SOME FOREST AND HEATH HABITATS

OF THE AVALON PENINSULA, NEWFOUNDLAND

SCALE FIELD TRIP - 1987

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INTRODUCTION

The Avalon Peninsula occupies the southeastern part of the island of Newfoundland and is joined to it by an isthmus. The Peninsula has a land area of about 9 835 km^2, or 972 400 ha.

The Peninsula was well known to fishermen from Europe before the fifteenth century, but no settlements were established until 1610. The early economic history of the Province was closely related to the varying success of the cod fishery, and therefore the Peninsula experienced a series of booms and depressions. Since Newfoundland became a province of Canada in 1949 attention has been directed toward industrial development and improvement in farming and fishing on the Peninsula.

The climate of the Peninsula is strongly influenced by the ocean (Figure 1). The Labrador current keeps the air cool in spring and summer and the presence of sea ice along the coast until late spring or early summer delays the planting season. Summers are short but pleasant. July temperatures are 13-16°C. Coastal fog is common throughout the year. Winters are usually mild, with temperatures of -4°C to 2°C from December to February. Precipitation is 100-165 cm and is evenly distributed throughout the year. The growing season is about 150-160 days.

The Peninsula is a highland area surrounding a large central lowland. The highland surface is rough and rugged, whereas that of the lowland is ridged and hummocky. Much of the coastline rises abruptly from the sea and is indented with numerous bays and inlets, some of which make good harbors. Many rivers drain the highlands and there are several lakes. About 9 percent of the area is covered by water.

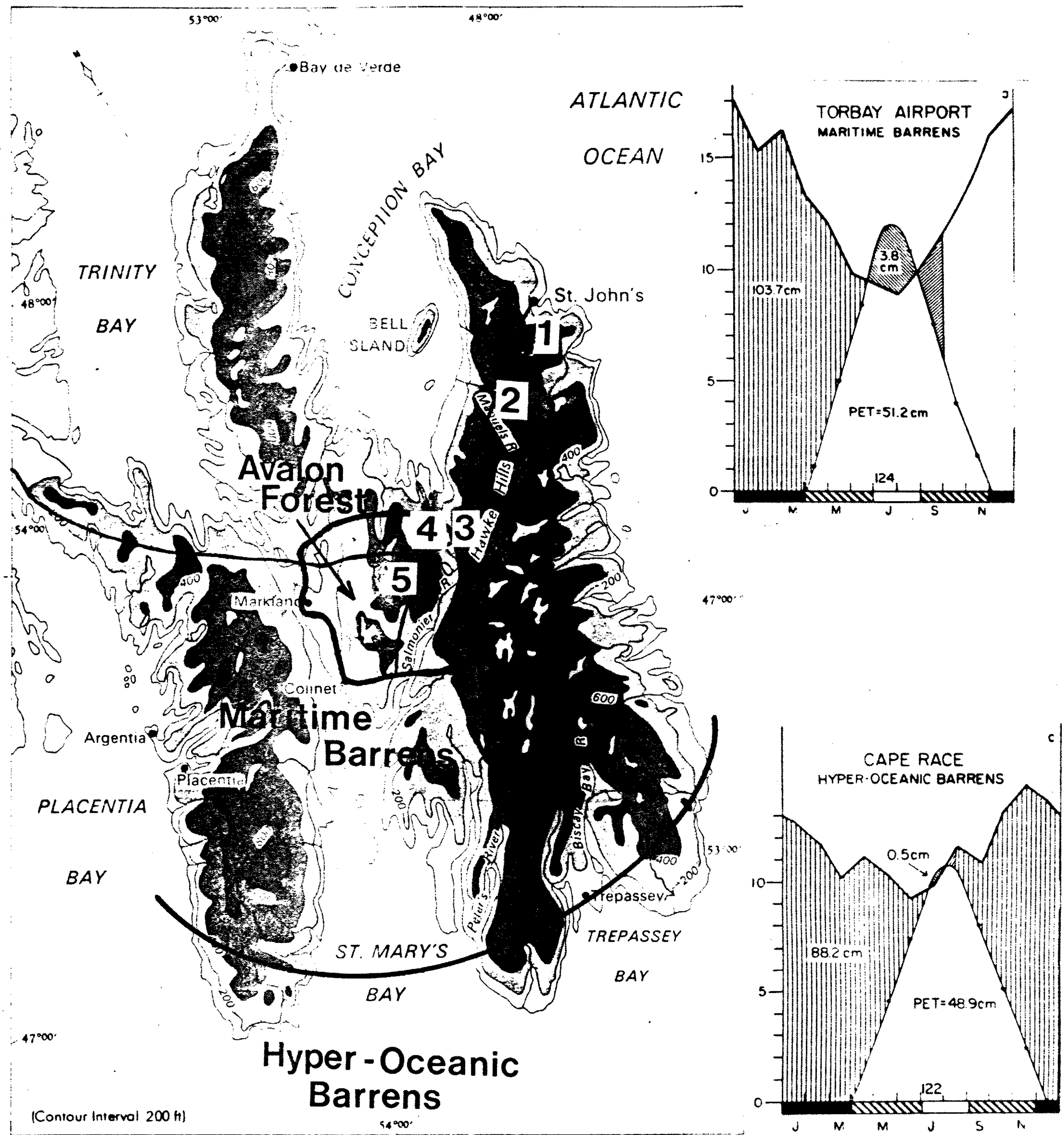

Figure 1. Climate, physiography and ecoregion boundaries of the Avalon Peninsula.

Nearly 40 percent of the Peninsula is forested. The main trees are balsam fir, black spruce, white spruce, and tamarack, along with some white and yellow birch and alder.

The soils of the Peninsula have developed from materials derived from the underlying slate, siltstone, sandstone, shale, limestone, conglomerate, and granitic and volcanic rocks. The whole area was glaciated and the materials were deposited in the form of ground moraine, outwash, and other glaciofluvial deposits. Some of the present streams have deposited alluvial sediments along their courses.

Most of the mineral soils are coarse to moderately coarse textured, stony, acid to extremely acid, and low in natural fertility. They belong mainly to the Humo-Ferric and Ferro-Humic Podzol great groups and some are Humic Podzols. Some of the soils have a thin iron or manganese pan in the profile. Where the parent materials are fine to moderately fine textured, the soils are less leached and have a profile typical of the Dystric Brunisol great group. Gleysolic soils with dull-colored, mottled profiles and organic soils are found in poorly drained positions.

Damman (1983) recognized three ecoregions in eastern Newfoundland; (i) Avalon Forest, (ii) Maritime Barrens, (iii) Eastern Hyper-oceanic Barrens. Due to time constraints we will only be visiting ecoregions (i) and (ii) (Figure 1). The following is a brief summary of the ecoregions from Damman (1983).

(i) Avalon Forest Ecoregion

General characteristics

This ecoregion occupies the sheltered, central part of the Avalon Peninsula (Figure 1). It is a heavily forested area within the Maritime Barrens Ecoregion and includes most of the commerical forests of the Avalon Peninsula.

The area is underlain by ribbed moraine (Prest 1968) and has a very irregular topography with low (15-20 m high), steep-sided hills. The area is dotted with innumerable small lakes and bogs. The entire area is located below 250 m.

This ecoregion covers only about 500 km^2. The vegetation pattern of the area is so different from other parts of the Island that it was separated in spite of its small size.

Vegetation

The vegetation is most similar to that of the deep, forested valleys of the southern coastal parts of the Maritime Barren Ecoregion. However, it has a much greater diversity of topographical conditions and moisture regimes than can be found in a river valley and, consequently, includes a greater variety of vegetation types. In addition, *Alnus rugosa* is completely absent.

The ecoregion is most clearly characterized by the very distinctive vegetation pattern of the ridges and the striking abundance of fruticose lichens on stems and branches of trees, *Alectoria sarmentosa*, *A. jubata* and *Usnea longissima* are the most prominent ones.

The ridges have a very distinctive vegetation pattern with the most productive Abies-Betula forests on the summits and north slope, poorer but merchantable Picea mariana-Abies forests on the lower north slope, and scrubby Abies-Picea mariana forests on the south slope (Delaney and Cahill 1978). The mature Abies trees on the better sites are generally only 10-12 m but show good diameter growth (Wilton 1956). The Abies-Betula forests have a luxuriant ground vegetation dominated by Dryopteris spinulosa var. americana. In contrast, the ground vegetation of the south slope is dominated by Sphagnum with abundant ericaceous species and Taxus canadensis.

Apparently, this peculiar pattern is caused by microclimatic conditions. Night frosts during the vegetative season are associated with the occasional northeast winds which blow cold, clear air over the area, whereas the prevailing southern winds bring fog. During cold, clear nights the highest temperatures occur on the summits and also on the north slope, where air turbulence prevents the stagnation of cold air. Consequently, these areas have an appreciably longer vegetative season than the lower south slopes where night frosts can occur until well into the summer.

It is further differentiated from the surrounding barren areas by the presence of convex raised bogs, the abundance of Rhacomitrium lanuginosum on the hummocks of the bogs indicative of the strong oceanic influence in this region, and the occurrence of Betula lutea on the summits and upper and middle north slopes of the moraines. Apart from the Western Newfoundland Ecoregion, this is the only forested ecoregion in which this species occurs regularly. Elsewhere, it is restricted to some sheltered valleys along the south coast.

The abundance of *Taxus canadensis* in forests on acid parent materials and the important role played by *Dryopteris spinulosa* var. *intermedia* are also characteristic for this ecoregion. The latter can replace *D. spinulosa* var. *americana* as the dominant fern on seepage sites. *Populus tremuloides* is present but never forms stands.

Climate

The climate of this ecoregion is in most respects similar to the surrounding parts of the Maritime Barren Ecoregion. The main differences are due to its sheltered position. Fog is frequently funneled into the area from the south, and the area appears to have higher fog frequencies in the summer than the surrounding barrens. A further distinguishing feature is the peculiar microclimate discussed earlier.

(ii) Maritime Barrens Ecoregion

General characteristics

This ecoregion includes most of the eastern peninsulas, the Central Barrens and the coastal strip extending west to just beyond Port-aux-Basques.

The ecoregion is characterized by extensive barren areas consisting mainly of dwarf shrub heaths, bogs and shallow fens. Forests are most common in valleys, but they can be found occasionally on hill tops and slopes. In general, forest cover increases northward. A peculiar feature of the ecoregion is the mingling of southern (Coastal Plain) species and arctic species; the former occur mainly in bogs and valleys whereas the latter are restricted to exposed sites without snow cover during most of the winter.

Fires occur regularly, and 73 280 ha were burnt from 1958 to 1974, which represents about 31 percent of the total area destroyed by forest fires during this period in Newfoundland. Fires appear to have played a major role in the development of this landscape. This area once had a forest cover with the exception of some of the higher ridges and coastal headlands. Most of the forest cover was gradually eliminated by the combined effect of frequent fires after the area became settled by European fishermen, poor regeneration after these fires, the marginal climatic conditions for tree growth, and the strong competition from ericaceous dwarf shrubs. The remaining patches of forest are generally of poor quality: height growth is particularly poor, especially in the eastern part of the ecoregion (Wilton 1956). The best forest stands occur in the deeper, sheltered valleys. It is difficult to assess the quality of the original forests since the development of the extensive barrens has undoubtedly influenced the climate of the area, particularly wind velocity and the severity of winter snow drifting. Presumably, the original forest had a poorer overall quality than the forest stands which are present today because the forest was first eliminated from the poorest sites.

The destruction of the forest and its replacement by a dwarf shrub heath with a thick raw humus horizon has led to increased organic matter concentrations in the B horizon of the soils and the development of placic horizons (McKeague *et al*. 1968; Damman 1967, 1975; Ivarson and Heringa 1972). They develop also in soils on topographically well-drained positions.

The most exposed and coldest sites support a *Diapensia-Loiseleuria* vegetation. Winter snow cover and a high spring moisture surplus prevent the development of normal blanket bogs (Damman 1979b). As a result, ombrogenous slope bogs, shallow oligotrophic bogs and fens are the dominant peatlands (Wells 1975; Damman 1979b), and blanket bogs are restricted to ridge tops.

Abies balsamea is by far the most important tree in the remaining forests. The stands are often very dense; height growth is poor, but diameter growth is very good (Wilton 1956). The forest floor vegetation of these stands is strikingly different from those in other ecoregions. Most conspicuous is the abundance of *Dicranum* spp., especially *D. majus*, *Rhytidiadelphus loreus* and *R. triquestrus* in the moss carpet, and the subordinate role played by *Pleurozium schreberi* and *Hylocomium splendens* in comparison with other ecoregions.

Arctic-alpine species occur only on wind-swept sites with a *Diapensia-Loiseleuria* vegetation. Southern species are found primarily in bogs (e.g. *Gaylussacia dumosa*, *Habenaria blephariglottis*, *Schizaea pusilla*, *Carex folliculata*) and ponds (e.g. *Juncus militaris*, *Myriophyllum tenellum*). *Sphagnum macrophyllum* is restricted to this ecoregion but rare. The southern species in this ecoregion are mainly Coastal Plain species limited by low winter temperature and tolerating a cool vegetative season. Many other southern species, e.g. *Epigaea repens*, are conspicuously absent. Oceanic species, such as *Sphagnum molle* and *S. strictum* are well-represented.

The shrubs *Nemopanthus mucronata* and *Viburnum cassinoides* are abundant throughout the ecoregion, even in the open barren vegetation. *Larix laricina* is common in the open barrens both as isolated individuals and as clumps of low trees. *Sorbus decora* is much more common than *S. americana*, and often forms thickets in coastal areas.

Climate

This ecoregion is characterized most clearly by the coldness of the summer (Hare 1952; Damman 1976), the relatively mild winters and the high fog frequency. In general fog frequency and winter temperatures decrease, and summer temperatures increase, inland and to the north.

Precipitation is over 1 250 mm in most of this ecoregion. Winter precipitation comes as either rain or snow. Consequently, snowfall varies greatly from year to year. The snow cover can be interrupted during any of the winter months when warm air masses bring heavy rain. Only the barrens of the southern interior, the Central Barrens, have as a rule a permanent snow cover (Potter 1965; Mercer *et al.* 1972).

Forest Management and Utilization

As unproductive as the forests of this region may appear, they have traditionally played an important role as a source of raw materials for houses, sheds, boats, stages and wharfs in small fishing villages. By mid-1900 fire protection policy had alleviated much of the extensive destruction of the forests. Wilton (1956) estimated that in 1953 approximately 160 000 m^3 of wood were used as forest products and annual increment was exceeding depletion by approximately 175 000 m^3. His comments on fuelwood cutting were of particular significance:

> "The use of wood for fuel is declining, even in rural areas, and this is one of the major factors contributing to the improved condition of the Avalon forests. From fragmentary data available it is estimated that 20 years ago the fuelwood consumption was three times what it is today."

This picture has changed dramatically in the last 30 years. The demand for building materials has declined considerably with the import of lumber from the Canadian mainland. However, coincident with increased fuel costs the fuelwood consumption has soared to 196 000 m^3 in 1983 (Northland Associates 1984). Fortunately, some of this demand is supplied from other parts of the island and some comes from scrub forest not included in inventory estimates of the annual allowable cut. Yet, since 1956 increased alienation of forest land in the region for residential use, agriculture, parks and recreation, transmission lines and highways has reduced the annual allowable cut to approximately 71 000 m^3. It hardly needs to be stated that the challenge to future forest management in the region is formidable. However, on a few sites where eastern larch and Scots pine were planted, fuelwood size trees have been produced within 20 years of planting (Hall 1986). In fact, some of these sites are upland heaths dominated by Empetrum nigrum suggesting that problems related to exposure can be overcome where spacing (1.5 m) is adequate to afford mutual protection. However, afforestation, although silviculturally feasible, is expensive and requires long periods for the forest to regain its original productivity.

The forests of eastern Newfoundland have been exploited by European man perhaps longer than most other regions of Canada. Although the loss in productivity caused by the widespread development of anthropogenic heath is insignificant on the national scale it does have a significant economic impact on the local economy. In the national context perhaps the most significant contribution this landscape can now make is its natural beauty. It also provides a graphic example to foresters elsewhere in Canada of what can happen on a regional scale when the forest resource is over-exploited and under-protected.

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STOP #1 RUBUS-BALSAM FIR FOREST TYPE (ABIETETUM RUBETOSUM)

(Harbour Arterial Road at Ruth Avenue Exit, Mount Pearl)

The Rubus-Balsam Fir forest type occurs on nutrient rich sites receiving seepage. The most frequent topographic positions include gently rolling terrain (such as this site) or at the base of steep valley slopes. The most common soil subgroups include the Gleyed Ferro-Humic Podzol or Humic Gleysol. The upper solum is usually characterized by fine texture and organic matter enrichment. The lower B horizon usually displays prominent and extensive mottling.

The vegetation of this forest type is distinguished by the following differential species:

Rubus pubescens	*Viburnum edule*
Dryopteris disjuncta	*Cornus stolonifera*
Ribes glandulosum	*Solidago macrophylla*

These indicators are not well represented under the extreme shading characteristic of overstocked balsam fir forests such as this forest stand. However, most of the indicators (particularly *Rubus pubescens*) are well represented on the adjacent cutover. The failure of plant indicators to survive disturbance is frequently cited as a critical limitation to using vegetation as a criteria in a forest site classification system. In Newfoundland our experience has been that most indicators survive disturbance and are better expressed in early seral stages following cutting and burning than they are in mature stage of stand development. Many of the feather moss forests which are so species poor and difficult to separate even on a wide range of moisture regimes have a much greater diversity of vegetation after disturbance. Also, even what might be considered a single stable edaphic type can potentially develop into several seral vegetation types after disturbance depending on the frequency, season and intensity of disturbance and resultant stocking condition. While the relationship between the edaphic site and potential yield is critical to priorize sites for intensive management, in deciding the type of treatment (site prescription) it is the vegetation that is being managed. For this reason, my current research in Newfoundland is focused on the development of a classification of seral vegetation types within the framework of the Damman forest site classification of mature types.

This site type supports some of the best forest growth on the Avalon Peninsula of Newfoundland. The forest CLI class is 5, yielding 120-200 m^3/ha over a 60 year rotation. However, the edaphic potential of such sites is nearly always suppressed compared to other parts of Newfoundland by the overriding influence of maritime winds. Thus site indices of 10-12 m are quite common throughout the region. The best growth occurs in valleys where the combined effects of nutrient rich seepage slopes and shelter overlap.

Correlations between the edaphic site and growth and yield are further obscured by the tendency of balsam fir to form overstocked stands from 5 - 50 thousand stems/ha after crown closure. The possibility of differentiating site quality of such sites is both an opportunity and challenge for forest site classification in Newfoundland. Precommercial thinning in such forests is considered a high priority in forest management particularly in western Newfoundland. Site classification is perceived as a possible means of identifying the most productive sites which will hopefully provide the greatest response to treatment.

Discussion Topics

(1) How should the relationship between site classification and potential yield be defined.

(2) Do we need to know more about vegetation development in order to develop forest management prescriptions.

Habitat Summary

Latitude: 47°30'30", Longitude: 52°49'15", Elevation: 175 m

Bedrock Geology: Precambrium Shale Sandstone Siltstone

Surficial Geology: Gently Rolling Ground Moraine

Soil Series: Pouch Cove (Gleyed Ferro-Humic Podzol) derived from gray slate

Soil Texture: Sandy Loam

Moisture Regime: 3 (Moist Seepage)

Forest Capability: $5^{6}U_{M}$ $7^{4}F_{W}$

CCELC Vegetation Classification:

a) Forest - Closed Intermediate Needleleaf Trees

b) Cutover - Open Intermediate Deciduous Shrubs

Vegetation

a) Forest

Tree Layer (12-14 m)

Abies balsamea $2^{+}\cdot 1$

Tree Layer (2-5 m)

Abies balsamea $3\cdot 1$

Tree Layer (0.2-1.0 m)

Abies balsamea $3\cdot 1$

Herb layer 0-30 cm

Maianthemum canadense $4\cdot 1$

Trientalis borealis $2^{+}\cdot 1$

Dryopteris spinulosa $1^{-}\cdot 1$

Linnaea borealis $2^{-}\cdot 2$

Solidago macrophylla $^{+}\cdot 1$

Moss Layer

Dicranum scoparium $3\cdot 2$

Dicranum fuscescens $1^{+}\cdot 2$

Dicranum majus $2^{-}\cdot 2$

Pleurozium schreberi $1^{+}\cdot 2$

b) Cutover

Shrub Layer (1-2 m)

Abies balsamea $1^{+}\cdot 1$

Sorbus americana $2^{-}\cdot 1$

Prunus pennsylvanica $3\cdot 1$

Amelanchier bartramiana $2^{-}\cdot 1$

Nemopanthus mucronatus $1^{+}\cdot 1$

Viburnum cassinoides $2^{+}\cdot 1$

Herb Layer (0.2-1.0 m)

Rubus idaeus $3\cdot 1$

Ribes glandulosum $2^{-}\cdot 2$

Solidago rugosa $1^{+}\cdot 1$

Solidago macrophylla $2^{-}\cdot 1$

Clintonia borealis $1^{+}\cdot 1$

Osmunda cinnamomea $1^{+}\cdot 2$

Ribes hirtellum $^{+}\cdot 1$

Calamagrostis canadensis $1^{+}\cdot 2$

Kalmia angustifolia $1^{-}\cdot 2$

Vaccinium angustifolium $2^{-}\cdot 2$

Herb Layer (< 0.2 m)

Cornus canadensis $3\cdot 1$

Linnaea borealis $2^{-}\cdot 2$

Rubus pubescens $2^{+}\cdot 2$

Festuca rubra $1^{+}\cdot 2$

Carex trisperma $1^{+}\cdot 2$

Maianthemum canadense $2^{+}\cdot 1$

Coptis groenlandica $1^{+}\cdot 1$

Carex interior $^{+}\cdot 1$

Moss Layer

Dicranum scoparium $2^{-}\cdot 2$

Dicranum fuscescens $1^{+}\cdot 2$

Pleurozium schreberi $1^{+}\cdot 2$

Ptilium crista-castrensis $1^{+}\cdot 2$

STOP #2 KALMIA HEATH AND FOREST ISLAND

(Round Pond on the TCH near Butterpot Park)

The Kalmia Heath landscape which dominates most of southern and eastern Newfoundland originated with extensive and repeated burning following settlement of the region by European man. The construction of the railway in the mid-1800s was particularly devastating to the forests of the region.

Normally, succession after fire in Newfoundland leads to the replacement of balsam fir by black spruce. Balsam fir, because it sheds its seeds annually, is not fire adapted. However, when two fires occur within 20-30 years the black spruce seed supply is obliterated over extensive areas. The same is true for cutting followed by forest fire. The maritime climate of eastern Newfoundland further complicates this general successional trend.

The forests of this region prior to European settlement evolved in the absence of fire and consequently most upland sites are dominated by monocultures of balsam fir. The black spruce working group in this region accounts for less than 5 percent of the total inventory. By and large black spruce only occurs as an edaphic type on the wet soil types in transition to organic soils. Following even a single fire most of these balsam fir stands can potentially develop to Kalmia Heath because of the lack of adequate black spruce seed supply.

This site was used as part of a study to test the hypothesis that heaths could regenerate to forest given adequate time for tree invasion from forest islands in the heath and peripheral forest stands. Figure 2 shows the recent history of the forest island as well as the vegetation and soil variation over the toposequence. A second site consisting of a small heath island surrounded by forest was used to supplement the conclusions drawn from the forest island site.

The following is a brief summary of conclusions reached from this study:

1. After nearly 20 years of secondary succession adequate tree invasion of 2500 stems/ha and 40 percent stocking occurred up to a maximum of 20 m in the heath island and 10 m from the forest island (Figure 3). Further analysis of tree age classes showed that the density of invading trees was inflated by 30-50 percent due to advance regeneration from black spruce vegetative layers (Figure 4) and balsam fir seedling banks. These sources of regeneration represent Initial Floristic Composition rather than Relay Floristics and furthermore their occurrence is an artifact unique to the forest edge where fire disturbance of the ground is least intense. Beyond 20 m on both study sites, subsequent tree invasion of the heath will be totally dependent on Relay Floristics. By removing the advance regeneration from total regeneration it can be demonstrated that subsequent invasion by Relay Floristics will be limited to 10 m from the stand edge in the downwind direction.

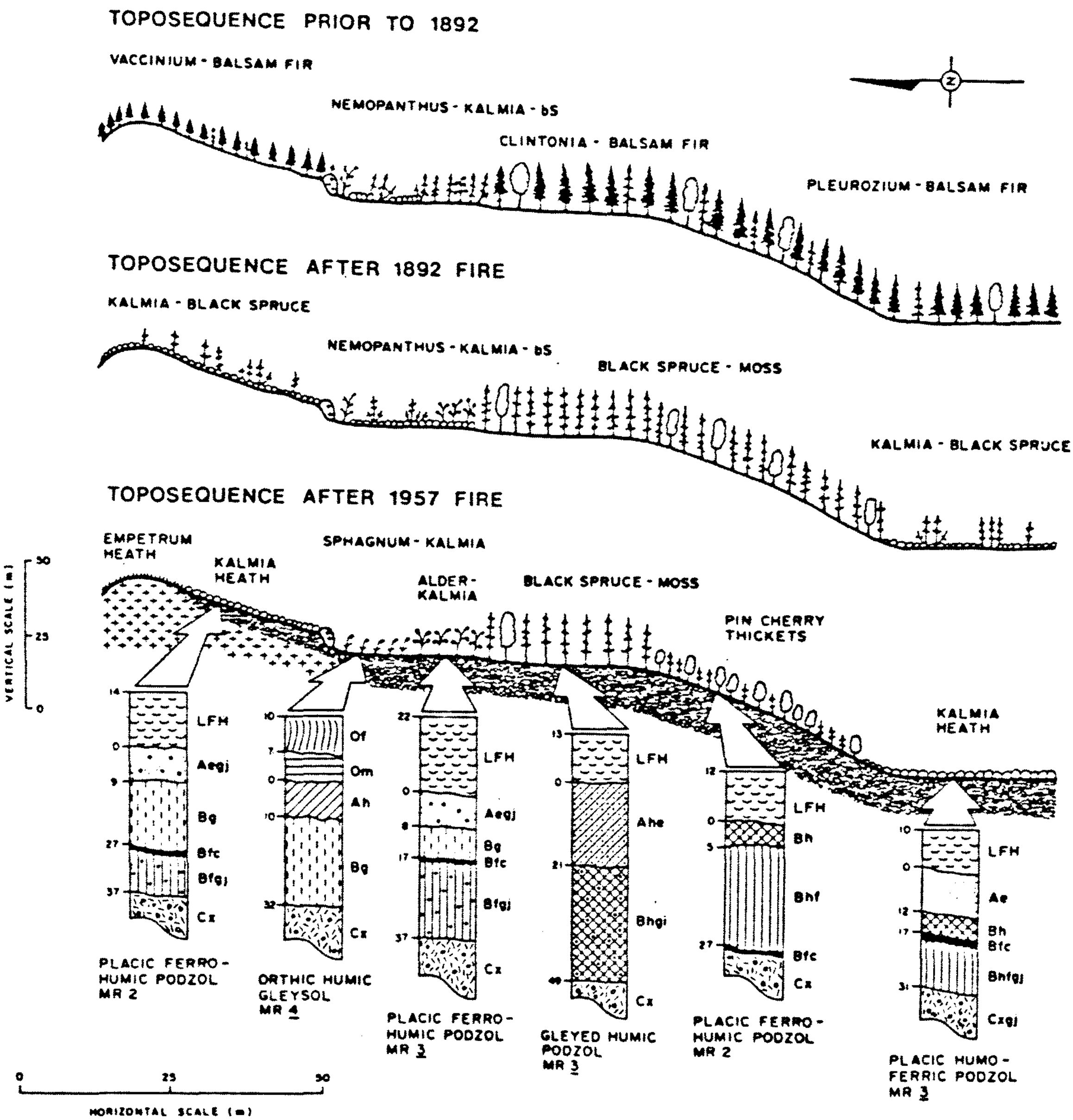

Figure 2. The vegetation-soil and topographic relationships on the forest island site following fires in 1892 and 1957.

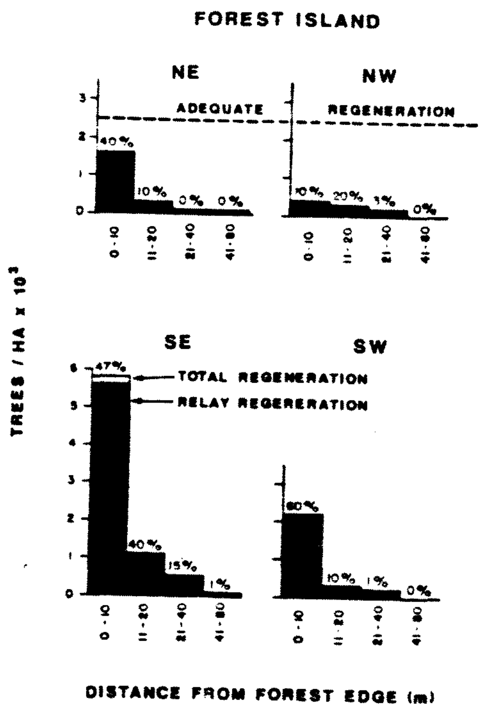

Figure 3. Density and stocking of regeneration surrounding the forest island. Nearly all regeneration is of post disturbance origin.

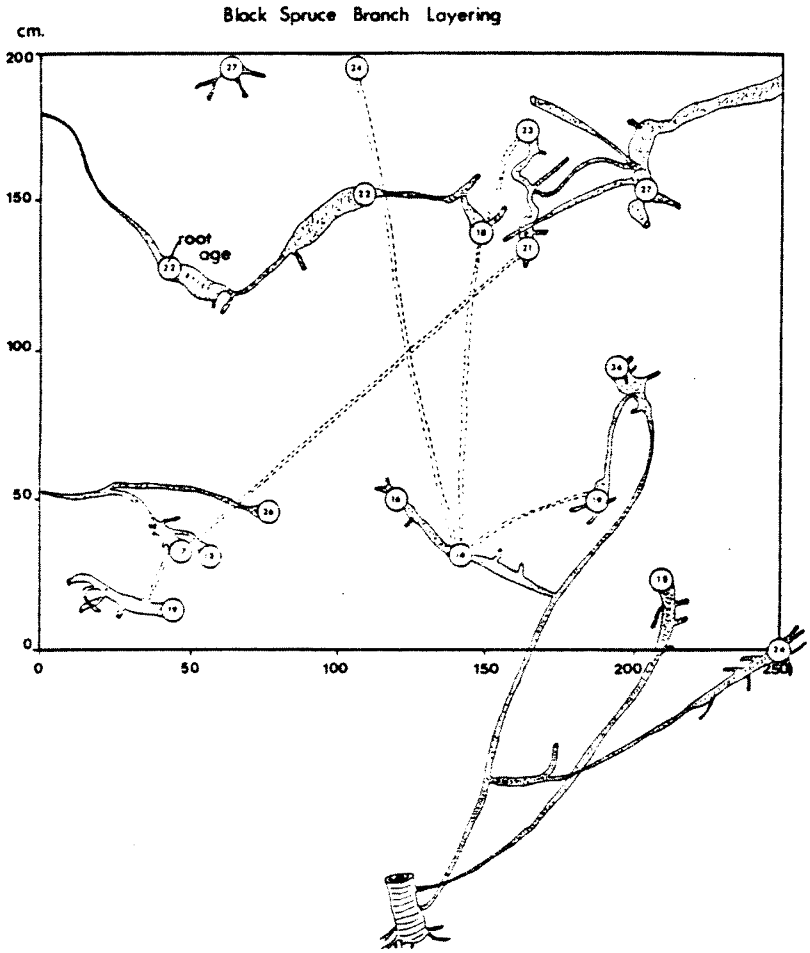

Figure 4.   Vegetative reproduction of black spruce regeneration in the southeast quadrant of the forest island site.

Analysis of the population age structure reveals that current tree invasion of the ecotone has ceased with few exceptions. Where invasion does occur, recruitment in the 0-5 year age class is probably inadequate to compensate for mortality, suggesting ecotone stability (Figure 5).

2. Analysis of the potential tree seed supply in the forest-heath ecotone shows that even with viability between 20-30 percent seed supply alone should not inhibit tree invasion up to distances of 30 m. However, in the forest island site, viability is reduced to 5.0 percent and seed supply could be limited from 10-30 m from the stand edge. Supplementary testing of seed viability in coastal forests and continuous, sheltered inland forests suggested the seed viability decreased with increasing climatic severity. Similar observations have been made by other researchers working in tree-line environments (Black and Bliss, 1980; Zazada *et al.*, 1978; Payette *et al.* 1982).

3. Eighty-five to ninety percent of the ground cover on both study sites is comprised of substrates considered to represent "unsafe microsites" for black spruce and balsam fir regeneration (Figure 6). Ericaceous litter and lichen (*Cladonia* spp.), in particular, are thought to have mechanical and chemical characteristics thought to be detrimental to successful seedling germination and survival (Peterson 1965; Brown and Mikola 1974; Foster 1985; Hobbs 1985; Mallik in press).

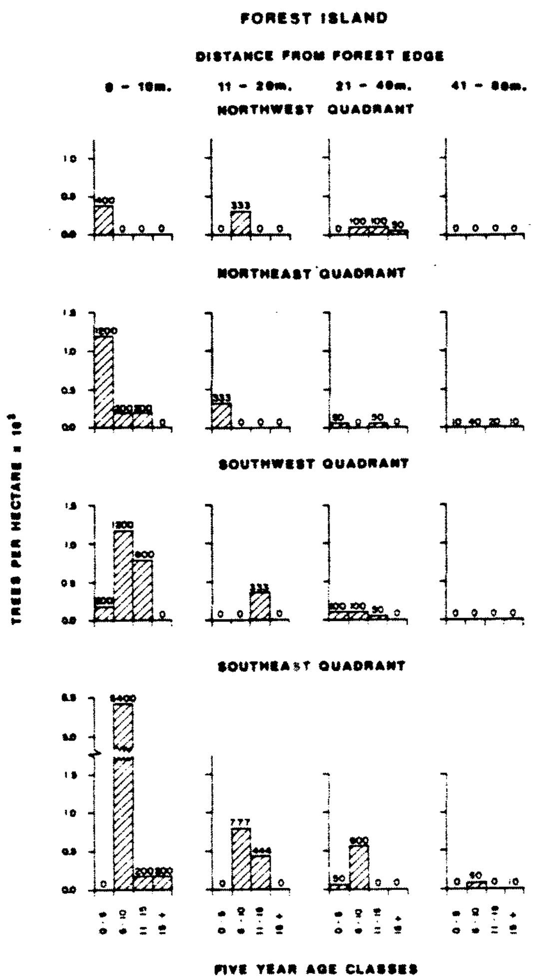

Figure 5. Age class distribution of regeneration in the forest-heath ecotone of the forest island site.

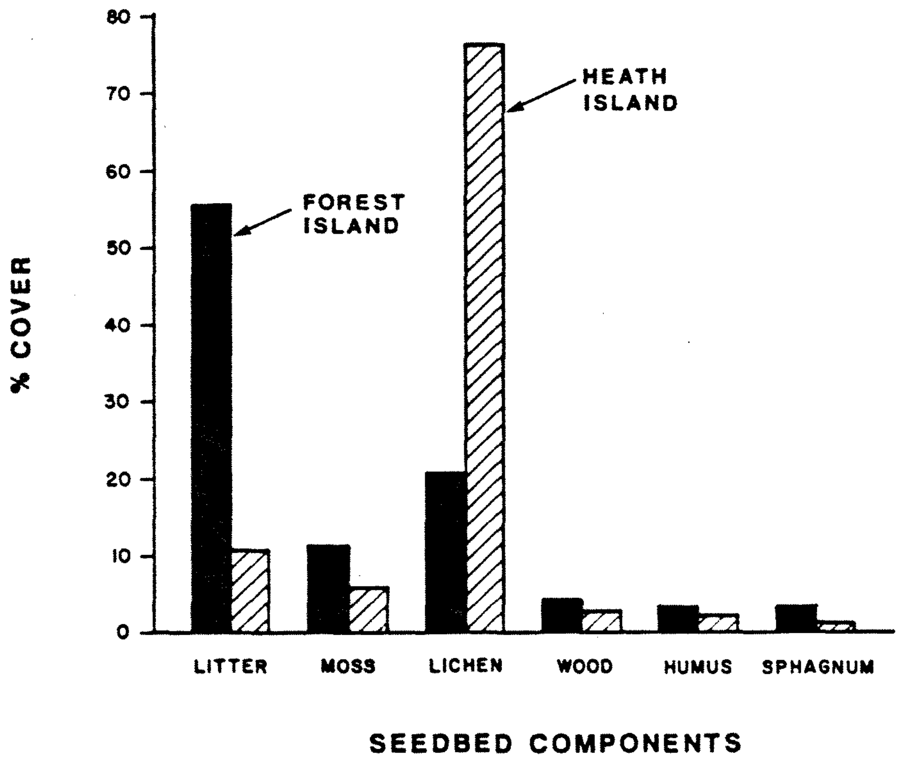

Figure 6. The composition of seedbeds in the ecotone surrounding the forest island and heath island sites.

4. Regeneration in the forest-heath ecotone shows different rates of height growth dependent on their history of tree establishment (Figure 7). Advance regeneration from vegetative layers or a seedling bank shows growth rates of 3.0-3.5 cm/yr for black spruce and 1.5-2.0 cm/yr for balsam fir. Regeneration representing Relay Floristics shows a growth rate of 2.0 cm/yr for black spruce and 1.0 cm/yr for balsam fir. The mean maximum height attained for tree populations in the heath ecotone (including advance regeneration), is 50.9 cm. The primary impact of these slow growth rates on succession is that even in overstocked portions of the ecotone the structural and functional transition to forest from heath is not perceptible after nearly 20 years of secondary succession. A secondary impact of these growth rates is that more than a century may be required for cone production to initiate any subsequent relay of tree seeds into the heath.

The exceedingly slow growth rates of conifers in the heath may be caused by nutrient immobilization by the ericaceous shrubs (Damman 1971, 1975). However, the results of several studies (Handley 1963; Bjorkman 1970; Mallik in press) suggest that nutrient competition between trees and shrubs may be aggravated by the chemical inhibition of tree mycorrhizal associations due to leachates from ericaceous shrub leaves. Further study is required to clearly demonstrate such a relationship exists in the Kalmia Heath.

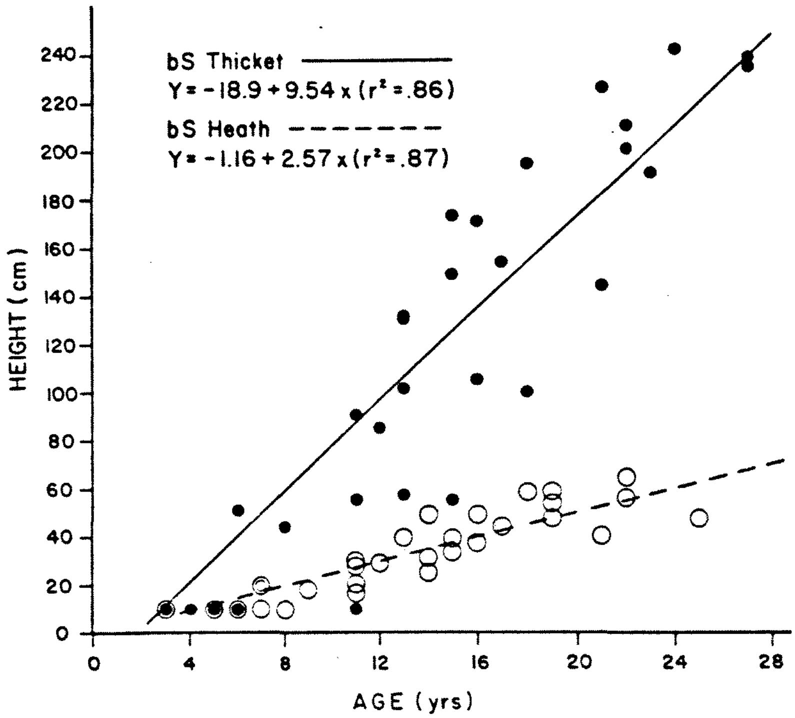

Figure 7. Height growth for black spruce regeneration growing in Pin Cherry Thickets and Kalmia Heath surrounding the forest island.

In conclusion, the results strongly suggest that the ecotone between coniferous forest and anthropogenic Kalmia Heath is stable even if human disturbance of the habitat is relaxed. Even if the rates of tree recruitment into the ecotone improved in the short-term, the short seed dispersal and exceedingly slow growth rates of trees would severely limit the rate of long-term movement of the tree-line. The absolute maximum rate that one could contemplate would be in the order of 10.0 cm/century. Considering the vast extent of the heath such succession would require time periods for in excess of that under which stable conditions of climate and soil would prevail. Such succession would represent long-term historical vegetation development rather than secondary succession within the context of a chronosequence.

Kalmia Heaths very similar in species composition to this site are now frequently observed developing on productive forest sites in central Newfoundland. These heaths originate where there is inadequate stocking in almost pure black spruce-feathermoss forests after harvesting and on sites that are burnt by wildfire after cutting. Black spruce planted on such sites are growing very poorly even where sites are scarified. Much of our silvicultural research effort in Newfoundland is now being focused on this problem.

Topics for Discussion

1. To what extent can forest site classification be used to identify potential regeneration problems in pre-harvest operational planning?
2. Putting time limits on successional predictions has traditionally been a problem in the relationship between research and forest management. is this a real problem or a communications problem?
3. Can GIS classification system be used to increase the accuracy of successional predictions particularly with reference to changes in the composition of commercial species.

Habitat Summary

Latitude: 47°23'50", Longitude: 53°02'30", Elevation 200 m

Bedrock Geology: Diabase Gabbro Diorite Granitics

Surficial Geology: Shallow Discontinuous Ground Moraine

Soil Series: Kelligrews (Gleyed Orthic Humo-Ferric Podzol derived mainly from granitics)

Soil Texture: Sandy Loam

Moisture Regime: 2-3

Forest Capability: 7V (exposure)

CCELC Vegetation Classification:

a) Spruce Forest

Closed Intermediate Needleleaf Trees

b) Spruce Thicket

Open Low Mixture Trees

c) Kalmia Heath

Closed Low Evergreen Shrubs

Vegetation

a) Forest Island

Tree Layer (8-10 m)

Picea mariana 4•1

Shrub Layer (1-3.0 m)

Betula papyrifera 2^{-}•1

Sorbus americana 1^{+}•1

Amelanchier bartramiana 1^{+}•1

Nemopanthus mucronatus 1^{-}•1

Viburnum cassinoides 2^{-}•1

Shrub Layer (0.2-1.0 m)

Vaccinium angustifolium 2^{+}•2

Kalmia angustifolia 2^{+}•2

Ledum groenlandicum 1^{-}•2

Picea mariana 1^{+}•2

Herb Layer (10-30 cm)

<u>Clintonia borealis</u> $3 \cdot 1$

<u>Trientalis borealis</u> $1^{-} \cdot 1$

<u>Cornus canadensis</u> $2^{+} \cdot 1$

<u>Osmunda cinnamomea</u> $1^{+} \cdot 2$

<u>Pteridium aquilinum</u> $+ \cdot 1$

<u>Pyrola secunda</u> $1^{-} \cdot 1$

<u>Vaccinium vitis-idaea</u> $+ \cdot 1$

Mosses and Lichens

<u>Pleurozium schreberi</u> $2^{+} \cdot 2$

<u>Hylocomium splendens</u> $1^{+} \cdot 2$

<u>Ptilium crista-castrensis</u> $1^{+} \cdot 2$

<u>Bazzonia trilobata</u> $2^{-} \cdot 2$

<u>Dicranum fuscescens</u> $2^{-} \cdot 2$

<u>Dicranum scoparium</u> $2^{+} \cdot 2$

<u>Cladonia elongata</u> $1^{+} \cdot 2$

<u>Cladonia squamosa</u> $+ \cdot 2$

<u>Alectoria sarmentosa</u> $2^{+} \cdot 2$

<u>Alectoria jubata</u> $2^{-} \cdot 2$

<u>Parmelia physodes</u> $1^{+} \cdot 2$

b. Black Spruce Thickets

Tall Shrub Layer (1-3 m)

<u>Betula papyrifera</u> $3 \cdot 1$

Alnus crispa $2^{-} \cdot 1$

Viburnum cassinoides $2^{+} \cdot 1$

Sorbus americana $1^{-} \cdot 1$

Amelanchier bartramiana $1^{+} \cdot 1$

Nemopanthus mucronatus $1^{-} \cdot 1$

Picea mariana $3 \cdot 1$

Low Shrub Layer (0.2-1.0 m)

Kalmia angustifolia $1^{+} \cdot 1$

Rhododendron canadense $1^{+} \cdot 1$

Vaccinium angustifolium $2^{-} \cdot 1$

Prunus pennsylvanicum $1^{-} \cdot 1$

Herb Layer (0.2-0.5 m)

Cornus canadensis $2^{+} \cdot 1$

Clintonia borealis $1^{P} \cdot 1$

Maianthemum canadense $2^{+} \cdot 1$

Trientalis borealis $1^{-} \cdot 1$

Pyrola secunda $^{+} \cdot 1$

Gaultheria hispidula $1^{+} \cdot 1$

Moss Layer

Pleurozium schreberi $3 \cdot 3$

Dicranum polysetum $1^{-} \cdot 2$

Dicranum scoparium $1^{-} \cdot 2$

Ptilium crista-castrensis $1^{-} \cdot 2$

Dicranum fuscescens $1^{-} \cdot 2$

Hylocomium splendens $1^{-}\cdot 2$

Polytrichum commune $1^{-}\cdot 2$

Cladonia arbuscula $^{+}\cdot 2$

Cladonia caccifera $^{+}\cdot 2$

Cladonia rangiferina $^{+}\cdot 2$

c. **Kalmia Heath**

Tall Shrubs (0.5-1.0 m)

Alnus crispa $1^{+}\cdot 2$

Nemopanthus mucronatus $1^{-}\cdot 2$

Betula papyrifera $(^{+}\cdot 1)$

Sorbus americana $(^{+}\cdot 1)$

Low Shrubs (0.2-0.5 m)

Kalmia angustifolia $5\cdot 1$

Rhododendron canadense $3\cdot 1$

Pteridium aquilinum $3\cdot 1$

Ledum groenlandicum $2^{+}\cdot 2$

Amelanchier bartramiana $2^{+}\cdot 1$

Viburnum cassinoides $2^{-}\cdot 1$

Nemopanthus mucronatus $2^{-}\cdot 1$

Herb Layer (0.1-0.25 m)

Cornus canadensis $2^{+}\cdot 1$

Maianthemum canadense $1^{P}\cdot 1$

Vaccinium angustifolium $3\cdot 1$

Trientalis borealis $1^{-}\cdot 1$

Picea mariana $+\cdot 1$

Moss and Lichen Layer

Dicranum polysetum

Dicranum undulatum

Cladonia terrae-novae

Cladonia rangiferina

Cladonia arbuscula

Cladonia crispata

Cladonia deformis

Cladonia cristatella

Cladonia elongata

Hypogymnia physodes

Note: There are two subassociations of the typical Kalmia Heath represented on the site.

1. Kalmia-Sphagnum

   Sphagnum nemoreum 4•4

   Vaccinium oxycoccus 1^{+}•1

   Sarracenia purpurea 1^{-}•2

   Osmunda cinnamomea $^{+}$•1

   Kalmia polifolia $^{+}$•1

   Chamaedaphne calyculata 1^{-}•1

2. Kalmia-Alder

   Alnus crispa 3•3

   Cyprepedium acaule 1^{+}•2

   Shrub Layer up to 1.0 m in height.

STOP #3 ALPINE HEATH AND ECOREGIONS VISTA

(Hawke Hill Summit)

This site represents one of the few areas in eastern Newfoundland that is above the natural climatic limit for tree growth. The landscape to the east and south is typical of the Maritime Barrens Ecoregion created by human disturbance over the last three centuries. To the north and west the best forest stands in the region characterize the Avalon Forest Ecoregion.

The Maritime Barrens actually represent two heath types. The Kalmia Heaths we observed at Stop #2 and Empetrum Heaths. The Empetrum Heaths are very similar in structure and species composition to the Alpine Heaths on the summit of Hawke Hill. The primary difference is the lack of true arctic alpine species such as _Diapensia lapponica_ and the more continuous cover of the crowberry. The differences are summarized in Tables 1 and 2. In general, the Empetrum Heaths occur on very exposed sites along the coast and above 250 m towards the interior. In my original investigations, I concluded that the Empetrum Heaths represented a climax type that never supported forest growth better than krummholz.

A ridge directly to the east approximately 300 m in elevation radically altered this interpretation of the successional status of Empetrum Heath as well as my total perception of the historical development of this landscape.

A wildfire crossed this ridge in May 1975 and exposed the remains of tree trunks as large as most trees presently growing in the

Table 1. Summary of floristic and edaphic characteristics of the Alpine Heath, Empetrum Heath and the Rhacomitrium Heath.

<table>
<tr><td colspan="6">VEGETATION STRUCTURE:</td></tr>
<tr><td colspan="2">Empetrum Cushions / Bare Gravel (1:1)</td><td colspan="2">Empetrum and Moss Cushions / Bare Soil in Patches (5:1)</td><td>Empetrum Cushions
Dwarf Shrubs (20-30 cm)</td><td>Sphagnum Carpet
Dwarf Shrubs (15-20 cm)</td></tr>
<tr><td colspan="6">*DIFFERENTIAL SPECIES WITH RESPECT TO THE KALMIETUM ASSOCIATION:</td></tr>
<tr><td colspan="6">Potentilla tridentata, Empetrum nigrum, Deschampsia flexuosa, Calamagrostis pickeringii, Juniperus communis, Prenanthes trifoliolata, Solidago uliginosa</td></tr>
<tr><td colspan="2">Diapensia lapponica, Arctostaphylos alpina, Loiseleuria procumbens, Cetraria nivalis, Ochrolechia frigida</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Juncus trifidus
Cetraria cucullata
Lycopodium selago
Platismatia glauca</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td>Betula pumila
Salix uva-ursi
Polygonum viviparum
Leontodon autumnalis</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="3">Vaccinium uliginosum, Empetrum eamesii, Cladonia boryi, Sphaerophorus globosus, Cetraria islandica</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="2">Myrica gale, Chamaedaphne calyculata, Coptis groenlandica, Clintonia borealis, Osmunda cinnamomea, Smilacina trifolia</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td>Sphagnum nemoreum
Mylia anomala
Vaccinium oxycoccus
Sarracenia purpurea
Drosera rotundifolia
Ptilium crista-castrensis</td></tr>
<tr><td colspan="6">CLIMATIC EXPOSURE:</td></tr>
<tr><td colspan="2">Extremely Exposed</td><td colspan="2">Exposed</td><td colspan="2">Moderately Exposed</td></tr>
<tr><td colspan="6">SOIL CONDITION:</td></tr>
<tr><td colspan="2">Well Drained Regosols or Shallow Podsols</td><td colspan="2">Well Drained to Somewhat Moist Podsols</td><td>Moist-Wet Gleyed Podsols</td><td>Wet Gleysols</td></tr>
<tr><td colspan="6">VEGETATION TYPE:</td></tr>
<tr><td>Diapensio-Arctostaphyletum Juncetosum</td><td>Diapensio-Arctostaphyletum Betuletosum</td><td>Empetreto-Rhacomitrietum lanuginosae</td><td>Empetretum typicum</td><td>Empetretum myricetosum</td><td>Empetretum sphagnetosum</td></tr>
<tr><td colspan="6">HEATH TYPE:</td></tr>
<tr><td>Alpine Heath</td><td>Sub-Alpine Heath</td><td>Rhacomitrium Heath</td><td>Empetrum Heath</td><td>Myrica-Empetrum Heath</td><td>Sphagnum-Empetrum Heath</td></tr>
<tr><td>Dj</td><td>Db</td><td>Er</td><td>Et</td><td>Em</td><td>Es</td></tr>
</table>

*The *Empetretum* association is separated from the *Vaccinietum* by the abundance of Empetrum nigrum, Vaccinium vitis-idaea, and Juniperus communis and the absence of differentials of the latter association.

Table 2. Summary of floristic and edaphic characteristics of the Kalmia Heath and Blueberry Heath.

VEGETATION STRUCTURE:				
Dwarf Shrubs 30-50 cm Bare Soil < 10% Humus 15-30 cm	Dwarf Shrubs 30-50 cm No Bare Soil Humus 10-30 cm	Sphagnum Carpets Dwarf Shrubs 10-30 cm No Bare Soil Peat 10-40 cm	Alder Thickets 50-100 cm Dense Litter Humus 10-30 cm	Blueberries and Herbs Bare Soil 20-30% Humus 5-10 cm
DIFFERENTIAL SPECIES OF THE KALMIETUM:				
Kalmia angustifolia 60-90 Cover [illegible] *Viburnum cassinoides* *Smilacina trifolia* [illegible] *Amelanchier bartramiana*				
DIFFERENTIAL SPECIES OF THE VACCINIETUM:				
				Vaccinium angustifolium 60-90% Cover *Luzula campestris* *Lycopodium obscurum* *Taraxacum officinale* *Achillea millefolium* *Hieracium* [illegible] *Solidago rugosa*
DIFFERENTIAL SPECIES OF THE SUB-ASSOCIATIONS:				
	Myrica gale *Chamaedaphne calyculata* *Osmunda cinnamomea*	*Coptis groenlandica* *Clintonia borealis* *Sphagnum* [illegible] *Mylia anomala* *Vaccinium oxycoccos* *Sarracenia purpurea* *Drosera rotundifolia* *Ptilium crista-castrensis*	*Alnus crispa* *Pteridium aquilinum* *Betula papyrifera* *Cypripedium acaule* *Dicranum undulatum* *Solidago macrophylla* *Sorbus americana* *Polytrichum commune*	*Polytrichum commune*
CLIMATIC EXPOSURE:				
Moderately Sheltered	Sheltered		Very Sheltered	Variable
SOIL CONDITION:				
Well Drained Podzols	Moist to Somewhat Wet Gleyed Podzols	Wet Gleysols	Moist Humic Gleysols	Very Variable
VEGETATION TYPE:				
Kalmietum typicum	Kalmietum myricetosum	Kalmietum sphagnetosum	Kalmietum alnetosum	Vaccinietum angustifolii
HEATH TYPE:				
Kalmia Heath	Myrica-Kalmia Heath	Sphagnum-Kalmia Heath	Alder-Kalmia Heath	Blueberry Heath
K	Km	Ks	Ka	V

lowland valleys. Currently, the only forest growth on this ridge is stunted balsam fir krummholz. The conclusions that can be drawn from this observation are summarized in Figure 8.

Afforestation attempts in the subarctic heath zone using black spruce and sitka spruce have failed miserably. However, there is at least one site near Come-by-Chance where eastern larch and Scots pine planted on ploughed Empetrum Heath in 1966 have attained marginal success in forming a forest cover.

Habitat Summary

Latitude: 47°20'00", Longitude: 53°07'30", Elevation: 315 m

Bedrock Geology: Granitic

Surficial Geology: Discontinuous Ground Moraine with Sorted Polygons

Soil Series: Bauline-Kelligrews

(mostly Orthic Regosol in this area)

Soil Texture: Sandy Loam - Loamy Sand

Moisture Regime: 2

Forest Capability: 7V (exposure)

CCELC Vegetation Classification:

a) Krummholz - Closed Dwarf Needleaf Trees

b) Alpine Heath - Open Very Low Evergreen Shrubs

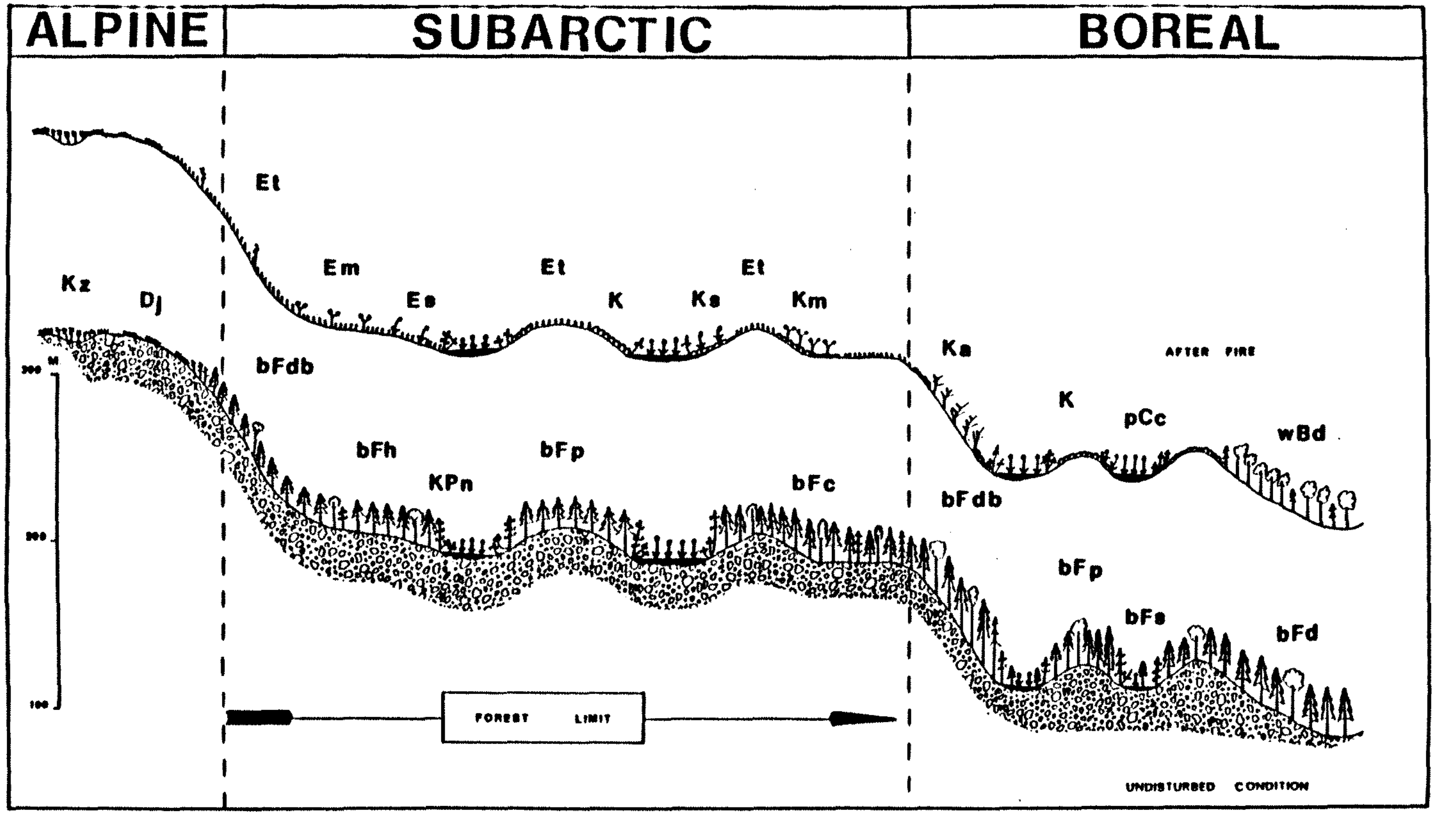

Figure 8. The toposequence of vegetation types before settlement and after repeated burning by European man. Extensive removal of forest caused a drop in the climatic forest limit.

Vegetation

Vegetation Carpet (0-10 cm)

Empetrum eamseii 3•3

Potentilla tridentata 2^+•1

Diapensia lapponica 2^-•2

Arctostaphylos alpina 1^+•2

Lycopodium solago 1^+•2

Juncus trifidus 1^+•2

Desclumpsia fleuxuosa 1^+•2

Vaccinium uliginosum var. alpinum 2^-•2

Calamagrostis pickeringii 1^+•1

Solidago hispidula 1^-•1

Maianthemum canadense 1^+•1

Picea glauca form parva $^+$•2

Loisleuria procumbens 2^-•2

Vaccinium angustifolium 1^+•2

Mosses and Lichens

Alectoria ochroleuca 1^-•2

Cladonia terrae-novae 2^-•2

Cornicularia aculeata 2^-•2

Sphaeophorius globosus 1^+•2

Cladonia boryii 1^+•2

Polytrichum jumperinum 1^-•2

Cetraria glauca 1^-•2

STOP #4 BAZZANIA-DRYOPTERIS-BALSAM FIR FOREST TYPE

(Island Pond Forest Access Road)

The Bazzania-Dryopteris-Balsam fir type dominates steep valley slopes and supports some of the best forest growth on the Avalon Peninsula. These sites are usually formed from rocky colluvium with seepage in the lower B horizon (Figure 9).

This particular site is a domestic woodlot where cutting is regulated through a provincial government permit system. The lower slope is probably a crevasse filling consisting of course textured material. The cutover here is more typical of succession on a nutrient poor dry site originating from a Pleurozium-Balsam Fir site. Notice the reduced increment on stumps, the sporadic occurrence of ericaceous plants and the chlorotic appearance of the fir regeneration.

Further up the slope hardwoods such as *Acer spicatum*, *Betula papyrifera* and *Sorbus americana* are more prominent. Also *Rubus idaeus* and *Ribes glandulosum* and *Solidago macrophylla* are common in the ground vegetation. Unlike most of the sites observed on Stops 1-3, this site does not have the potential to develop to Kalmia Heath. If softwood stocking fails on these sites, hardwood thickets will develop into semi-stable white birch forest. A good example of this succession an be seen in hillsides surrounding St. John's which were burnt three times in the nineteenth century.

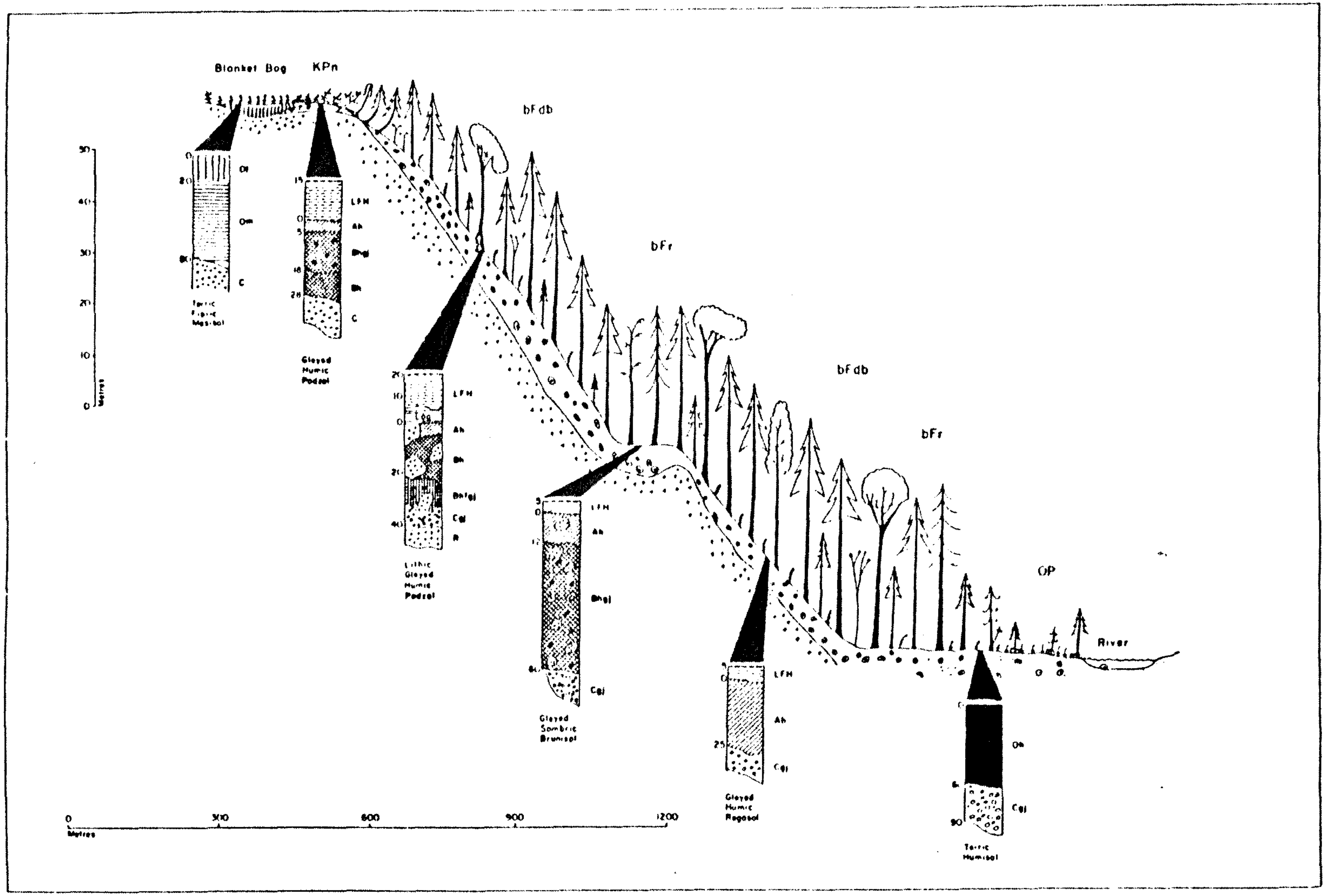

Figure 9. Vegetation-soil toposequence in a hilly landscape.

Discussion Topics

1. The importance of forest site classification in identifying different successional trends on different surficial deposits.
2. What should be the minimal scale for mossing forest site classification systems?

Habitat Summary

Latitude: 47°20'30", Longitude: 53°10'00", Elevation: 160 m

Bedrock Geology: Felsic volcanic rocks and elastic sedimentary

Surficial Geology: Ground moraine over colluvium and ice contact deposits

Soil Series: Cochrane (Lithic Gleyed Humic Podzol on rocky colluvium)

Soil Texture: Sandy Loam

Moisture Regime: 3

Forest Capability: 5V6V

CCELC Vegetation Classification:

a) Forest

Closed Intermediate Needleleaf Trees

b) Cutover

Open Low Mixture Trees

Vegetation

Tree Layer (12-14 m)

<u>Abies balsamea</u> 4•1

<u>Betula papyrifera</u> 2^+•1

<u>Betula lutea</u> 2^-•1

<u>Picea glauca</u> 1^+•1

Tall Shrub Layer (3-5 m)

<u>Abies balsamea</u> 2^+•1

<u>Sorbus americana</u> 1^+•1

<u>Betula papyrifera</u> 1^+•1

<u>Acer spicatum</u> 1^-•1

Low Shrub Layer (0.5-1.0 m)

<u>Viburnum cassinoides</u> 1^+•1

<u>Nemopanthus mucronatus</u> 1^-•1

<u>Ribes glandulosum</u> 1^+•1

<u>Ledum groenlandicum</u> 1^-•1

Herb Layer (0.2-0.5 m)

<u>Dryopteris spinulosa</u> 2^-•2

<u>Solidago macrophylla</u> 1^+•1

<u>Trientalis borealis</u> 1^-•1

<u>Cornus canadensis</u> 1^+•1

<u>Gaultheria hispidula</u> 1^-•1

<u>Maianthemum canadense</u> 1^+•1

<u>Monotropa uniflora</u> 1^-•1

Moss Layer

Rhytidiadelphus loreus $2^{-}\cdot 2$

Rhytidiadelphus triquetrus $2^{-}\cdot 2$

Pleurozium schreberi $2\cdot 3$

Dicranum majus $2^{+}\cdot 2$

Hylocomium splendens $1^{+}\cdot 2$

STOP #5 DRYOPTERIS-BALSAM FIR FOREST ON RIBBED MORAINE

The Ribbed Moraine represents a system of low ridges between 10-15 m high at 200-300 m intervals. This glacial deposit dominates the central Avalon Peninsula and it is believed to have been formed as a recessional moraine originating where tongues of ice projected beyond the main ice mass. These are the deepest tills in the study area ranging 9-15 m. Hard siltstone and slate with some greywacke and arkose, comprise the bulk of the material in the ridges. The composition of a typical till is 62 percent gravel, 24.5 percent sand, 11.0 percent silt and 2.5 percent clay with very few large erratics (Henderson 1972).

Figure 9 shows the toposequence of vegetation on the Ribbed Moraine landtype. The Pleurozium-Balsam Fir forest occupies the well-drained summit position coinciding with an Orthic Ferro-Humic Podzol. The proximal slope appears to be affected by considerable surface seepage as evidenced by mottling in the upper solum of the soils. The Balsam Fir-Clintonia forest is stable on the gleyed podzol of the upper slope and the Nemopanthus-Kalmia-Black Spruce (Taxus type) forest occupies a peaty phase of the gleyed podzol on the lower slope. Basin Bogs are usually present in the intervening depressions between the ridges. On the distal slope the upper solum appears well-drained and mottling is limited to the lower B horizon. This slope is occupied by the Dryopteris-Balsam Fir forest with *Dryopteris spinulosa* covering as much as 90 percent of the understory. At the base of the slope shallow depressions are occupied by the Sphagnum-Balsam Fir forests. Rounding of stones under these deposits suggests that some sites were old riverbeds that later infilled with vegetation. The moraine portrayed in Figure 9 represents one of the largest deposits in the study area. On smaller deposits with less extensive slopes the toposequence is limited to the Dryopteris-Balsam Fir (Typical type) on upper slopes, the Nemopanthus-Kalmia-Black Spruce on midslopes and the Sphagnum-Black Spruce forming transitions to organic deposit in depressions. This abbreviated toposequence was frequently observed in the small moraine islands found in large blanket bogs in the Avalon interior.

Habitat Summary

Latitude: 47°15'00", Longitude: 53°16'00", Elevation: 130 m

Bedrock Geology: Sedimentary Sandstone; Siltstone, Shale, ? ___

Surficial Geology: Ribbed Moraine

Soil Series: Cochrane and Pouch Cove (Orthic and Gleyed Podzols)

Soil Texture: Sandy Loam-Loam

Moisture Regime: 2

Forest Capability: 5^{6}_{MF} 7^{4}_{FW}

CCELC Vegetation Classification System: Closed Intermediate Needleleaf Trees

Vegetation

Tree layer (12-14 m)

Abies balsamea $4\cdot 1$

Betula papyrifera $1^{+}\cdot 1$

Tall Shrub Layer (1-2 m)

Abies balsamea $2^{-}\cdot 1$

Betula papyrifera $1^{+}\cdot 1$

Sorbus americana $1^{+}\cdot 1$

Low Shrub Layer (0.2-1.0 m)

Ribes glandulosum $1^{+}\cdot 1$

Abies balsamea $2^{-}\cdot 1$

Taxus canadensis $1^{+}\cdot 1$

Herb Layer (0.2-1.0 m)

Dryopteris spinulosa spp. *americana* $3\cdot 1$

Cornus canadensis $2^{+}\cdot 1$

Trientalis borealis $1^{+}\cdot 1$

Maianthemum canadense $1^{+}\cdot 1$

Monotropa uniflora $1^{-}\cdot 1$

Moss Layer

Pleurozium schreberi $2^{+}\cdot 3$

Hylocomium splendens $2^{-}\cdot 2$

Ptilium crista-castrensis $1^{-}\cdot 2$

Dicranum majus $2^{-}\cdot 2$

Rhytidiadelphus loreus $1^{+}\cdot 2$