0.063 mg/g for eutrophic fens.

Micro-organisms involved in the breakdown of nitrogenous compounds are greatly influenced by the acidity of the soil. According to Miller, et al. (1965), the optimum reaction for nitrifiers, namely Nitrosomonas, Nitrosococcus, and Nitrobacter, is pH 7.0 to 8.0; although some strains will grow between pH limits of 3.5 and 10.0, their activity is retarded in both strongly acid and highly alkaline soils.

Buckman and Brady (1960) report peat soils as having a high carbon-nitrogen ratio, i.e., the relationship that exists between the organic matter and nitrogen content of soils. In effect, this ratio is a measure of nitrogen content. Soils with small or narrow ratios are relatively rich in nitrogen while those with higher or wider ratios are relatively low in nitrogen. Although such peat soils, in spite of their wide carbon-nitrogen ratio, may show exceedingly vigourous nitrification, most of the available nitrate is used by the soil micro-organisms involved in the humification process.

The relatively low nitrogen values of the associations, *Kalmio-Sphagnetum fusci* and *Calamagrostio-Sphagnetum fusci* reflect the nutrient-poor conditions of these acid, *Sphagnum* peats. Both Kaila (1956) and Gorham (1953) report *Sphagnum* peat as considerably and significantly lower in nitrogen than other peats. Although the surface vegetation of the associations *Scirpo-Sphagnetum tenelli* and *Scirpo-Sphagnetum subniti* are characterized by an abundance of *Sphagnum*, the underlying peats are slightly more decomposed and, in the case of the latter association, the *Sphagnum*-sedge/sedge-*Sphagnum* peats are often influenced by weakly minerotrophic seepage.

The more highly decomposed sedge-*Sphagnum*/sedge fen peats of the associations, *Betulo-Sphagnetum stricti* and *Betulo-Thalictretum polygoni*, are characterized by higher pH values, minerotrophic conditions and correspondingly higher total nitrogen contents. Likewise, the relatively high nitrogen content of blanket peats (*Kalmio-Sphagnetum fusci* association) results from the more humified conditions of the underlying *Sphagnum*-sedge/sedge peats and the possible influence of seepage; higher precipitation and sea-salts.

(ii) Total Calcium

Although peat soils are acid, often extremely so, they are comparatively high in calcium. Buckman and Brady (1960) report that most of the calcium present in peat soils is in an exchangeable condition and that the cation adsorption capacity of peat soils is so great that they may be at a low percentage base saturation and yet be carrying exceptionally large amounts of exchangeable calcium. Furthermore, much of the water entering fens is from seepage which has had ample opportunity to dissolve lime after passing through the subsoil and substratum of the surrounding uplands. Since decaying organic matter is highly adsorptive and calcium ions plentiful, the sedge peat accumulates large amounts of exchangeable calcium ions.

The peatlands of eastern Newfoundland are underlain by such an acid substrate that, excepting the fens of the Betulo-Thalictretum polygoni association, the major vegetation units show very little variation with respect to calcium content. Pollett (1972c) reports that calcium is the most reliable indicator of site "richness", and is related to the corresponding pH values for the major peatland associations throughout Newfoundland. However, the higher pH values of the last four associations are primarily attributable to water movement and a gradual decrease in Sphagnum cover.

(iii) Total Iron

Unlike nitrogen and calcium, iron is required in such small quantities for plant and micro-organism growth, that it is called a micronutrient. However, Pollett (1972a) reports the "...overall Fe concentration can be used as a quick analysis to separate poor and rich peats and is thus a parameter for site selection in industry".

Buckman and Brady (1960) report a relative abundance of Fe ions in very acid soils. However, as the pH is raised, its solubility and availability to plants decreases. At high pH values, oily surface films may be found in fen pools, indicating the precipitation of insoluble forms of iron (Puustjarvi, 1952). According to Kivinen (1972) iron is transported by ground water from the mineral soils surrounding fens. At higher pH it is precipitated on the bottom of peat layers as iron hydroxide, and on the bottom of rimpis as iron carbonate or iron phosphate. The unhumified _Sphagnum_ peat on the surface of raised bogs, on the other hand, contains very little or no iron.

The presence of total iron in eastern Newfoundland peatlands is greatest in the fen associations --- _Betulo-Sphagnetum stricti_, and _Betulo-Thalictretum polygoni_. Such peat soils are characterized by seepage and frequent occurrences of oily surface films of ferrous hydroxide.

There is a gradual decrease in total iron concentrations from the weakly minerotrophic associations, Scirpo-Sphagnetum subniti and Calamagrostio-Sphagnetum fusci, to the nutrient-poor associations, Scirpo-Sphagnetum tenelli and Kalmio-Sphagnetum fusci.

C. Rate of Thaw in Selected Peatland Types

Classifications of peatlands generally involve phytosociological, morphological and ecological criteria which include such characteristics as vegetation, physiognomy, and chemical and physical attributes of the peat soil. Yet frost, although it is an important criterion used in the classification of subarctic peatlands (e.g. permafrost), is seldom used in the classification of peatlands in more boreal regions.

The presence of frost in peatlands is dependent on climate, topography and the physical characteristics of the peat. For example, the time and depth of freezing, as well as the time and rate of thaw, are dependent on the moisture content, thermal conductivity and water retention of the different types of peat. Similarly, snow cover, which is instrumental in determining depth of frost in peatlands, is governed by exposure and plant cover.

Depth to ice, thickness of ice, and measurements of temperatures at 0, 5, 10, 20 and 50 cm depths were recorded for selected peatland types of eastern Newfoundland in the spring of 1973 (Table 4-2). Although such measurements are variable from year to year, the experiment was designed to illustrate certain physiognomic, hydrologic, floristic, topographic and climatic characteristics associated with the different bog and fen types of eastern Newfoundland.

The $0^{o}C$ isotherm was used as an indicator of frost depth. In a similar experiment on heathlands, Meades (1973) observed that the ground was still frozen at $1.11^{o}C$. However, according to Ramanov (1961) most of the water in peat soils freezes at $0^{o}C$ because the pores are large and the mineral content small.

The Betulo-Sphagnetum stricti association is representative of the aapa fens of eastern Newfoundland. Such peatlands generally occur in exposed regions of higher elevation experiencing slightly cooler temperatures and a possible reduction in evaporation. The underlying sedge/sedge-Sphagnum peats are characterized by high moisture contents and, because of their high latent heat of fusion, freeze late in the season (Brown and Williams, 1972).

TABLE 4-2: Rate of spring thaw in the organic soils of selected peatland types of eastern Newfoundland (1973). Sites were selected according to phytosociological units. Temperatures (°C) were measured at approximately noon of each day.

	Depth (cm)	Apr 12	Apr 17	Apr 24	Apr 27	Apr 30	May 4	May 9	May 14	May 18	May 24	May 28
Kalmio-Sphagnetum fusci (Hummock-Raised Bog)												
	0	4.44	11.11	11.11	10.00	10.00	11.67	13.33	12.22	16.11	7.22	26.67
	5	0.00	1.11	5.00	11.67	5.56	3.89	8.33	7.78	13.33	7.22	13.33
	10	0.00	0.00	0.00	7.22	2.22	2.22	4.44	6.11	7.78	5.56	9.44
	20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56	1.11	2.78	2.78
	50	1.11	0.56	0.56	0.56	0.56	1.11	0.56	0.56	0.56	1.11	1.11
Depth to ice (cm)		5	6	10	12	12	14	16	20	21	24	-
Thickness of ice (cm)		35	32	24	21	21	19	17	12	9	4	0
Kalmio-Sphagnetum fusci (Hollow-Raised Bog)												
	0	4.44	18.89	12.78	7.22	18.89	12.78	12.22	17.22	20.00	6.67	21.11
	5	0.00	0.56	4.44	6.11	3.33	3.33	5.56	7.22	10.56	7.78	14.44
	10	0.00	0.00	0.00	0.00	1.67	2.22	3.33	6.11	6.67	7.22	9.44
	20	0.56	0.56	0.56	0.56	0.56	1.11	2.22	4.44	5.00	7.22	5.56
	50	1.67	1.11	1.67	1.11	1.11	1.67	1.67	2.22	3.33	6.11	4.44
Depth to ice (cm)		5	5	8	9	10.5	-	-	-	-	-	-
Thickness of ice (cm)		7	7	4	3	1.5	0	-	-	-	-	-
Scirpo-Sphagnetum tenelli (Wet Hollow-Raised Bog)												
	0	1.11	15.00	11.11	9.44	12.22	8.89	14.44	13.33	15.56	7.78	20.00
	5	0.56	5.00	5.00	8.33	5.56	3.33	7.78	9.44	17.22	8.89	14.44
	10	0.00	0.00	1.67	4.44	2.22	1.67	6.11	8.33	13.33	8.89	10.00
	20	0.00	0.56	0.56	1.67	0.56	3.33	5.56	7.22	7.78	8.89	7.78
	50	1.67	1.11	1.11	1.67	1.67	2.78	3.89	5.56	5.00	7.78	6.11
Depth to ice (cm)		9	9	13	14	15	15	-	-	-	-	-
Thickness of ice (cm)		13	8	4	3	2	2	0	-	-	-	-
Calamagrostio-Sphagnetum fusci (Hummock-Flat Fen)												
	0	7.22	16.67	4.44	9.44	9.44	8.89	16.11	12.22	14.44	7.78	22.22
	5	0.56	7.22	1.67	8.33	8.89	6.11	13.33	9.44	14.44	7.78	14.44
	10	0.00	0.00	0.56	3.89	6.11	6.11	10.00	8.33	12.78	7.22	9.44
	20	0.56	1.11	1.11	3.33	2.78	4.44	6.11	7.22	7.22	7.22	8.89
	50	2.22	2.22	2.22	2.78	2.78	3.89	5.56	6.11	6.11	6.67	6.67
Depth to ice (cm)		5	6	10	11	11	-	-	-	-	-	-
Thickness of ice (cm)		11	9	3	2	1	0	-	-	-	-	-
Calamagrostio-Sphagnetum fusci (Hummock-Aapa Fen)												
	0	5.00	15.56	10.00	5.00	7.78	7.78	15.56	9.44	14.44	3.89	26.67
	5	0.00	0.56	0.00	5.00	6.67	3.33	10.00	6.67	8.33	3.89	12.22
	10	0.00	0.00	0.00	0.00	0.00	0.00	4.44	2.78	5.00	2.22	6.11
	15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56	1.67
Depth to ice (cm)		4	5	5	6	6	9	13	14	-	-	-
Thickness of ice (cm)		11	10	10	9	9	6	2	1	0	-	-
Betulo-Sphagnetum stricti (Flat-Aapa Fen)												
	0	4.44	11.11	6.67	6.67	7.78	6.11	17.20	8.89	10.56	4.44	21.11
	5	0.00	2.22	1.11	5.00	3.89	5.00	9.44	7.78	11.67	6.11	7.22
	10	0.00	0.00	0.00	2.78	1.11	3.89	6.67	6.67	8.33	6.11	6.11
Depth to ice (cm)		4	5.5	8	-	-	-	-	-	-	-	-
Thickness of ice (cm)		7	5.5	3	0	-	-	-	-	-	-	-

Extreme exposure and high winds combine to prevent any significant buildup of snow on the aapa fens. Consequently, as a result of extremely low winter temperatures, frost completely penetrates the shallow peat layer. The peat soil of this association, however, was completely thawed out as early as April 27 (Table 4-2). As a result of snow melt water the peat is characterized by a high thermal conductivity thereby promoting a rapid thaw (Brown and Williams, 1972).

The hollows of the raised bog -- dry hollow (Kalmio-Sphagnetum fusci association) and wet hollows (Scirpo-Sphagnetum tenelli association) -- had thawed out in early May. Such hollows are generally filled with drifting snow during the winter months. According to Brown and Williams (1972) "...the thermal resistance of snow in the hollows and Sphagnum in the hummocks creates an effective insulating layer". An early snowfall will, therefore, prevent significant frost penetration in the depressions for the remainder of the winter. Like the aapa fen, the snow melt water in spring transfers heat by conduction, producing a rapid thaw of the thin ice layer.

The rate of thaw for the hummocks of the eastern Newfoundland peatlands is considerably slower than for the hollows. The flat fen hummocks had thawed by May 4, the aapa fen hummocks by May 18 and the raised bog hummocks by May 28. Although the hummocks of the flat and aapa fens are floristically and physiognomically similar, the flat fen is sheltered and usually thermally insulated with a thicker layer of snow, thereby retarding frost penetration during fall and winter. The buildup of spring solar heat at ground level is very significant (Table 4-2) in comparison to that for the exposed aapa fen hummocks, and is the main reason for such an early thaw. The late thaw of raised bog hummocks is probably attributed to the low thermal conductivity of the Sphagnum mosses (Brown and Williams, 1972).

The dry raised bog hummocks freeze quite rapidly during the fall because of their low water content and relatively low latent heat of fusion. Chechkin (1965) reports the drainage of water from hummocks as affected by the time and rate of freezing. Steep-sloped hummocks, which are characterized by good drainage of water, freeze more rapidly than hummocks with shallow slopes. Furthermore, since snow cover is less than that found in hollows, frost penetration is greater. These conditions, plus the very low thermal conductivity of the Sphagnum fuscum peat, are instrumental in retarding spring thaw in the raised bog hummocks (Table 4-2).

Summary

The peatlands of eastern Newfoundland have been ecologically assessed with regards to pH, concentrations of selected total nutrients and spring thaw. Although the data discussed in this chapter do not define ecological units of peatlands, as such, the argument for peatland classifications based on phytosociological or morphological characteristics is validated.

Concentrations of iron correspond closely with pH values, with an overall increase from poor to rich peats. Although total nitrogen and total calcium vary in concentrations throughout the associations, fens are characterized by comparatively higher values. Such conditions are indicative of the more humified and minerotrophic status of fen peats.

The depth of frost and rate of spring thaw in peatlands are influenced by such factors as plant cover, amount of snow cover, degree of exposure, as well as the moisture content, water retention, and thermal conductivity of peat. Similarly, the rates of thaw in eastern Newfoundland peatlands vary with both morphological and phytosociological types. For example, sheltered peats, which are generally characterized by a thick layer of winter snow and a buildup of spring solar heat at ground level, thaw out before exposed peats; sedge peats, because of their high thermal conductivity, thaw out before Sphagnum peats; likewise, hollows accumulate spring melt water and thaw out more quickly than adjacent hummocks.

CHAPTER V. SUMMARY AND CONCLUSIONS

The peatlands of eastern Newfoundland have been classified into six morphological peatland types and eleven vegetation types. The ecological significance and interrelationships of these morphological and phytosociological peatland units as well as the delimitation of the phytosociological units is greatly enhanced by the ecological criteria discussed in Chapter IV.

The most extensive peatland type is slope bog, which develops on poorly-drained slopes throughout the region. Although many slope bogs are characterized by seepage water, the acidic nature of the underlying substrate results in only weakly minerotrophic conditions. Consequently, Sphagnum mosses (e.g. Sphagnum papillosum, S. magellanicum, S. subnitens) dominate the surface vegetation. These peatlands are characterized mainly by the Scirpo-Sphagnetum subniti association.

The forested regions of the Avalon and Bonavista peninsulas are characterized by raised bogs, so named because of their convex surface and raised centers. Unlike the typical raised bogs of central Newfoundland, this peatland type is characterized by minimal surface doming and an abundance of Scirpus cespitosus tussocks. The predominant vegetation type is the Kalmio-Sphagnetum fusci association which is representative of all nutrient-poor, ombrotrophic bog conditions. Wet hollows are characterized by the Scirpo-Sphagnetum tenelli association, whereas bog pools, and mudflats are characterized by the Nuphar variegatum community, Sphagnum torreyanum community and Utricularia cornuta community. Extremely dry sites dominated by Cladonia lichens are characterized by the Cladonio-Vaccinietum vitis-idaea association.

Similar vegetation types characterize the blanket and basin bogs of eastern Newfoundland. Extensive areas of blanket bog occur within the more humid regions of southeastern Newfoundland. These bogs are shallow (1-1.5 m deep) ombrotrophic, and generally blanket the valleys and hillsides. Small basin deposits of peat, or basin bogs, are restricted to the Hawke Hill range of the central Avalon peninsula. These peat deposits are shallow (generally not more than 1 m deep), ombrotrophic and subjected to extreme exposure.

Minerotrophic peatlands are not abundant in eastern Newfoundland. However, small flat fens, which have developed in catchment basins are characteristic of forested areas. This peatland type is characterized by the Betulo-Thalictretum polygoni association.

Patterned fens are scattered throughout the more exposed, higher regions of the Avalon and Bonavista peninsulas. This peatland type, represented by the Betulo-Sphagnetum stricti association, is characterized by shallow peats (0.5 m deep), weakly minerotrophic conditions and numerous flarks, orientated at right angles to slope. The hummocks of both patterned and flat fens are characterized by the Calamagrostio-Sphagnetum fusci association. Likewise, the more minerotrophic pools occur on both fens, represented by the Drosera intermedia community.

The ecological criteria -- pH, nutrient analysis, and rate of thaw -- substantiate the morphological and phytosociological classifications. pH is lowest in the Kalmio-Sphagnetum fusci (raised, basin and blanket bogs) and highest for the Betulo-Thalictretum polygoni (flat fens). Total nitrogen is lowest in the Kalmio-Sphagnetum fusci and Calamagrostio-Sphagnetum fusci (fen hummocks) because of the abundance of undecomposed Sphagnum fuscum. Total calcium, which is a reliable indicator of site richness (Pollett, 1972c), is relatively low for all peatland types except the Betulo-Thalictretum polygoni (flat fens). Total iron, described by Pollett (1972a) as a quick means of separating poor and rich fens is lowest in the Kalmio-Sphagnetum fusci (bogs), and gradually increases to the highest value in the Betulo-Thalictretum polygoni (fens).

A major problem associated with any peatland classification system is its practicality and applicability. A phytosociological approach to peatland classification defines definite plant communities which are primarily used by plant ecologists. However, the same vegetation type may occur on several morphological peatland types (e.g. Kalmio-Sphagnetum fusci occurs on raised, blanket, basin and slope bogs). Engineers and hydrologists, on the other hand, may require a knowledge of the origin, depth and botanical constituents of a peat deposit. For agricultural, forestry and commercial use, morphological and ecological data are quite often required. The classification of eastern Newfoundland peatlands has clearly demonstrated the practicality of such a multidisciplinary approach to peatland classification. Furthermore, the three approaches -- morphological, phytosociological and ecological -- complement and enhance one another in forming a basis for land-use planning of peatlands for integrated resource management involving agriculture, recreation, wildlife and forestry.

The phytosociological classification of eastern Newfoundland peatlands has demonstrated the validity of the Zurich-Montpellier method for classifying peatlands. This method has been applied to heathlands (Meades, 1973) in eastern Newfoundland, forest classification (Damman, 1964, 1967) in central and western Newfoundland, and peatland classification (Pollett, 1972a, 1972b; Pollett and Bridgewater, 1973) in central, western and northern Newfoundland. Consequently, the peatlands of eastern Newfoundland can be ecologically assessed in relation to the peatland types described for other areas of the Province. Furthermore, this method of classification has the added advantage of incorporating all three terrestrial vegetation types - peatland, heathland and forest - within a uniform classification system.

The classification of any terrestrial or aquatic ecosystem by the Zurich-Montpellier method involves the formation of ecological units which are defined by the distribution of the particular vegetation types. A vegetation type occurring in North America, Europe, and Asia may constitute a "Class" in the classification hierarchy. Similarly, a peatland vegetation type characteristic of only North America may comprise an "Order".

The peatland vegetation types of eastern Newfoundland have been described at the association level because the survey was confined to a small region. However, two of the associations, Kalmio-Sphagnetum fusci and Calamagrostio-Sphagnetum fusci, occur throughout most of Newfoundland. Consequently, consideration must now be given to the formation of alliances. Such vegetation units may be defined as the Fuscion, representative of nutrient-poor, ombrotrophic peatlands, and the Calamagrostion, representative of nutrient-poor hummocks of fens.

Raised and blanket bogs which are characteristic of the Kalmio-Sphagnetum fusci association, occur throughout other regions of North America. Further phytosociological investigations may reveal this association as occurring through North America suggesting the possible formation of an order representing the nutrient-poor ombrotrophic bogs.

Since most of the peatlands of eastern Newfoundland are highly exposed and nutrient poor, effective afforestation programs are dependent not only on nutritive additives but on the introduction of wind-resistant species or shelter species as a pre-planting procedure. However, large areas of nutrient-poor raised bog are presently being reclaimed for agricultural purposes in eastern Newfoundland. Similarly extensive areas of blanket bog in southeastern Newfoundland and slope bogs on the Avalon peninsula have been successfully reclaimed as community pasture. Furthermore, one raised bog deposit near St. John's is presently being excavated for peat moss.

The nutrient-rich peatlands most suitable for forestry and agricultural reclamation include the flat fens defined by the Betulo-Thalictretum polygoni association. These areas are easily drained and are characterized by peat depths several feet deep. However, their small size and scattered distribution make large scale reclamation programs unfeasible.

Recreational resources of the peatlands of eastern Newfoundland have not yet been utilized. The variety and abundance of wildflowers, particularly wild orchids, together with sedges, lichens and insectivorous plants offer an exciting range of subject matter to the nature photographer. Furthermore, many tasty berries such as bake apple (<u>Rubus chamaemorus</u>), small cranberry (<u>Vaccinium oxycoccus</u>) and blue berry (<u>Vaccinium angustifolium</u>) can be harvested for use in jams, jellies, juices and liquers.

Today's resource manager must be aware of the multiple use of peatlands with consideration given to their characteristics as a habitat of particular flora and fauna as well as its potentials for producing food and wood products. The material presented here should assist in wise management of one peatland region, that of eastern Newfoundland.

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APPENDIX I

LOCATION OF MORPHOLOGICAL PEATLAND TYPES INVESTIGATED IN EASTERN NEWFOUNDLAND

Site No.	Peatland Type	Nearest Place Name	Map Reference
1	Raised Bog	Hodgewater Line Jct.	1 N/6 W 207 565
2	Slope Bog	Hodgewater Line Jct.	1 N/6 W 207 565
3	Slope Bog	Argentia Acc. Jct.	1 N/5 E 020 601
4	Raised Bog	Whitbourne	1 N/6 W 137 577
5	Basin Bog	Butterpot Park	1 N/6 E 462 495
6	Basin Bog	Butterpot Park	1 N/6 E 466 497
7	Basin Bog	Butterpot Park	1 N/6 E 432 374
8	Basin Bog	Butterpot Park	1 N/6 E 481 502
9	Flat Fen	Hodgewater Line Jct.	1 N/6 W 207 565
10	Raised Bog	Ocean Pond Jct.	1 N/6 W 158 577
11	Flat Fen	Avondale	1 N/6 E 315 473
12	Slope Bog	Salmonier Line Jct.	1 N/6 E 343 461
13	Patterned Fen	Witless Bay Line	1 N/6 E 451 446
14	Patterned Fen	Witless Bay Line	1 N/6 E 484 448
15	Patterned Fen	Witless Bay Line	1 N/7 W 530 448
16	Slope Bog	Come-By-Chance Jct.	1 N/13 W 781 023
17	Slope Bog	Burin Pen. Jct.	1 N/13 W 790 030

Site No.	Peatland Type	Nearest Place Name	Map Reference
18	Slope Bog	Arnold's Cove Jct.	1 N/13 W 780 003
19	Slope Bog	Arnold's Cove Jct.	1 N/13 W 782 915
20	Slope Bog	Arnold's Cove Jct.	1 N/13 W 782 910
21	Blanket Bog	Cappahayden	1 K/14 468 841
22	Blanket Bog	Trepassey	1 K/11 E 143 772
23	Blanket Bog	St. Shott's Jct.	1 K/12 E 083 763
24	Blanket Bog	St. Shott's Jct.	1 K/11 W 065 796
25	Blanket Bog	St. Shott's Jct.	1 K/11 W 034 632
26	Blanket Bog	St. Shott's Jct.	1 K/11 W 021 581
27	Blanket Bog	St. Shott's	1 K/12 075 714
28	Blanket Bog	Cappahayden	1 K/14 450 828
29	Raised Bog	Hodgewater Line Jct.	1 N/6 W 207 565
30	Slope Bog	Salmonier Line Jct.	1 N/6 E 343 461
31	Slope Bog	Colinet	1 N/4 044 334
32	Slope Bog	Little Catalina Jct.	2 C/11 470 812
33	Raised Bog	Knight's Cove	2 C/6 264 718
34	Slope Bog	Port Union	2 C/6 445 705
35	Slope Bog	Port Union	2 C/6 414 685
36	Slope Bog	Port Union	2 C/6 373 660
37	Raised Bog	Sweet Bay Jct.	2 C/5 950 600
38	Flat Fen	Lethbridge Jct.	2 C/5 937 600

Site No.	Peatland Type	Nearest Place Name	Map Reference
39	Flat Fen	Lethbridge Jct.	2 C/5 813 486
40	Patterned Fen	Long Pond Brook	1 M/16 W 990 091
41	Slope Bog	Long Pond Brook	1 M/16 W 964 055
42	Slope Bog	Long Pond Brook	1 M/16 W 950 024
43	Flat Fen	Terrenceville Jct.	1 M/10 735 621
44	Patterned Fen	Marystown	1 M/3 279 250
45	Patterned Fen	Marystown	1 M/3 268 268
46	Blanket Bog	Fortune	1 M/4 839 076
47	Blanket Bog	Fortune	1 L/13 797 012

APPENDIX II

LOCATION OF THE 6 REPRESENTATIVE MORPHOLOGICAL PEATLAND TYPES INVESTIGATED IN EASTERN NEWFOUNDLAND

Figure No.	Peatland Type	Nearest Place Name	Map Reference
2-1	Raised Bog	Whitbourne	1 N/6 W 169 575
2-2	Blanket Bog	Trepassey	1 K/12 E 763 083
2-3	Slope Bog	Whitbourne	1 N/6 W 206 565
2-4	Basin Bog	Holyrood	1 N/6 E 462 495
2-5	Patterned Fen	Holyrood	1 N/7 W 530 448
2-6	Flat Fen	Whitbourne	1 N/6 W 206 565

APPENDIX III

LOCATION OF PHYTOSOCIOLOGICAL SITES INVESTIGATED IN EASTERN NEWFOUNDLAND

Site No.	Nearest Place Name	Map Reference
71-4	Southern Harbour	1 N/12 905-818
71-5	Whitbourne	1 N/16 W 121 589
71-6	Trepassey	1 K/11 W 101 752
71-7	Rocky River	22TBH 334 044
71-8	Cataract Brook	22TBH 352 008
71-9	Holyrood	1 N/6 443 447
71-10	Butterpot Park	1 N/6 462 497
71-11	Portugal Cove	1 N/10 W 627 766
71-12	Bauline Line	1 N/10 W 633 775
71-13	Bauline Line	1 N/10 W 637 794
71-14	St. Phillips Rd.	1 N/10 W 635 697
71-16	Whitbourne Intersection	1 N/6 W 119 577
71-17	Whitbourne Intersection	1 N/6 W 137 577
71-18	Whitbourne Intersection	1 N/6 W 169 577
71-19	Whitbourne Intersection	1 N/6 W 199 568
71-21	Roaches Line Overpass	1 N/6 W 229 561

Site No.	Nearest Place Name	Map Reference
71-23	Salmonier Line	1 N/6 E 343 461
71-24	Salmonier Line	1 N/6 E 357 452
71-25	Salmonier Line	1 N/6 E 358 454
71-26	Witless Bay Line	1 N/6 E 452 482
71-27	Butterpot Park	1 N/6 E 462 495
71-28	Soldier's Pond	1 N/6 E 488 527
71-29	Foxtrap Access Rd.	1 N/7 W 510 557
71-30	Witless Bay Line	1 N/6 E 451 446
71-31	Witless Bay Line	1 N/6 E 467 445
71-33	Witless Bay Line	1 N/7 W 504 450
71-34	Witless Bay Line	1 N/7 W 510 451
71-35	Witless Bay Line	1 N/7 W 530 448
71-43	Lockston Path Park	2 C/6 W 265 718
71-44	Champneys West	2 C/6 W 288 617
71-45	Champneys East	2 C/6 W 299 624
71-48	Melrose	2 C/6 W 322 638
71-49	Melrose	2 C/6 W 323 639
71-50	Melrose	2 C/6 W 341 647
71-51	Melrose	2 C/6 E 349 648
71-52	Melrose	2 C/6 E 368 659
71-53	Catalina	2 C/11 E 459 835

Site No.	Nearest Place Name	Map Reference
71-54	Catalina	2 C/11 E 475 777
71-55	Catalina	2 C/11 E 474 777
71-56	Catalina	2 C/11 E 389 784
71-57	Melrose	2 C/6 E 421 690
71-58	Trinity	2 C/5 E 127 612
71-59	Trinity	2 C/5 E 126 613
71-60	Trinity	2 C/5 E 123 612
71-61	Sweet Bay	2 C/5 E 045 671
71-62	Sweet Bay	2 C/5 E 049 659
71-64	Lethbridge	2 C/5 W 937 601
71-65	Lethbridge	2 C/5 W 841 547
71-66	Harcourt Intersection	2 C/5 W 812 486
71-67	Clarenville	2 D/8 E 155 487
71-68	Terra Nova	2DYD 1677
71-69	Terra Nova	2DYD 1476
71-70	Terra Nova	2DXD 9369
71-71	Terra Nova	2DXD 9167
71-72	Terra Nova	2DXD 8866
71-73	Terra Nova	2DXD 7359
71-74	Argentia Access Rd.	1 N/5 E 047 588
71-75	Argentia Access Rd.	1 N/5 E 020 601
71-76	Argentia Access Rd.	1 N/5 E 020 601

Site No.	Nearest Place Name	Map Reference
71-78	Long Harbour Turnoff	1 N/12 E 962 646
71-79	Long Harbour Turnoff	1 N/12 E 942 678
71-80	Witless Bay Line	1 N/7 W 531 449
71-81	Burin Pen. Rd.	1 M/16 E 176 103
71-82	Burin Pen. Rd.	1 M/16 E 173 093
71-83	Burin Pen. Rd.	1 M/16 E 164 079
71-84	North Hr. Jct.	1 M/16 E 144 073
71-85	North Hr. Jct.	1 M/16 E 134 084
71-87	North Hr. Jct.	1 M/16 W 007 103
71-88	North Hr. Jct.	1 M/16 W 994 103
71-89	North Hr. Jct.	1 M/16 W 993 102
71-90	North Hr. Jct.	1 M/16 W 976 081
71-91	North Hr. Jct.	1 M/16 W 964 055
71-92	North Hr. Jct.	1 M/16 W 953 026
71-93	North Hr. Jct.	1 M/16 W 947 018
71-94	North Hr. Jct.	1 M/16 W 913 003
71-98	Terrenceville	1 M/10 E 766 855
71-99	Terrenceville	1 M/10 E 768 856
71-105	Red Harbour	1 M/7 W 565 468
71-108	Red Harbour	1 M/6 E 469 375
71-110	Lewin's Cove	1 L/14 W 303 044
71-113	St. Lawrence	1 L/14 W 197 981

Site No.	Nearest Place Name	Map Reference
71-114	St. Lawrence	1 L/14 W 143 985
71-116	Grand Bank	1 M/3 W 166 242
71-117	Grand Bank	1 M/3 W 161 226
71-120	Fortune	1 M/4 W 853 082
71-122	Fortune	1 L/13 W 818 043
71-123	Fortune	1 L/13 W 811 032
71-125	Lamaline	1 L/13 W 896 905
71-126	St. Lawrence	1 L/14 W 191 983
71-127	Mobile	1 N/2 W 599 323
71-130	Grates Cove Turnoff	2 C/2 W 566 296
71-132	Argentia	1 N/5 E 022 509
71-133	Argentia	1 N/5 E 929 463
71-134	Ship Cove	W 54° 04' N 47° 06'
71-135	Cape St. Mary's Turnoff	1 L/16 E 617 002
71-136	Cape St. Mary's Jct.	1 L/16 E 620 000
71-140	Cape St. Mary's	1 L/16 E 607 977
71-143	Come-By-Chance Turnoff	1 N/13 W 878 033
71-144	Clarenville	2 C/4 W 791 239
71-145	Cape Race Jct.	1 K/15 W 496 907
71-146	Cape Race Jct.	1 K/14 E 463 855
71-148	Cape Race Jct.	1 K/14 E 394 828

Site No.	Nearest Place Name	Map Reference
71-150	Cape Race	1 K/11 E 389 685
71-152	St. Shott's Jct.	1 K/11 W 769 125
71-154	St. Shott's Jct.	1 K/12 E 763 083
71-157	Colinet	1 N/4 E 088 324
71-158	North Harbour Jct.	1 N/4 E 943 226
71-159	North Harbour Jct.	1 N/4 E 952 337
71-161	Colinet	1 N/4 W 881 325
71-162	Colinet	1 N/4 W 864 332
71-163	Hodgewater Line	1 N/6 W 198 568
71-164	Ocean Pd. Rd.	1 N/6 W 158 577
71-165	Ocean Pd. Rd.	1 N/6 W 122 579
71-166	Witless Bay Line	1 N/6 E 470 440
71-167	Witless Bay Line	1 N/6 E 474 441
71-168	Witless Bay Line	1 N/7 W 506 450
71-169	Witless Bay Line	1 N/7 W 525 448
71-170	Soldiers Pond	1 N/6 E 488 522
71-171	Witless Bay Line	1 N/7 W 504 450
71-172	Witless Bay Line	1 N/7 W 530 448
71-173	Witless Bay Line	1 N/6 E 484 448
71-174	Avondale Jct.	1 N/6 E 315 473
71-175	Hodgewater Line Jct.	1 N/16 E 213 567

Site No.	Nearest Place Name	Map Reference
71-176	Argentia Acc. Rd.	1 N/5 E 020 601
71-177	Argentia Acc. Rd.	1 N/5 E 020 601
71-179	Whitbourne Jct.	1 N/6 E 315 473
71-180	Sunnyside	1 N/13 782 008
71-182	Whitbourne Jct.	1 N/5 E 089 579
71-186	North Harbour Jct.	1 M/16 W 992 100
71-187	North Harbour Jct.	1 M/16 W 953 026
71-188	North Harbour Jct.	1 M/16 W 950 020
71-189	Terrenceville Jct.	1 M/16 W 916 028
71-190	Terrenceville Jct.	1 M/10 741 736
71-191	Parkers Cove Jct.	1 M/7 583 494
71-192	Marystown	1 M/3 443 302